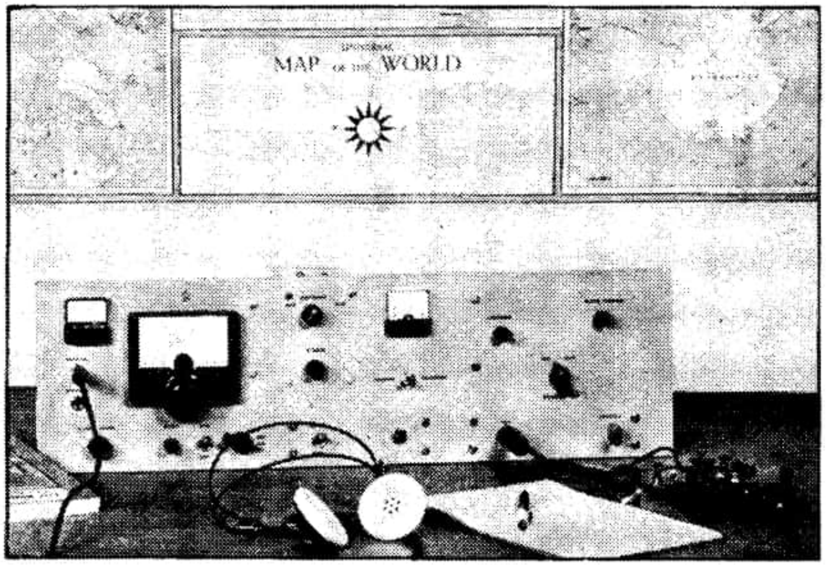
build this

TWO BAND HAM STATION



- ***Superhet Receiver***
- ***Regulated Power Supply***
- ***40-Watt Transmitter***

By Harry Kolbe

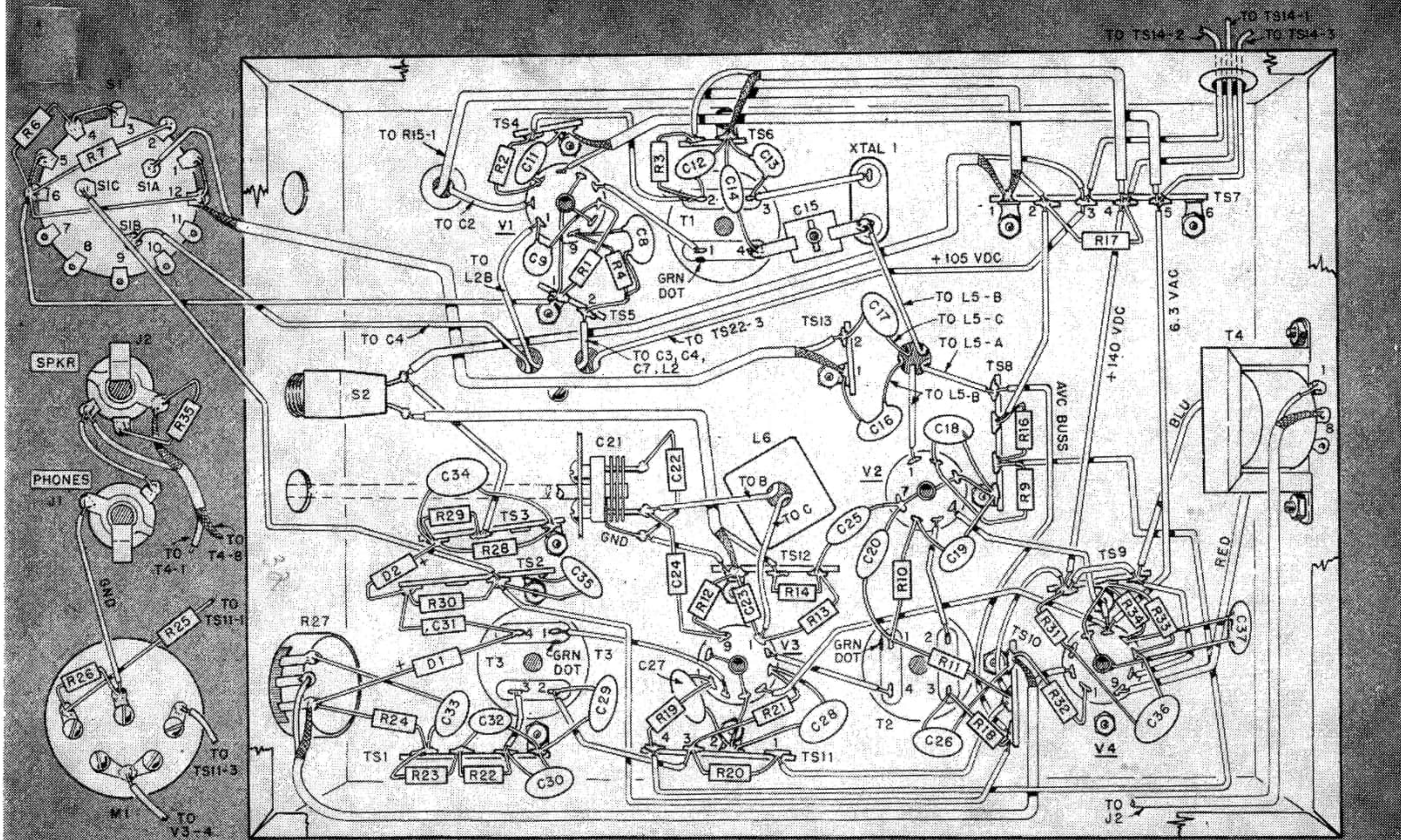
IN the good old days, hamming was a real adventure. That was back when kits were still a thing of the future and half the challenge of going on the air was in building your own equipment. The equipment may have lacked all the spit and polish that kits now have, but the real spirit of hamming came through to those who cut, drilled, added a turn or rolled a coil with their own hands.

The ambitious Novice or General amateur who would like to see what it once was like can now build a complete ham station with components. EI's rig consists of a hot four-tube superhet receiver; a one-tube, 40-watt CW transmitter and a power supply. The station provides complete coverage of the 40 and 80 meter ham bands and the cost runs to about $50.

At first glance you may wonder why the station is built on three chassis. The answer—versatility. The station actually is three projects and may be built as such. For example, if you wish to build only the receiver, use a 12-inch panel instead of a 24-inch panel. A smaller power supply can be built on the receiver chassis. On the other hand, if you own a receiver, you may only want a transmitter and power supply. Or you may only want a good regulated power supply for experimental work.

The Receiver

Although the receiver has only four tubes, its sensitivity and selec-



TO TS14-1
TO TS14-2
TO TS14-3
S1
R6
R7
SIC
S1A
S1B
SPKR
J2
R35
PHONES
J1
TO T4-1
TO T4-8
GND
R25
TO TS11-1
R26
TO TS11-3
M1
TO V3-4
TO R15-1
TO C2
TS4
R2
C11
V1
C9
R1
R4
C8
TO L28
TS5
TO C4
TO C3, C4, C7, L2
TO TS22-3
S2
TS6
R3
C12
C14
C13
T1
GRN DOT
XTAL 1
C15
+105 VDC
TS7
R17
+140 VDC
6.3 VAC
T4
TO L5-B
TO L5-C
TO L5-A
TS13
C17
C16
TO L5-B
TS8
R16
R9
AVC BUSS
C18
V2
C19
C20
R10
C25
L6
TO B
TO C
C21
C22
C24
GND
C34
R29
TS3
R28
TS2
C35
D2
R30
C31
D1
T3
GRN DOT
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TS11
R20
GRN DOT
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TS10
R32
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TS9
R34
R33
C37
C36
V4
BLU
RED
TO J2

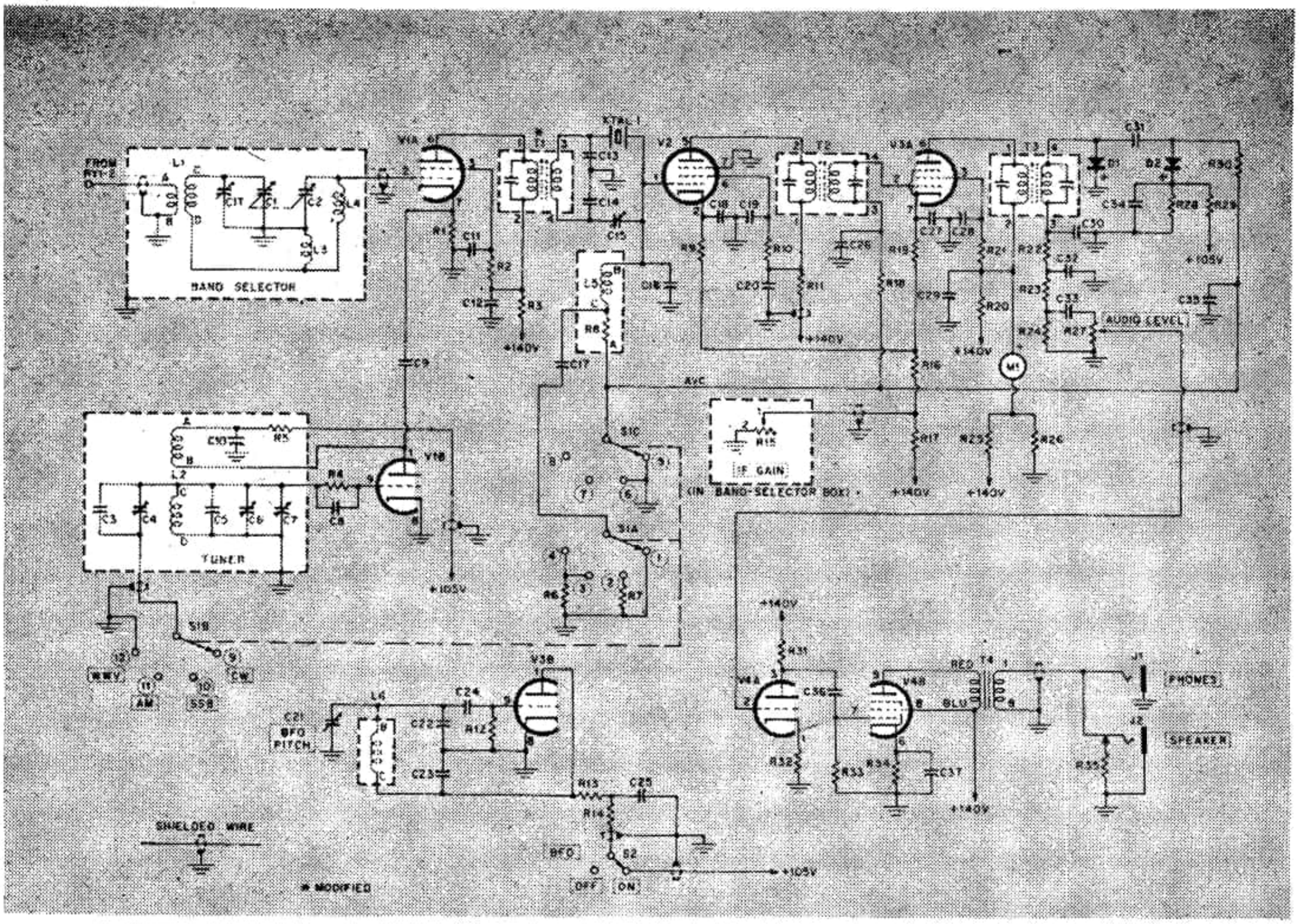


Fig. 1—Receiver schematic. Switching mode-selector switch S1 to the WWV position adds an additional capacitance (C3, C4) across oscillator coil L2 so that 5-mc signal can be received without tuning C7.

Fig. 2—Receiver pictorial (left). C21 should be mounted where shown to keep connections to it short. The control knob on front of chassis is connected to it with extension shaft and coupler (not shown).

tivity are excellent. After careful alignment we measured a sensitivity of about ½ to 1 microvolt for a 10db signal-to-noise ratio. Many features are incorporated in the receiver's design which usually are found only in high-priced communications receivers.

● **Construction.** The receiver can be built on a 7x9x2-inch aluminum chassis without crowding. Follow closely the layout of the components shown in Figs. 2 and 14. The front panel is a 7x24-inch rack panel (Premier Metal Products ARP-724). The receiver chassis is held to the panel by R27, S1 and S2.

It is necessary to modify IF transformer T1 and antenna-tuning capacitor C1/C2. T1 is a standard IF transformer with built-in fixed capacitors across both the primary and secondary windings. To provide the correct feed to the crystal filter (XTAL 1, C15, C16 and L5) the capacitor across T1's secondary must be removed (C13 and C14 mounted outside T1 are used instead of the removed capacitor).

Refer to Fig. 7. Bend back the two tabs that hold the transformer in its can then pull off the can. The secondary winding is connected to the lugs marked 3 and 4. These lugs are bent 90 degrees where they enter the plastic base. As they overlap each other and are separated by a mica dielectric, they form a fixed capacitor.

Carefully break off one corner piece of the plastic base with a pair of diagonals. Pull either lug out sideways, taking great care not to break the fine wire attached to it. Cut off the horizontal part of the lug, which forms one half of the capacitor. Now return the lug to its original position and cement it in place with Duco cement. Allow the cement to dry several hours, then replace the transformer in its shield can.

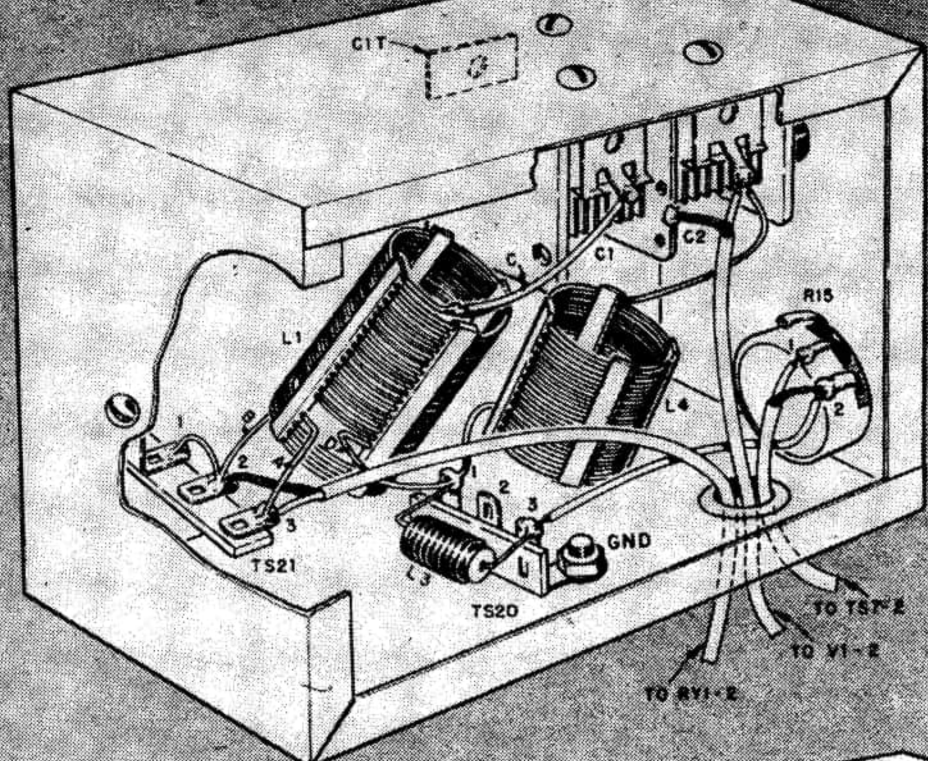


Fig. 3—Band-selector box (above). C1T is a trimmer capacitor on the other side of C1. L1 and L4 are supported by their own leads, which should be kept as short and direct as possible.

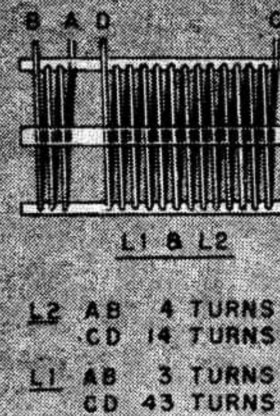


Fig. 6—L1 and L2 details. Letters correspond to connections in pictorials and schematic.

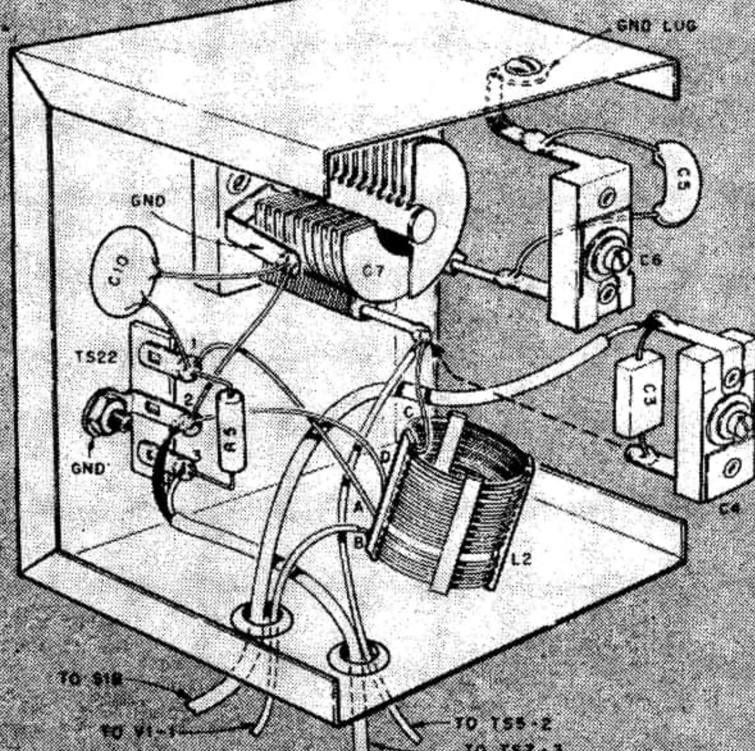
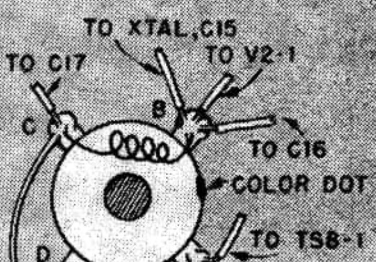


Fig. 4—Tuner (right). Wiring in size Minibox specified is tight, so watch out for shorts. Keep L2's leads short. If they're too long, L2 may flop around and the receiver oscillator will be unstable.

Fig. 5—R8 (below) must be connected directly to coil terminals. Orient lugs with the color dot.



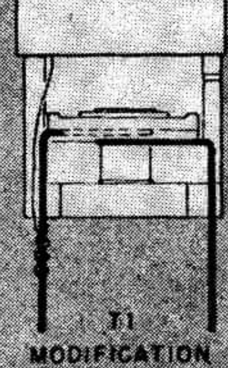


Fig. 7—Cutaway view of base of T1. Lugs overlap in base, forming capacitor. Dotted line is part that must be cut off to remove the built-in capacitor.

RECEIVER PARTS LIST

Resistors: ½ watt, 10% unless otherwise indicated
R1—2,200 ohms
R2,R8,R12,R13,R14,R18,R23 — 100,000 ohms
R3,R11,R20—1,000 ohms
R4,R22—47,000 ohms R5—3,300 ohms
R6—27 ohms R7—10 ohms
R9,R19—330 ohms
R10,R21—15,000 ohms
R15—2,500-ohm linear-taper potentiometer
R16—1,200 ohms
R17—39,000 ohms, 2 watts
R24—56,000 ohms R25—390 ohms
R26—33,000 ohms
R27—500,000-ohm audio-taper potentiometer
R28—220 ohms, 5%
R29—82,000 ohms, 5%
R30—270,000 ohms
R31—68,000 ohms R32—1,000 ohms
R33—470,000 ohms
R34—470 ohms, 1 watt R35—47 ohms
Capacitors: 500 V ceramic disc unless otherwise indicated
C1,C2—2-gang variable capacitor, 365 mmf per gang (Allied 60 L 725 or equiv. Modified, see text)
C3—240 mmf mica
C4—55-300 mmf trimmer (ARCO 427 or equiv.)
C5—150 mmf mica
C6—7-100 mmf trimmer (ARCO 423 or equiv.)
C7—3.2-50 mmf variable (Hammarlund MAPC-50 or equiv.)
C8—100 mmf mica
C9—.001 mf
C10,C11,C12,C17,C18,C19,C20,C26, C27,C28,C29,C33,C34,C36,C37—.01 mf
C13,C14—120 mmf mica
C15—3-35 mmf trimmer (ARCO 403 or equiv.)
C16—47 mmf mica
C21—2.3-15 mmf variable (Hammarlund MAPC-15 or equiv.)
C22,C23—330 mmf mica
C24—200 mmf mica C25,C35—.05 mf
C30,C31—100 mmf C32—100 mmf
S1A,B,C—3-pole, 4-position switch (Mallory 3243J or equiv.)
S2—SPST toggle switch
T1,T2,T3—1,750 kc IF transformer (Lafayette HP-226 or equiv.)
T4—Universal output transformer (Lafayette TR-12 or equiv.)
L1—Antenna transformer (see text)
L2—Oscillator transformer (see text)
L3,L4—Choke (see text)
L5—105-200 microhenry coil (North Hills Electronics S-120-H and S-120 can.)
L6—36-64 microhenry coil (North Hills Electronics S-120-F and S-120 can.)
J1—Phone jack
J2—Shorting-type phone jack
D1,D2—1N54 diode
M1—Illuminated S-Meter (Lafayette TM-11 or equiv.)
XTAL—1,750 kc crystal
V1—6EA8 tube
V2—6BJ6 tube V3—6U8A tube
V4—6CX8 tube
Misc: — 2¾x2⅛x1⅝-inch Minibox (tuning); 5x4x3-inch Minibox (band selector); crystal socket; Millen No. 10039 dial; 9x7x2-inch chassis; shaft coupler (Lafayette MS-917); knobs; brackets (Bud MD-458 or equiv.), 7- and 9-pin tube sockets

Now modify variable capacitor C1/C2 by removing all but four rotor plates in each section. Open the capacitor fully, hold a plate with a pair of long-nose pliers and then pull, wiggling it at the same time.

Coils L1, L2 and L4 are made from Barker and Williamson No. 3012 Miniductors. Fig. 6 tells you the number of turns for each winding. (The separation between the windings is one turn.) After counting off the total number of turns (plus one turn), the coil stock must be cut. Push in a turn, cut it inside the coil, and then push the newly cut ends through to the outside of the coil. Peel the wires back with pliers. The plastic support bars can be cut with a fine-tooth jeweler's saw. L3 is 18 turns of No. 22 enamel wire closewound on a 100K, 1-W resistor, L4 is 43 turns.

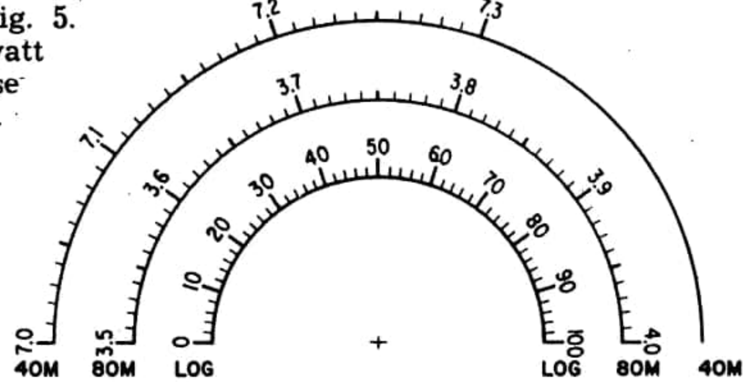
To build the filter assembly consisting of L5 and R8, remove L5 from the can and line the inside of the can at the bottom with tape. Note the color dot and orient the coil as shown in Fig. 5. Solder R8, a 100,000-ohm, ½-watt resistor to lugs A and C. (These letters do not appear on the coil. We have designated the lugs A,B,C,D with respect to the color dot to facilitate wiring.) The lug designations for coil L6 are the same. However, there isn't a resistor on L6.

Oscillator tuning capacitor C7 and the following parts are mounted in a 2¾x2⅛x1⅝-inch Minibox as shown in Fig. 4: C3, C4, C5, C6, L2, C10 and R5. A ¼-inch diameter shaft and shaft coupler connect C7 to the front-panel dial assembly. First mount the parts in the Minibox to determine where the dial should be mounted so it can be coupled to C7.

The antenna tuner/band selector consists of L1, L3, L4, C1 and C2. Trimmer C1T is part of C1. These parts are mounted in a 5x4x3-inch aluminum box for shielding as shown in Fig. 3. The box is mounted in the center section of the panel over the power-supply chassis as shown in Fig. 15.

The rest of the receiver construction and wiring is straightforward. Terminal-strips are used generously in the receiver for mounting components and

Fig. 8—Paste scale on paper, insert in dial.



TRANSMITTER PARTS LIST

R36—33,000-ohm, ½-watt, 10% resistor
R37—100-ohm, 2-watt, 10% resistor
R38—100-ohm, 1-watt, 10% resistor
C38—3-35 mmf trimmer capacitor (ARCO 403 or equiv.)
C39—100 mmf, 500 V mica capacitor
C40,C42,C43—.001 mmf, 500 V disc capacitor
C41—.01 mf, 500 V disc capacitor
C44,C45—.001 mf, 1.6 kv disc capacitor
C46—365 mmf variable capacitor (Lafayette MS-214 or equiv.)
C47—1,000 mmf, 500 V mica capacitor
C48—Dual 365 mmf variable capacitor (Lafayette MS-142 or equiv.)
L7,L9,L11—2.5-millihenry, 125 ma RF choke (National R-50 or equiv.)
L8—10 turns No. 18 wire closewound on R38
L10—Inductor (see text)
J3—Phone jack
J4—Coaxial cable connector type SO-239
M2—0-100 ma meter (Lafayette TM-403 or equiv.)
RY1—DPDT relay, 117 VAC coil (Potter and Brumfield GP11 contacts and GPA 115 VAC coil)
S5—SPDT rotary switch (Centralab 1460 or equiv.)
V5—6DQ6B tube
Misc.—Feed-thru insulators (Johnson 135-44 or equiv.); plate cap (Millen 36004 or equiv.); ceramic octal tube socket; 5x6x4-inch Minibox; 9x7x2-inch chassis; terminal strips; crystal socket; 40- or 80-meter crystal

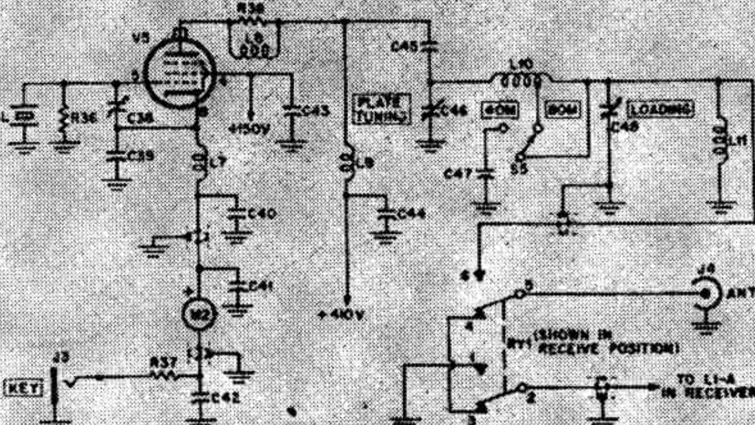
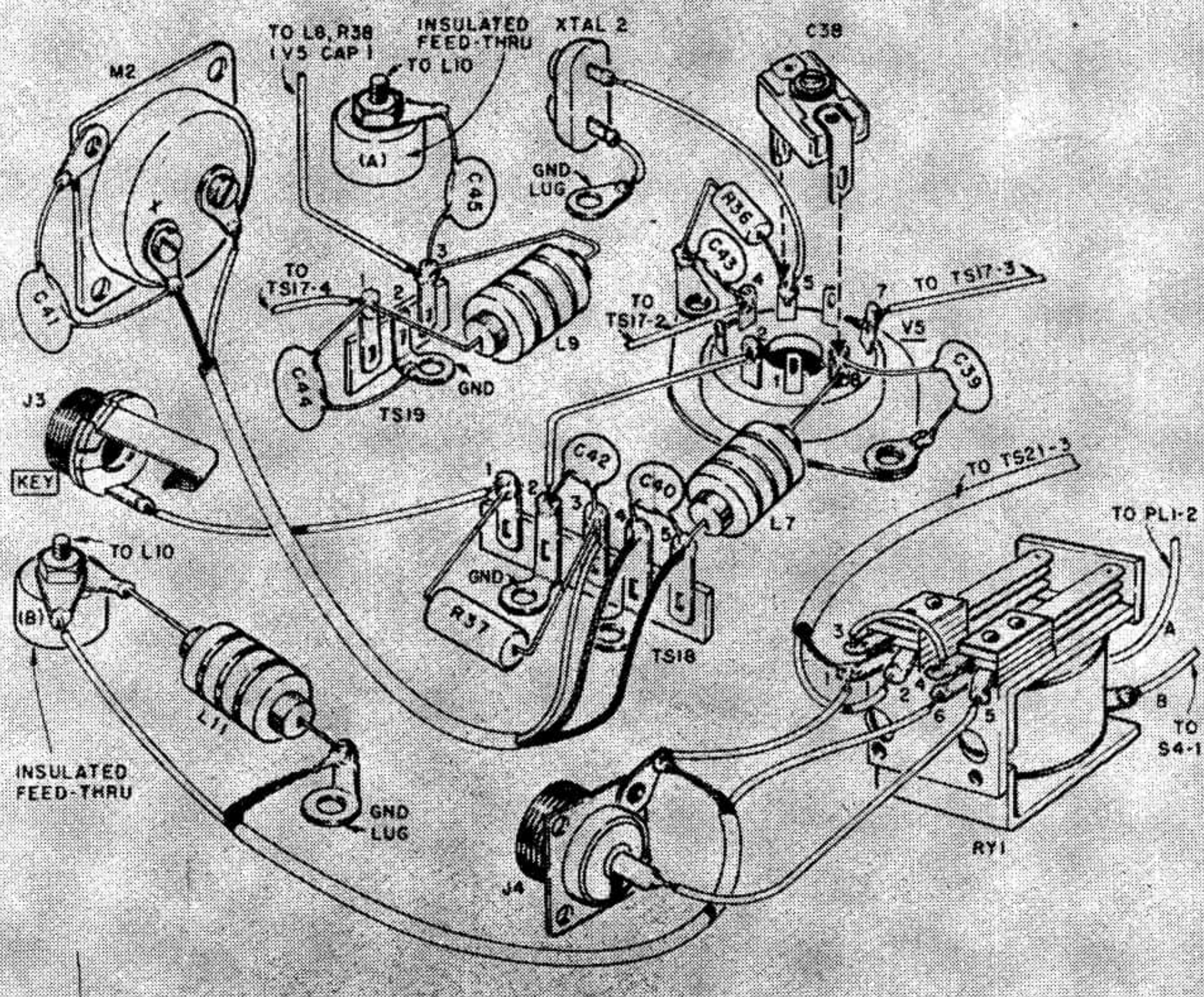


Fig. 9—Transmitter schematic. Two 365 mmf sections of loading capacitor C48 are connected in parallel for total capacitance of 730 mmf. Range of 0-730 mmf is sufficient to couple transmitter output to 50-75-ohm transmission line on the 40-meter band.

Fig. 10—Transmitter pictorial. Parts appear in perspective to show all connections more clearly. Try to follow the layout that was used by the author and which can be seen in the left chassis in Fig. 14.



inter-connecting wiring. On the pictorials the terminal strips are designated, for example, TS12-2. The last number refers to the lug. In several places the receiver is wired with RG174/U coaxial cable to minimize hum and radiation, especially around the crystal filter. The places where the coax is used are shown on the schematic.

Now build the power supply and then proceed to the receiver alignment.

● **Alignment.** After turning on the power, you should hear a hum when R27 is advanced fully clockwise. If you don't hear hum, touching a screwdriver to pin 3 on T3 should produce a loud hum and click. This means the *audio* section is working. If you still don't hear anything, check over the wiring.

Set the front-panel controls to the following positions: *IF gain* (R15) full clockwise; S1 to *CW*; and BFO switch S2 to *on*. The next step is to peak T1, T2, T3, L5 and L6 to 1,750 kc, the crystal and IF transformers' frequency. If you own or can borrow an RF signal generator, feed a 1,750 kc signal from it to pin 2 of V1A. Lacking a signal generator, you can use an ordinary broadcast-band receiver tuned to 1,295 kc. Since most broadcast receivers have a 455 kc IF, the set's local oscillator will be operating on 1,750 kc when the receiver is tuned to 1,295 kc. But don't depend on the broadcast receiver's calibration. Verify its dial calibration first by checking it with stations whose frequency you know. The oscillator of the broadcast receiver can supply the 1,750 kc signal, which can be picked up by the Station's receiver. Run a wire from pin 2 of V1A to a point near the antenna of the broadcast receiver.

With the plates of C21 (*BFO pitch*) half open, adjust the slug of L6 until you hear the beat note resulting from the broadcast receiver's 1,750 kc signal and the BFO oscillator's signal. Now adjust the slugs on the top and bottom of T1, T2, T3, and the slug of L5 for the loudest sound. If the Station's receiver overloads, reduce the strength of the 1,750 kc signal from the broadcast receiver by moving the antenna wire away from the broadcast receiver until you are just able to hear the beat note. Turn S2 off and slowly change the frequency of the broadcast receiver by tuning it back and forth. You should notice a spot where the noise increases, then falls off quickly. The crystal frequency is at that point where the noise is maximum. *Repeak* T1, T2, T3 and L5 for loudest noise, regardless of the broadcast receiver's dial setting.

You should now hear a few signals with an antenna connected to the receiver. When C1/C2 is almost unmeshed, the receiver will tune the 40-

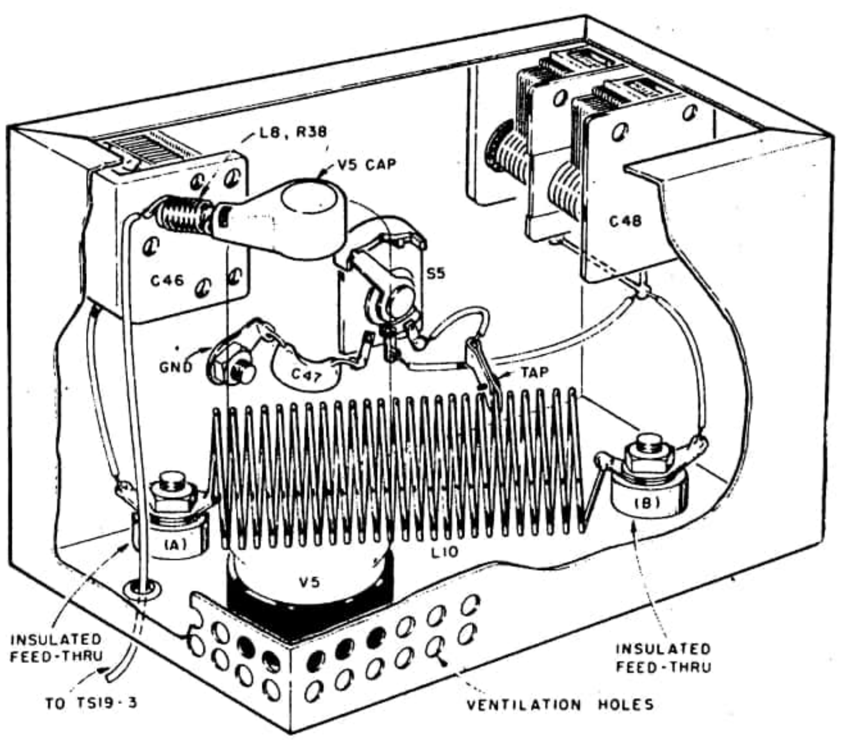


Fig. 11—Transmitter components that are mounted in 4x5x6-inch box above chassis. V5 is mounted in corner of box in foreground. L10 is ⅝ inch above chassis and on other side of V5.

POWER SUPPLY PARTS LIST

R39—2,400-ohm, 2-watt, 10% resistor
R40—4,500-ohm, 20-watt 10% resistor
R41—20,000-ohm, 5-watt, 10% resistor
C49—.05 mf, 500 V disc capacitor
C50A,B,C—40-40-40 mf, 450 V electrolytic capacitor
S3,S4—SPST toggle switch
F1—2-amp fuse and holder
PL1—3-watt, 117 V pilot lamp
PL2—Pilot lamps in M1
SR1-SR4—750 ma, 400 PIV silicon rectifiers
V6—OB2 tube V7—OA2 tube
RY1—See transmitter parts list
CH1,T5 — Available from Mike Kranz, 80 Cortlandt St., N. Y. 7, N. Y. Specify Berkshire power transformer, $2.45, and Philco 150 ma cased choke, $1.40. Add 75¢ postage for both. T5's secondaries are: 700 V center-tapped @ 120 ma, 6.3 V @ 5 A (Allied 62 G 044 or equiv.). Choke: 150 ma, 100 ohms (Allied 61 G 483 or equiv.).
Misc.—Tube sockets; terminal strips

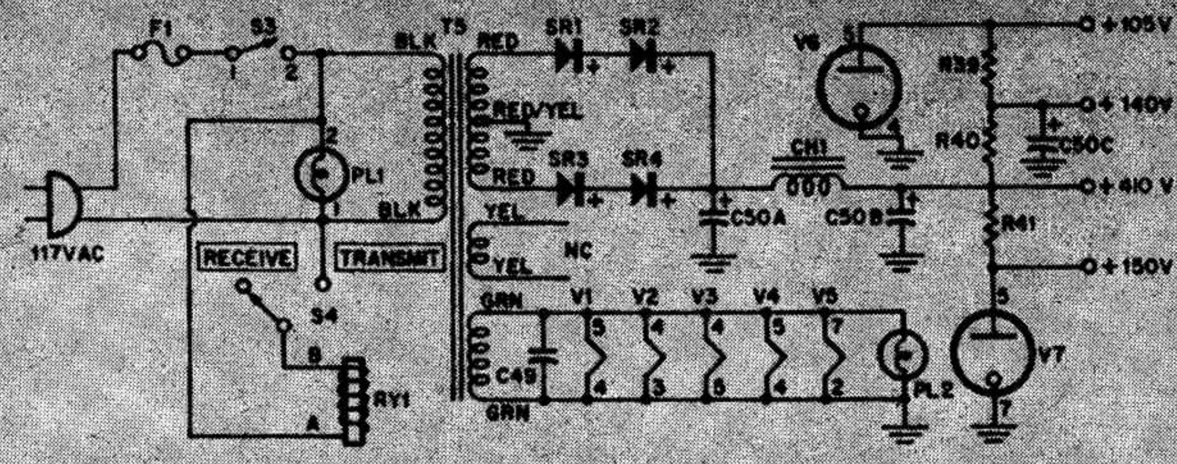


Fig. 12—Power supply. Four 400 PIV silicon rectifiers provide full-wave rectification. Filtering is provided by the pi-network filter consisting of C50A, CH1 and C50B. V6 and V7 supply regulated 105-volt and 150-volt outputs. Resistor R40 and C50C furnish 140 V at 40 ma for the receiver. PL2 is in M1.

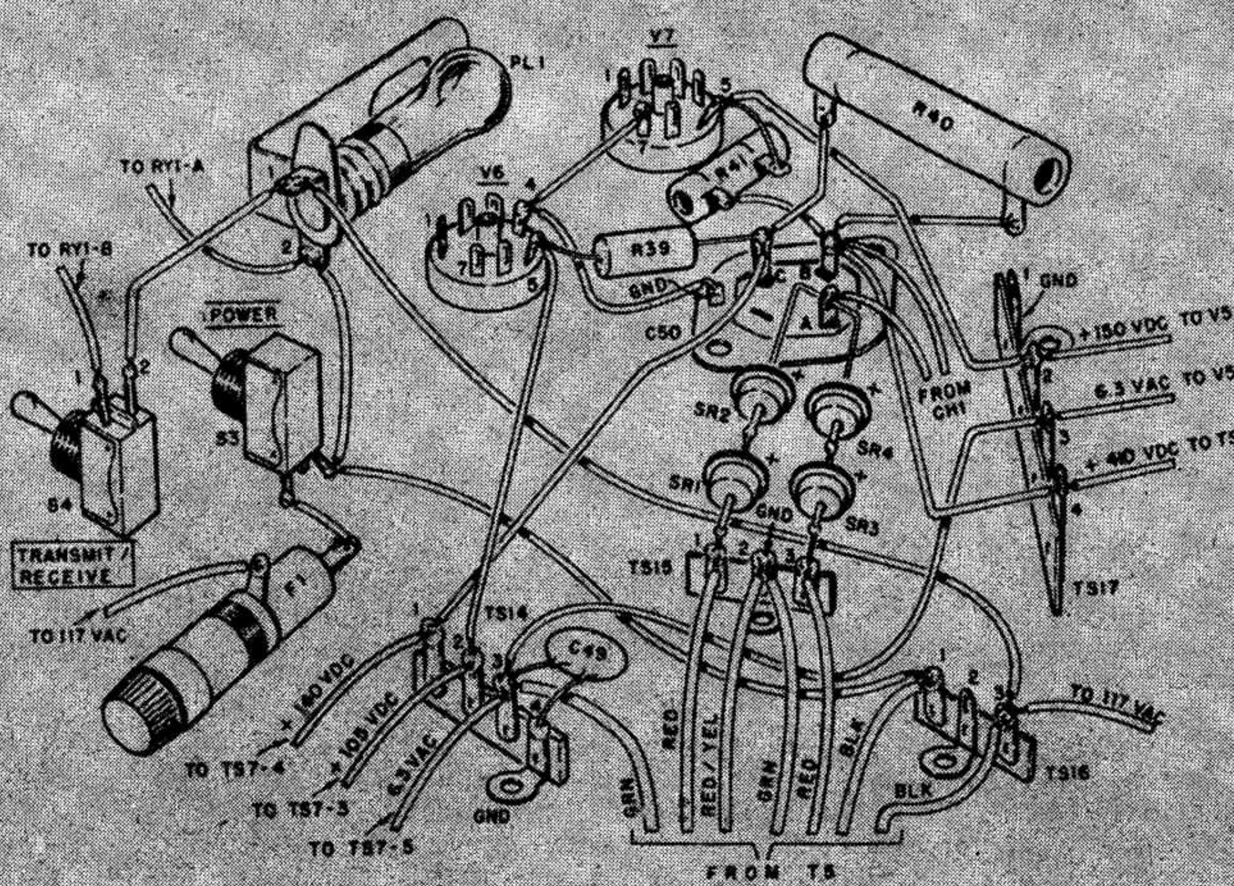


Fig. 13—Power supply. Parts have been shown in perspective to show all connections clearly. Follow layout shown in center chassis in Fig. 14. If you plan to build the receiver only, you can omit V7 and R41.

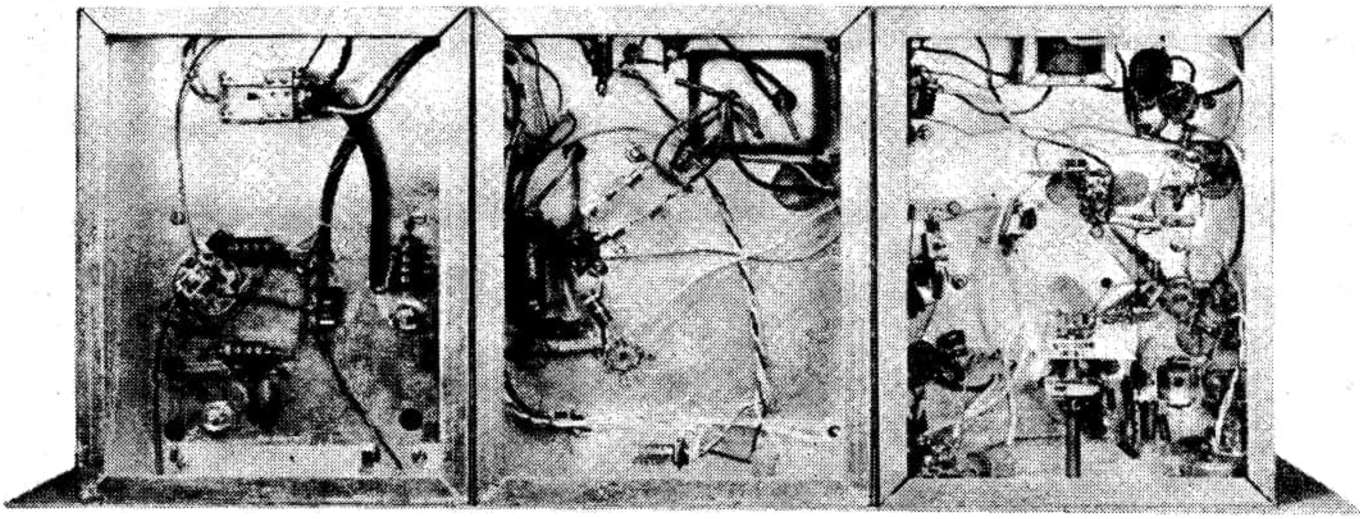


Fig. 14—Underside view of station chassis: transmitter (left), power supply (center), receiver (right).

meter band. When C1/C2 is almost meshed, the receiver tunes the 80-meter band. Tune in a signal of known frequency with the main tuning knob (a signal generator or the station's transmitter may be used as the signal source). Now adjust trimmer C6 until the signal comes in at maximum strength. Adjust C1T (trimmer on the opposite side of C1) for maximum volume.

You may notice that tuning C1/C2 and C1T changes the location of the signal on the dial. In other words, C1/C2 or C1T pull the oscillator slightly. To remedy this would have made the receiver more complicated. The simple solution is first to peak C1/C2 on noise on the desired band, then tune with C7.

Turn the BFO back on and tune in a CW signal. When tuning through the signal, note that it is louder on one side of zero beat than on the other. Experiment with the setting of C21 until what's called the maximum single-signal effect (signal *louder* on one side of zero beat than the other) is obtained. It may be necessary to adjust C15 and to retune T1 and L5 to achieve this effect. After a little adjustment, the single-signal effect should be quite apparent.

If T1, T2, T3 and the crystal filter (XTAL 1, C15, C16 and L5) have been aligned correctly, the dial calibration for 40 and 80 meters should coincide. If alignment is incorrect, the calibration will be offset on the two bands.

To align for WWV at 5 mc, set S1 to the WWV position, set C1/C2 to 80 meters, and adjust C4 to bring in WWV at any quiet spot on the dial. Mark that spot on the dial. To tune in WWV later, reset C1/C2, set S1 to WWV and set the dial to the mark.

● **How it Works.** Refer to the schematic in Fig. 1. The receiver is a superheterodyne with a 1,750 kc IF. The pentode section (V1A) of the 6EA8 is used as a mixer and the triode section (V1B) is the local oscillator. The receiver is tuned by changing the frequency of the local oscillator, which tunes from 5.25 to 5.75 mc. With this range, both the 3.5-to-4-mc and 7-to-7.3-mc bands may be tuned. Here's how. If the local oscillator is set by C7 so its output is 5.25 mc, the difference between 5.25 mc and 3.5 mc is 1,750 kc, the IF. And the difference between 5.25 mc and 7 mc also is 1,750 kc. Although you might expect to hear a 3.5 mc and 7 mc signal at the same setting of the tuning dial, the two signals never reach the mixer because of the double-tuned rejection filter, consisting of L1, L3, L4 and C1/C2, between the antenna and mixer grid.

This double-tuned filter is extremely selective and provides close to 70db rejection of the band to which it is tuned.

The advantage of this design is that by eliminating coil switching it is easy to build a stable high-frequency oscillator, which results in a stable receiver. Additional stability is obtained by using regulated 105-VDC power for V1B.

The high degree of selectivity is obtained by using a crystal filter and two IF stages. The frequency of the crystal

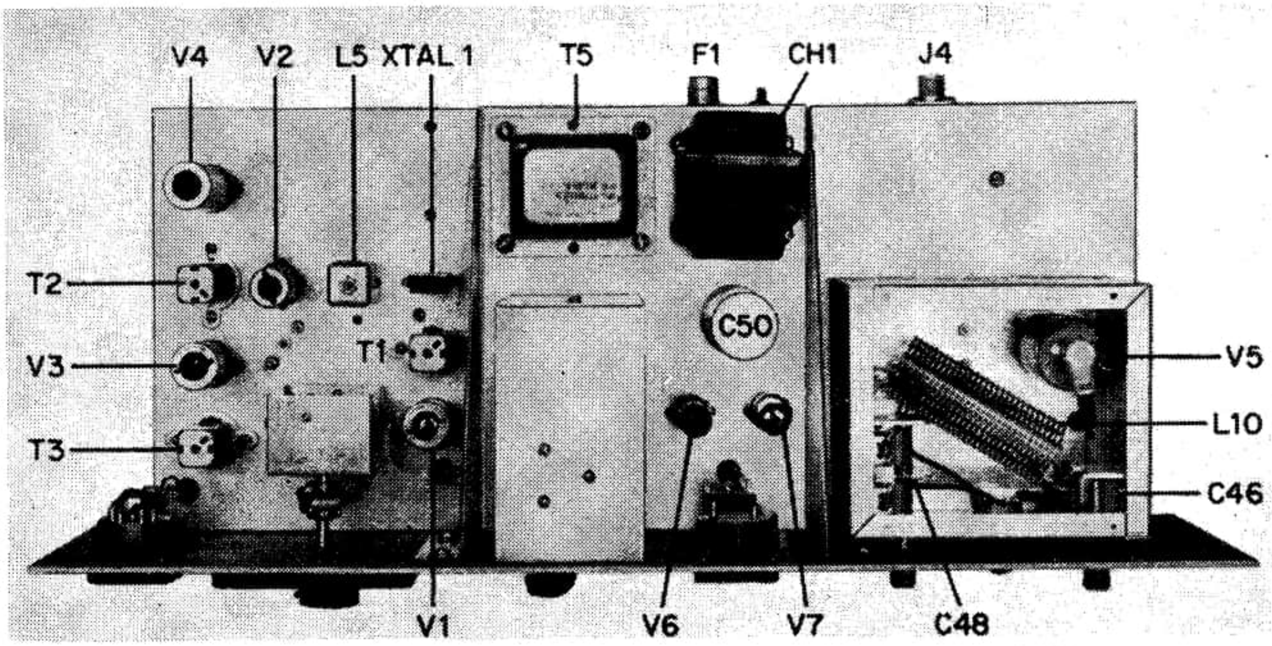


Fig. 15—Top view of station. Receiver (left), power supply (center), transmitter (right). Tuning unit is in box in front center of receiver. Band selector is over power supply chassis in front of T5.

is 1,750 kc, the same as the IF transformers. In combination with the resonant circuit consisting of L5, C15, C16 and the tuned secondary of T1, XTAL 1 forms a filter that sharply attenuates all signals on both sides of the IF frequency.

For CW reception set S1 to *CW*. This is the narrowest IF passband and results in sharp tuning and a clean signal. When S1 is in the SSB or AM position, R7 or R6, respectively, is inserted between L5 and ground, Placing either resistor in series with L5 broadens the response of the filter.

The crystal filter is followed by two stages of IF—a 6BA6 (V2) and the pentode section of the 6U8 (V3A). The gain of the IF stages is controlled by R15. However, when S1 is set to AM, S1 inserts an AVC loop. Voltage for the AVC loop is rectified by D2. This AVC is delayed—that is, the AVC is not effective at low signal levels. This is achieved by back-biasing (R28, R29) AVC diode D2 with a small positive voltage so it does not conduct until the IF voltage reaches the same level as the back-bias voltage. This occurs when the signal at the antenna is 4 microvolts or greater.

D1 is the audio detector. The audio signal across R27 is applied to triode voltage amplifier V4A and then to pentode power amplifier V4B. The output of V4B is sufficient to drive a speaker or low-impedance headphones.

The BFO, V3B, is a triode Colpitts oscillator whose frequency is set close to the IF frequency by adjusting the slug of L6. Fine-frequency or pitch adjustment control is provided by C21. Stray coupling to V3A at its socket and within the tube envelope provides adequate BFO signal injection.

The Transmitter

● **Construction.** All transmitter components except C46, C47, C48 and S5 are mounted on a 9x7x2-inch aluminum chassis. The aforementioned parts are mounted on a 5x6x4-inch aluminum Minibox which acts as a shield to reduce BCI. You can reduce radiation further by putting a bottom plate on the transmitter chassis, but you *must* put a plate on the top of the Minibox. Don't forget the ventilation holes at the bottom and top of the Minibox or V5 will overheat.

Tank coil L10 is 29 turns of a Barker and Williamson No. 3018 Miniductor, tapped six turns (with a Barker and Williamson No. 3942 clip) from the end marked B in Fig. 11. It is mounted ⅝ inch above the chassis on ceramic or polystyrene feed-through insulators. Mount C46, C48 and S5 on the front of the Minibox first.

The transmitter chassis is held to the front panel by key jack J3, the crystal

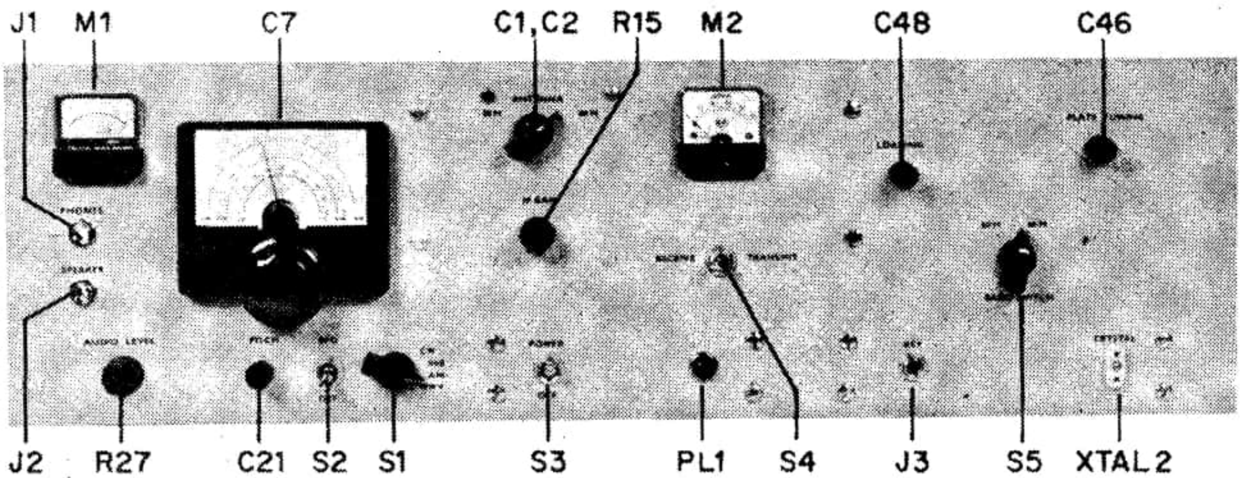


Fig. 16—Front view of station shows control locations and can be used as guide in laying out panel.

socket and four heavy bolts and nuts.

If you're going to build only the transmitter, the power supply easily will fit in a corner of the transmitter chassis and you'll be able to get away with a 7x19-inch rack panel.

● **Transmitter Tune-up.** Connect a 15- or 25-watt lamp bulb between the output at J4 and chassis ground. Plug in a 40- or 80-meter crystal and a key. Set S5 to the same band as the crystal, turn on the power and set transmit-receive switch S4 to *transmit*.

Set C48 to maximum capacitance (plates closed) and hold the key closed. Tune C46 quickly to resonance, which will be indicated on M2 by a dip in current. Gradually open the plates of C48 while readjusting the tuning of C46 as loading increases. Increasing lamp brilliance means increased loading. M2 also should indicate a higher current. The cathode current should be between 85 and 100 ma when the transmitter is fully loaded. To determine actual input power, multiply the current indicated by M2 by 410, the plate voltage of V5.

Adjust C38 for the best keying characteristic. To do this, listen to the transmitter keying through the receiver (there is a small amount of signal leakage from the transmitter to the receiver) while adjusting C38.

Don't adjust C38 with a lamp dummy load as the lamp resistance changes during keying. Use a regular antenna and load the transmitter with the same technique as is used with the dummy load. Maximum loading is now indicated by peak current on M2 rather than maximum lamp brilliance.

● **Transmitter Operation.** V5 functions as both a crystal-controlled Colpitts oscillator (the screen grid acts as the oscillator plate) and an RF amplifier. V5's input power is 40 watts on the 40-meter band and about 34 watts on the 80-meter band. Regulated voltage (+150 V) on V5's screen grid minimizes key chirp or frequency skip.

Power output is taken from a pi-network tank circuit consisting of L10 and C46. C46 tunes the tank. At the pi-network output, antenna and transmission-line loading are controlled by C48.

Operation on 80-meters requires that C47 be paralleled with C48. S5 takes care of this. When RY1 (S4) is in the *transmit* position, the antenna input of the receiver is grounded and the transmitter is connected to the antenna. When S4 (RY1) is set to *receive*, the antenna is disconnected from the transmitter and is connected to the receiver.

The Power Supply

The power supply also is built on a 7x9x2-inch aluminum chassis. Follow the layout shown in Figs. 13 and 14. The chassis is held to the front panel by PL1, S3 and four bolts. Because of the weight of T5 and CH1, 8-inch chassis mounting brackets must be used on both sides of the chassis for mechanical rigidity. For additional support, put bolts through the sides of the transmitter and receiver chassis and the support brackets into the power supply chassis. ■