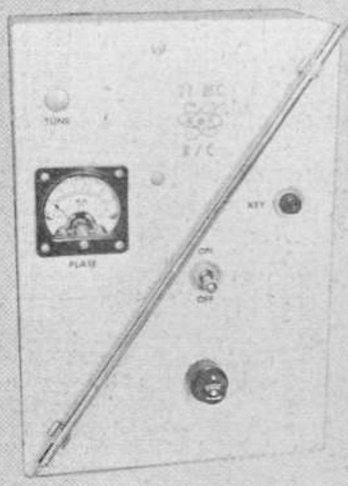
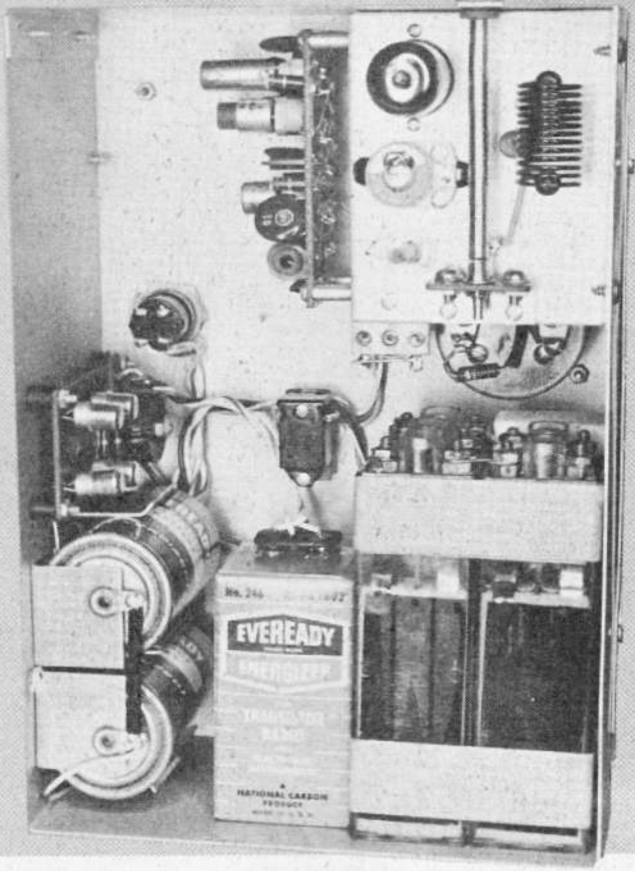
Designed by Howard G. McEntee, W2SI





"Legal-Mac" Transmitter

At last...home-bilt radio control rig meets FCC regulations . . . permits changing the "27" frequencies at will!

Under F.C.C. rules radio-control modelers are not allowed to tune up or change frequency on most home-built transmitters without enlisting the services of a Commercial Operator licensee for check-up. Here is a transmitter you can build, tune and change frequency—if you follow directions carefully. It is a bit more complex and costly than many R/C transmitters now in use; but the era of the single tube, single-tuned-circuit home-built transmitter is past. If you want to construct sets and do your own tuning, a more complex approach will be necessary. Here is one way to do it. This is definitely not a beginner's project, but one for the fairly experienced R/Cer who has the equipment and know-how to follow the instructions.

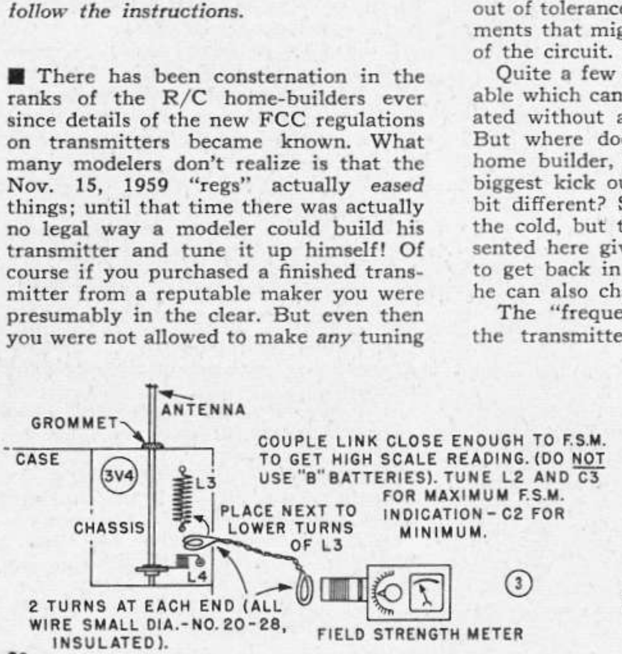
■ There has been consternation in the ranks of the R/C home-builders ever since details of the new FCC regulations on transmitters became known. What many modelers don't realize is that the Nov. 15, 1959 "regs" actually *eased* things; until that time there was actually no legal way a modeler could build his transmitter and tune it up himself! Of course if you purchased a finished transmitter from a reputable maker you were presumably in the clear. But even then you were not allowed to make *any* tuning adjustments, nor could you change frequencies. Any such tuning or change required the services of a government licensed Commercial Operator with appropriate equipment to make sure the signals were within the legal tolerances. Despite the fact that the FCC set up five new spot frequencies for R/C in the Fall of 1958 most of us could not use them without digging up that all-important Commercial "Op" to check tuning after a crystal had been changed.

With the November regs it has become possible to build a transmitter and tune it yourself, *provided* the frequency-determining elements were tuned and sealed by a reputable maker, who must certify that the frequency will not shift out of tolerance, regardless of any adjustments that might be made in other parts of the circuit.

Quite a few transmitter kits are available which can legally be built and operated without a Commercial Op tuneup. But where does this leave the chronic home builder, the modeler who gets his biggest kick out of making something a bit different? So far he has been out in the cold, but the transmitter to be presented here gives such R/Cers a chance to get back in business, and as a bonus he can also change frequency legally.

The "frequency determining unit" of the transmitter is a completely built, tuned and "sealed" transistor oscillator and amplifier chassis, a tiny item on a printed circuit base, which works on low voltage and low power—and has low power output. It is International Crystal's model TRT, and the maximum power output is 25 milliwatts (that is, 25 thousandths of a watt). Now it is quite possible to work a good distance with this unit feeding an antenna, given a sensitive receiver and careful tuning all around. The average R/C modeler, particularly those who operate planes, feels more comfortable with considerably more power than this—if only because it allows him to be a little sloppy in his tuning and battery checking. So what we do here is to build the output of the TRT up in a conventional tube amplifier; power *output* from the tube is a half watt or a little more, depending upon the power supply used (yep, you have several choices there too).

The TRT has two transistors and two tuned circuits; the oscillator circuit tuning is sealed and should not be altered. Amplifier tuning can be changed at will, with practically no change in crystal oscillator frequency. By the same token, when the 3V4 amplifier is properly adjusted, you can tune it too, with hardly any noticeable change in frequency. The maker assures us that the TRT circuit is such, and the crystals made for it are so



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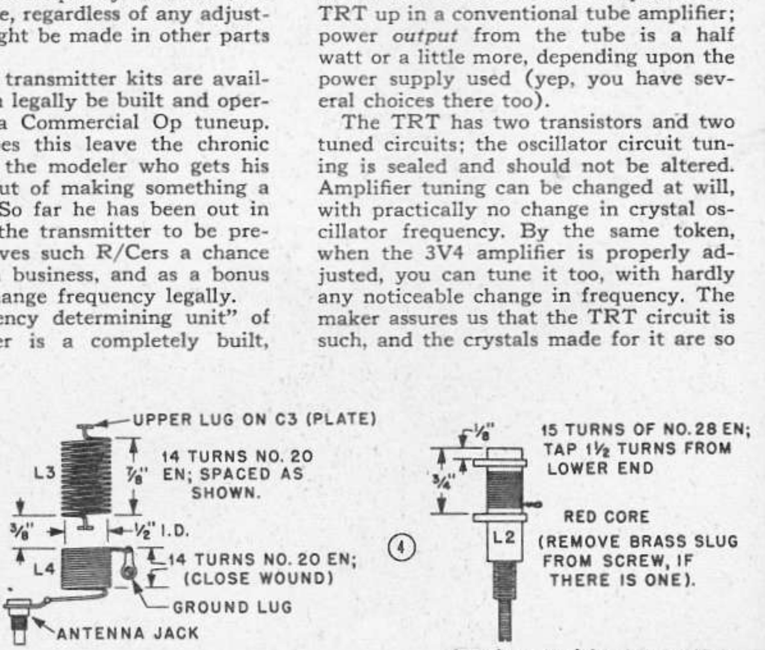

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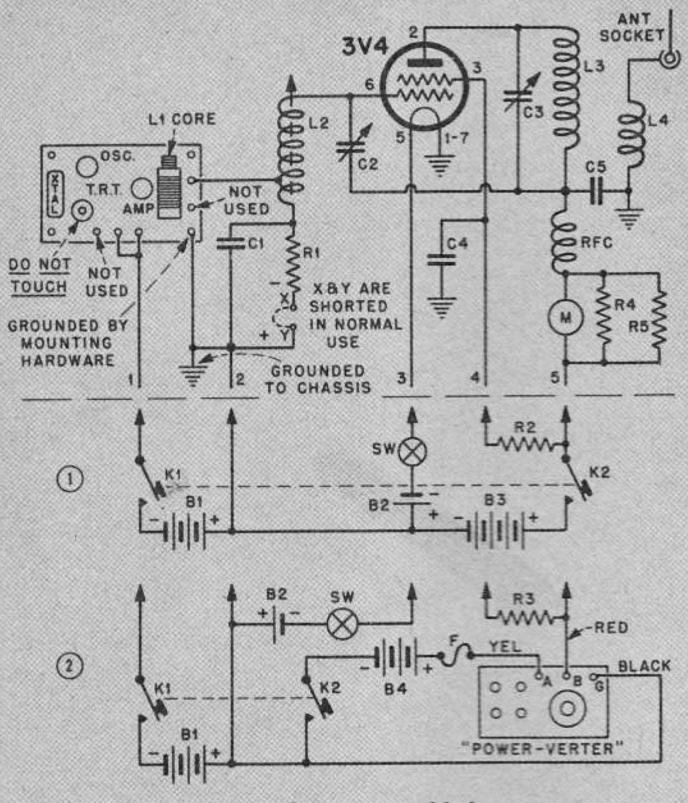
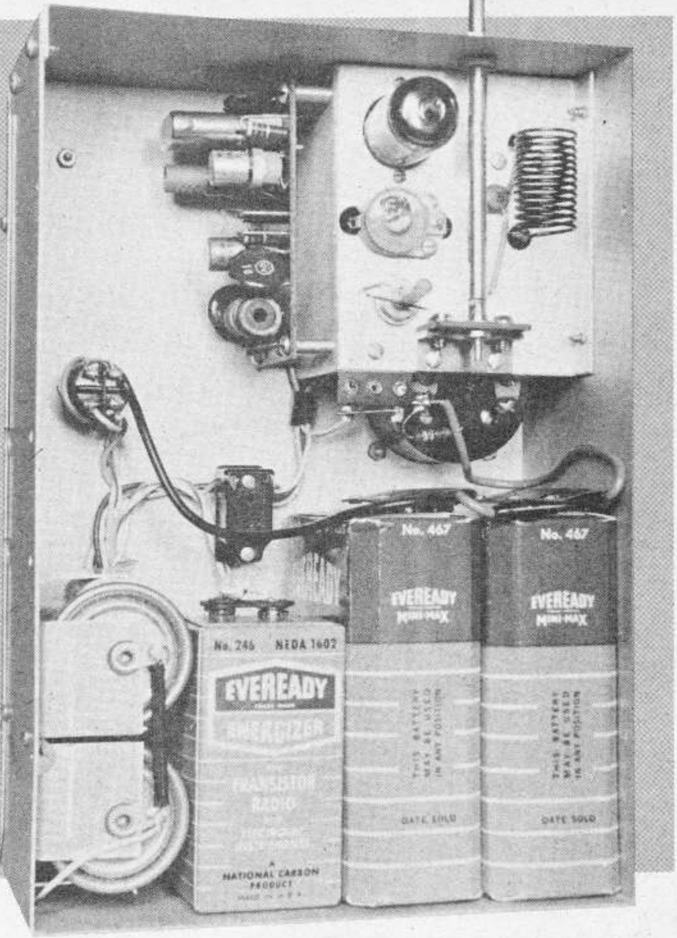


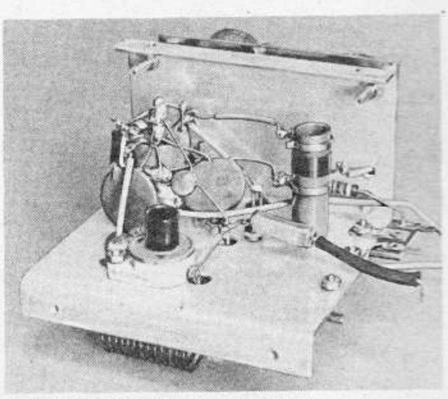
Since photos were made, L4 was added.

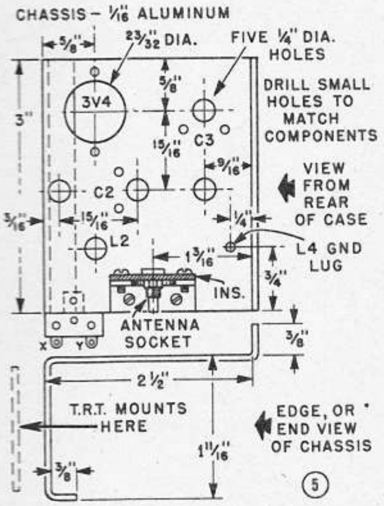


accurate you can change these crystals within the limits of our R/C frequencies (26.995 to 27.255 mc) with no need to retune the oscillator and with little change in power output. We have found this to be true. The crystals are International type F-605 (.0025% tolerance) —*no other crystals should be used.*

Since the TRT is not exactly a powerhouse of RF output, a bit more complex circuitry is required to get sufficient drive for the 3V4. It was necessary to use a tuned grid circuit, and to keep things completely stable the 3V4 has to be neutralized. Thus there are more tuning adjustments than in many other transmitters. Once the neutralization is accomplished you won't have to go through it again, even if you change crystals or tubes.

A good deal of experimental work proved that the transmitter is completely stable and quite easy to tune up. Furthermore, we were happy to find that it has greater output (as checked on an FSM) than any of half a dozen other hand-held transmitters tried, even though most of them used a 3A4 and considerably more power input to the tube feeding the antenna. A good deal of thought went into the layout to keep circuits isolated; make any change in such layout or in the parts specified and you are strictly on your own! We don't claim improvements can't be made on the transmitter—simply that this version has been carefully checked and we are sure of it as it stands.





The main chassis is bent from aluminum sheet and holds all the parts of the RF circuits, with the TRT attached to one side (with hardware that comes with it). A shielded-type tube socket is used mainly to allow a simple mounting without spacers below the chassis. Long #3 screws (they are the type sold for mounting small model engines) clamp the upper opening of the socket shield against the chassis; the hole is big enough to pass the tube, but not to allow the shield to slip through. The two variable condensers C2 and C3 have their lugs bent at right angles and are held to the sheet with small screws (take it easy when you tighten these—that ceramic isn't steel, you know!). The plate coil L3 is held on the lugs of C3; Dwg. 4 shows how the grid coil L2 is made. When mounting this one, make a spring from 1/32" music wire to bear against the core adjusting screw to keep it from shifting after adjustment. This is easier than trying to tighten a nut on the screw. If you find a brass slug next to the core on the adjusting screw of the coil form you get, remove carefully and discard this slug.

Wiring is simple and should be done with solid wire for the RF parts of the circuit on the chassis. The TRT unit is grounded by the mounting hardware, so all you need do is connect a single lead from the point shown in Dwg. 1 to the tap on L2. Connect together the two eyelets and run a lead to the Key (K1). We strongly suggest that the chassis be assembled and wired, then tested as a unit, before mounting in the case (it's easier to check boo-boos this way).

On the lower edge of the chassis (as it sets in the case) is an insulated bracket to hold the jack for the antenna. Also on the lower edge of the chassis may be seen two lugs, X and Y, for connections of a meter during tune up. All ground connections seen above the dotted line in Dwg. 1 (except the one labelled "Chassis"—which it is) are made to the metal rim around the tube socket; connect the center "shield" of the socket to this point also. Then run a single lead from the socket to the power department—this is lead 2.

Perhaps we had better explain the

(*Continued on page* 64)

Legal-Mac

(*Continued from page 21*)

power options at this point. The simplest and lowest cost battery arrangement is seen below the dotted line in Dwg. 1; it consists of a 9 volt battery (B1) for the TRT, two D cells in parallel (B2) to run the tube filament, and two 67½ volt B batteries for B3. The 9 volt battery should last several hundred hours, as the current drain on it is low—about 6 ma total—and even this is on only when the key button is depressed. The filament drain is 100 ma, and the two D cells should last 60 to 80 hours, if you get the type specified. B battery life is also good, for again, current is drawn only when the key is punched; we would guess about 15 hours. That's a lot of button punches!

For those who want something a bit more deluxe, check Dwg. 2; this shows the arrangement used with a transistor power converter to supply the high voltage for the 3V4. Again, since the button is only pushed for short intervals it is practical to use a 6 volt lantern battery at B4; with this the voltage will be somewhat higher, at least when the battery is fresh, and the screen grid resistor R3 should be higher than with the arrangement in Dwg. 1. Drain on B4 is about ½A, with the tube plate at 10 ma and the screen grid drawing 3 ma. At this drain the battery should last several hours—how long is difficult to say, as battery life charts are not generally available for such service. But the lantern batteries are fairly low in cost and available at most every hardware store. A 6 volt radio battery can also be used.

Most deluxe high voltage setup of all, and one that will last many years with a little care, is the same transistor converter but powered by a set of surplus (or other) ni-cad cells. One of the photos shows five of these cells in the case, those shown being the ABC 2 AH style. A wood dummy was cut the same size as a cell and taped into a block with the five ni-cads. This size of cell will give about four hours of operation (and again remember that this is 4 hours worth of *button-down* operation, which adds up to an awful lot of flying) on a charge, and can of course be charged many many times.

This setup will provide the highest output and also will maintain this output the best, since the ni-cads hold their voltage level very well, while the 6 volt dry battery sags down fairly rapidly. It was found that only four ni-cads did a nice job too, and with them the high voltage is just about the same as with fresh B batteries; for this reason, if you use only *four* ni-cads you can install resistor R2 to supply the screen grid power of the 3V4. For five ni-cads, a higher resistor (R3) must be used.

You might as well finish up the hole-drilling before commencing the radio checkout. The case should be drilled for meter, key button (note that K1-K2 must be a double pole type, as it breaks the power to the TRT and to the 3V4 in two separate circuits), on-off switch. If you use the transistor converter with any of the suggested power supplies, the maker strongly advises installation of a fuse, so Dwg. 2 includes F and you'll need a holder for same, seen near the lower edge of the front panel.

Plate current of the 3V4 should not run over 10 ma, which means a meter of about 20 or 25 ma would be the best. Unable to obtain one in the low cost line used, we employed a 5 ma. meter shunted by resistors R4 and R5; these should be 5 percenters, preferably wire-wound as specified in the parts list. They will give very close to 25 ma full scale reading on the 5 ma meter (better check it to make sure, though, if you have an accurate meter of this or higher range).

The two cell battery case is attached to one side of the box and if you use it, the power converter can go just above. It's best to use insulated bushings for the latter, so you won't short any of the printed circuitry to the case.

Batteries B1 and B3 (or B4 if used) should be fastened in place so they can't shift; it was found that two strips of ½" thick foam plastic tape on the back cover of the case would do a good job; Tesa-moll tape which has a strong adhesive on one side was used.

A hole in the top of the case with a close-fitting rubber grommet guides and supports the antenna. When not in use the antenna is snapped into a pair of small fuse clips bolted to the front of the case. We used a 48" long antenna; you can get one of 36" length that is the same diameter and fits the same socket (which comes with either antenna) but the shorter one will not give as good output, of course.

It was found handy to cement a ⅜" length of ¼" ID tubing over the slotted tuning screw on C3; makes it much easier to hit the slot with your tuning tool. Bakelite, polystyrene or even rolled paper tubing can be used, held in place with ordinary model cement.

Now, how about tuning up? You'll need an insulated tuning tool, one with no metal on the end; hard fibre is best, but polystyrene is okay if you cut the tip to fit the slots on C2 and C3. A piece of fuel line tubing was slipped on the screw of L2 as a handle, and a matchstick cut to hex shape was stuck into the core of L1. Open the short across terminals XY and connect a one ma or (preferably) 500 microamp meter at this point. Turn on the filament and also connect B1 into the circuit without K1, so that the TRT runs continuously. *Do not close* K2 or put any B voltage on the 3V4 at this point. Set C2 so the movable plate is at half-capacity—full capacity of this type of condenser is had when the silvered semi-circular plate is nearest the end with mounting holes. You should get a reading on the grid meter, which can be peaked up by adjustment of L1 and L2. When the reading is highest (it should be at least .2 ma) try tuning C3 throughout its range; at some point near midrange you will probably see the grid meter give a downward kick. If you *don't* see such a kick, shift C2 an eighth turn toward lower capacity, retune L2 for peak grid current and try C3 again. If you can get a kick in grid current with C3 anywhere at all near mid-range, all is well so far; this will prove that the 3V4 plate circuit will tune to the desired frequency.

Now shift C2 in the direction that minimizes the kick in grid current as C3 is rotated. L2 and C2 interact to a great extent, so after each move of C2 you will have to retune L2 for maximum grid current. L1 is also affected but to a lesser extent. You should be able to reach a point on C2 where there is no discernible kick in grid current no matter where you set C3; this means you have the 3V4 and associated circuits neutralized.

For those who are not too sure of this term, here's a little explanation: Any vacuum tube has a certain amount of capacity between grid and plate, some much more than others. This capacity is necessary in some circuits—oscillators must have it to work at all. But too much (and it only takes a tiny amount) will make a tube oscillate when you don't want it; or it will be regenerative, which means it isn't quite oscillating but is getting ready to. Oscillation of a tube—the 3V4 in this case—would mean that you could be putting out a signal on some frequency well removed from that of the TRT. Neutralization is a means to counterbalance or nullify the grid-plate capacity, so that the tube becomes entirely stable with no tendency to oscillate.

All the above sounds like a lot of complicated work, but it actually only takes a few moments (provided you have done a good construction job and the parts are all right). Next step is to assemble the chassis and case, finish the wiring and install the antenna. You will have to re-neutralize now, proceeding the same way as before. C2 will doubtless end up at a slightly different position. If you have a Field Strength Meter with a tuned circuit you can get *exact* neutralization, by means shown in Dwg. 3. Don't apply plate voltage at any time with this setup though, or your FSM meter will practically explode! After neutralizing, remove the FSM link (if you have used this system) but leave the grid meter connected. Install the B batteries (and antenna) and hit the key button, holding onto the case with one hand while you tune C3 to resonance. The plate meter will indicate around 14 ma off resonance, and should be around 9 to 10 ma when you are tuned on the nose.

If coils L3 and L4 are made as specified, and the distance between them is 3/8", antenna coupling should be about right. It's easy enough to check, by noting if the plate current is 9 to 10 ma when C3 is tuned to resonance, and you hold the case with one hand (this changes antenna loading and tuning). If it is more than 9½ ma, space the coils a little farther apart. You will not get more output if the coils are put close together to raise plate current over 10 ma; actually, output will drop, as the tube will be overloaded.

After these adjustments have been made run a "bead" of model plane cement along the surface of the turns of both L3 and L4, to stiffen them up; this line of cement should be no wider than about 1/8", and you can put a similar line on the opposite side of the coil (on the inside, which is all you can reach) for further stiffening.

When you apply plate and SG voltage to the 3V4, you will note the grid current drops somewhat, so you should retune L1 and L2 at this time; don't shift C2. Then touch up C3 and check for proper plate current.

We found it possible to change crystals for any of the R/C spot frequencies and after touching up L1, L2 and C3 output was about the same on each spot. Again, no change of C2 is necessary, after you have neutralized the circuit properly. Remember to use only International's Type F-605 crystals, and when ordering specify you want them for the TRT unit. You get one crystal to your specified frequency when you purchase the TRT.

For test work at close range or in the shop you can collapse the antenna all the way to cut down the signal output. This detunes the 3V4 plate circuit, of course, and you should retune it, but only to drop the plate current to about 9 or 10 ma, *not* to minimum plate current (which would be around 4 ma with the short antenna—this can damage the tube as the screen grid current will rise too high). Or you could install a low power switch to drop the B voltage from

135 volts with two batteries in series to just a single one and 67½ volts; with the antenna at any desired length and at the lower voltage no retuning would be needed.

B1 should be discarded when its voltage with key depressed drops to 7½, and B2 when the cells are down to 1¼ volts. B3 can be allowed to drop quite low—as low as 90 volts—but power output suffers drastically when the voltage is under 115 or so. Similarly, with the B converter, B4 should be replaced when the high voltage is down to around 100.

Well, there's your "home builder's special." It has ample output for most any CW receiver—and more than most hand held transmitters. And it's legal to build, tune up and operate—provided you follow the instructions carefully. As with any home-built transmitter, we advise a check-up by an experienced R/C modeler, if you can arrange this. But it's pretty hard to go wrong on this one. Let us know how you make out.

PARTS REQUIRED: TRT, complete MOPA P.C. transmitter unit ($24.95 from International Crystal Mfg. Co., 18 N. Lee, Oklahoma City, Okla.) Condensers: C1, C4, .01 mf. ceramic (CRL type DD103); C2, 1.5-7 mmf ceramic variable (CRL type 822-EZ); C3, 4-25 mmf ceramic variable (CRL type 822-AZ); C5, 100 mmf ceramic (CRL DD-101). Resistors: R1, 50K, ½W carbon; R2, 15K, ½W carbon, 5%; R3 used only with power converter and five ni-cads, 36K, ½W, 5% carbon; R4, 1 ohm, 5% wirebound (IRC type BW½); R5, 15 ohm wirewound (IRC type BW½). One 7 pin miniature socket, (Lafayette MS-495). One CTC coil form type LS3, with red core. One 48" collapsible antenna (Laf. F-440). One 70 microhenry RF choke, RFC (Gyro). One 5 ma 1½" sq. meter (Laf. TM-401). One DPST key pushbutton K1-K2 (Gyro). One 3V4 tube (Gyro). One SPST toggle switch, SW. B1, 9 volt battery, Eveready type 246 or equiv. B2, two heavy duty D size flashlight cells in parallel, Eveready D99 or equiv. One Acme #12 holder for B2. B3, two 67½ volt batteries in series, Eveready 467 or equiv. B4, one 6-volt battery, Eveready 744 or 509, or equiv. One fuse holder (Laf. Littlefuse #342012) and 1 amp fuse to fit. One 8 x 5½ x 3" aluminum case (Ace #3). Two snap connectors for B batteries and one for 9-volt battery (Gyro). #28 en. wire for L2 and #20 en. for L3 and L4. Fuse clips to mount antenna, grommet for latter, hardware, chassis aluminum, Techni-Labels to mark panel.

To use converter, order B & S Power-Verter, omit B3 and connectors, also R2, use B4 listed above, or ni-cads or other 6 volt source. For B battery power, omit R3, fuse and holder, B4 and converter.