Cheap and Easy S.S.B.

ANTHONY VITALE, W2EWL

THE AUTHOR'S interests have been directed at mobile s.s.b. operation, because the boost in "talk power" for a given power supply one gets with s.s.b. really works to advantage in mobile work. W2EWL has been on 14-Mc. mobile s.s.b. since 1953, and during that time has participated in four-way QSOs involving ZLs and VKs, and a 7-way involving two African countries, one European country and three W call areas.

The exciter/transmitter to be described is not a one-of-a-kind deal, but represents a design that has evolved over the years. It is built around the v.f.o. portion and on the modified chassis of a BC-458 (or T21/ARC-5), which tunes 5.3 to 7.0 Mc. in the original unit. These units sell from $3.95 to $7.95 in the surplus market, depending upon their condition. The design to be described uses the original output stage of the BC-458; the output will vary with the available plate voltage, and will be about 100 watts peak with a 1000-volt supply. The current W2EWL rig uses only one of the two 1625s in the original output stage, with 300 volts on the plate, to drive one 837 that in turn drives four 837s in a grounded-grid amplifier. The exciter hangs under the dash of the car, and the amplifier mounts in the trunk.

The Circuit

The photographs show two different units; one is for 14 Mc. only and the other is switchable to either 14 or 3.9 Mc. If you want only 3.9- or 14-Mc. operation, you can omit the unwanted circuits and a couple of toggle switches, but the rest of the circuit remains unchanged.

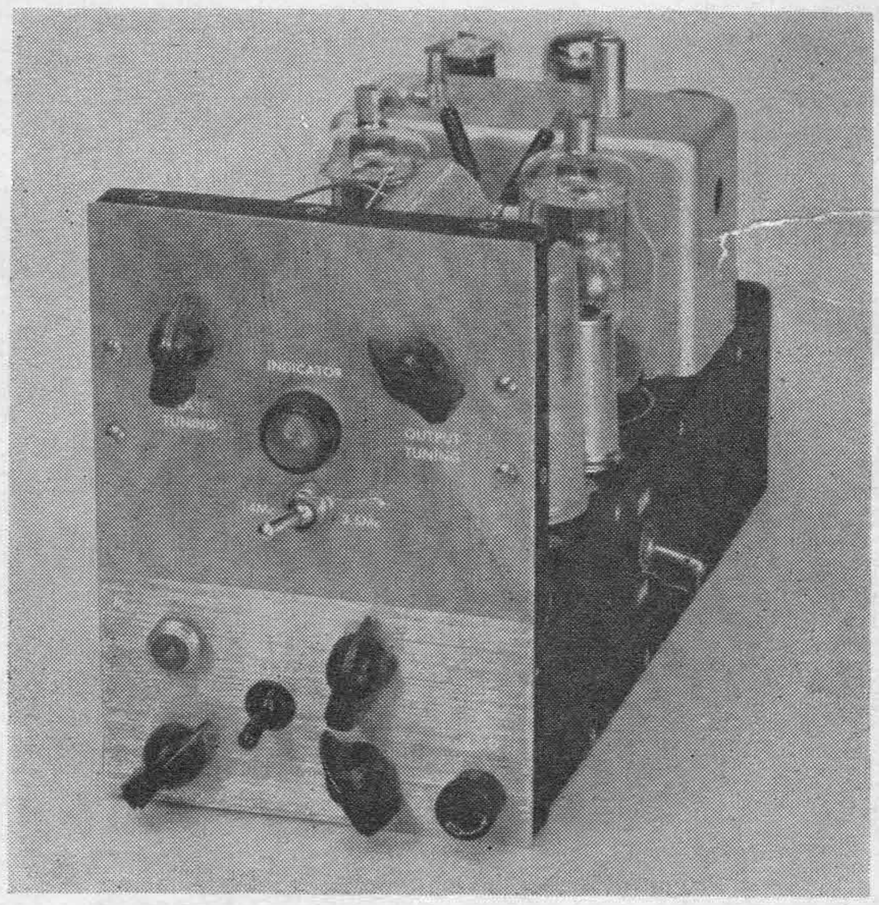
The circuit of the exciter is shown in Fig. 1. Much of the circuit is similar to "S.S.B. Jr.," the excellent design published some years ago.[1] The s.s.b. signal is generated at 9 Mc. and heterodyned to either 14 or 3.9 Mc. by beating against the v.f.o. unit of the BC-348. To change bands, it is only necessary to flip two toggle switches and change the v.f.o. setting.

Running through the circuit, the microphone signal is amplified through V_1 and V_{2A}. The gain is controlled by the setting of the 1-megohm gain control. The audio signal is then coupled through T_1 through a low-pass audio filter to an audio phase-shift network. This network isn't shown in the schematic, but J_2 is the octal tube socket it plugs into. For anyone who has fears about the complexity of an audio phase-shift network, forget them; the B&W Model 350 is inexpensive, comes sealed in a metal tube envelope, and all you do is plug it into the socket.

The phase-shift network requires two audio signals of different amplitudes in the input to give equal signals in the output, and the 500-ohm potentiometer across the output of the audio filter is included to obtain the proper ratio. The two output signals, of equal amplitude but differing in phase by 90 degrees, are applied to the grids of V_3 for further amplification. To insure equal gain through V_{3A} and V_{3B}, the 500-ohm audio-balance control is included. The two signals are coupled to the balanced modulators through T_2 and T_3, and these transformers are shunt-fed to

From *QST*, March, 1956.

[1] In the November–December, 1950, issue of *G-E Ham News*.



This two-band mobile sideband transmitter is capable of up to 100 watts peak output, depending upon the power supply. Built on the chassis of a BC-458 transmitter, it uses the original v.f.o. portion and the two output tubes. The phasing type of sideband generation is used, and the audio amplifier has adequate gain for use with a crystal microphone.

On the panel, the upper knobs control output stage tuning and loading. The indicator light is used instead of a plate milliammeter, and the upper toggle switch is one of the two band switches. (The other bandswitch can be seen on the right-hand side of the chassis.) The lower left-hand knob is for the audio gain control, the toggle switch selects the sideband, and the two pointer knobs next to the switch are for carrier balance adjustments of the balanced modulator. The remaining knob tunes the v.f.o.

minimize undesirable phase-shift characteristics.

The balanced modulator circuit is similar to that in "S.S.B. Jr." except that 6AL5 dual diodes are used instead of germanium diodes. The two 1000-ohm carrier-balance controls permit compensating for inequalities in the diodes. Selection of either upper or lower sideband is provided for by the d.p.d.t. sideband-selector toggle switch, S_3. Of the controls mentioned thus far, only the gain and sideband selector are panel controls, unless you count the mention of the bandswitch.

The r.f. for the balanced modulator is furnished by a 9-Mc. crystal oscillator stage, V_{2B}. The two tuned circuits are link-coupled to the balanced modulator, and L_1 is coupled inductively to L_2. When these circuits are undercoupled and detuned from resonance, the r.f. on the coils and in the links can be adjusted to be 90 degrees apart. This is an adjustment that is made once, when the transmitter is finished.

The 9-Mc. s.s.b. suppressed-carrier signal is amplified in V_6 and coupled to the grid of the mixer tube, V_7. Output from the 5-Mc. v.f.o. (BC-458 oscillator stage) is coupled to the grid of the mixer. The output of the mixer will be the sum (14) or difference (4) frequency, depending upon the frequency to which the plate circuit is tuned. This is selected by the position of the toggle switch, S_1. Output of the mixer stage drives the output stage, V_8V_9. The plate circuit of the output stage is a pi network, band-switched by toggle switch S_2. A small panel lamp in the plate-power lead of the output stage is used to indicate the plate-current changes and is useful in tuning and in monitoring the voice level. The lamp socket should be well insulated from the chassis, of course, and the value of the shunting resistor, R_2, will depend upon the current drain of the final which, in turn, depends upon the plate voltage and the operating conditions. The

(Fig. 1 — See facing page)

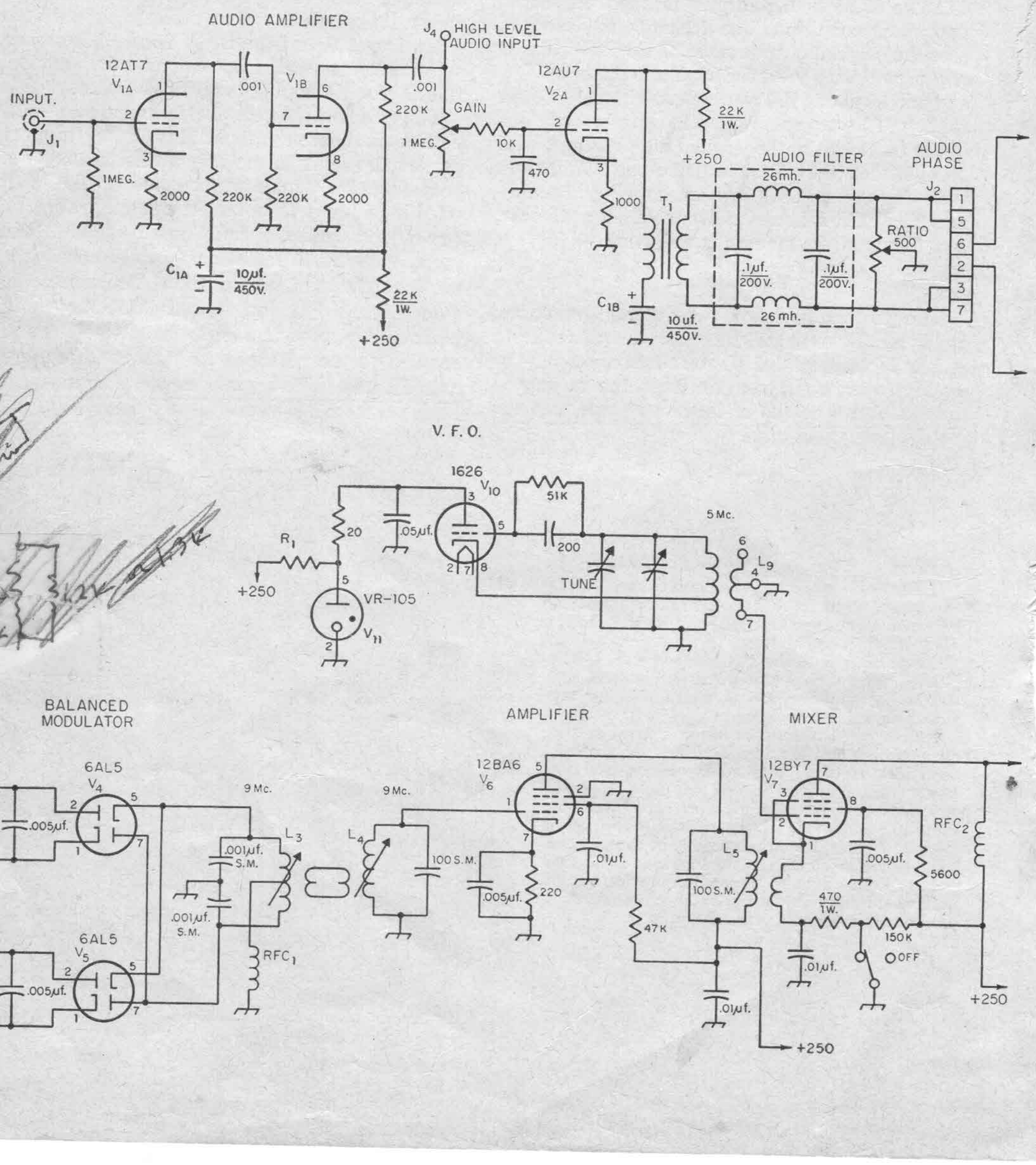


Fig. 1 — Revised diagram of the W2EWL s.s.b. transmitter. Unless otherwise noted, resistors are ½ watt and capacitance values are in $\mu\mu$f. SM = silver mica.

C_1 — Quadruple electrolytic, 10–10–10–10 μf. at 450 volts.

C_2, C_3 — 140-$\mu\mu$f. midget variable (Hammarlund HF-140).

C_4 — 500-$\mu\mu$f. 20-kilovolt ceramic.

I_1 — 2-watt pilot lamp.

J_1 — Microphone jack.

J_2 — Octal socket for B&W 350 Phase shift network.

J_3 — Coaxial cable receptable, UG-290/U.

J_4 — Pin jack.

L_1, L_2, L_4, L_5 — 25 turns No. 22 enam. Link, 4 turns hook-up wire over cold end.

L_3 — 8 turns No. 16 enam. 1-turn link at center.

L_6 — 40 turns No. 26 enam.

L_7 — 25 turns No. 22 enam.

Coils L_1 through L_7 are wound on slug-tuned forms 5/16 inch in diameter. L_1-L_2 spaced 7/8 inch on centers.

L_8 — 46 turns No. 20 bare, wound 16 turns per inch, 1-inch diam. Tap at 8½ turns from C_2 end. (B & W 3015.) For 14 Mc. only, use 12 turns No. 14 wound to occupy 1⅝ inches, 1⅛ diam.

R_1 — 5000 ohms 5-watt when 250-volt supply used.

R_2 — Adjust for full brilliance of I_1 at maximum plate current.

RFC_1 — 500μh.

RFC_2 — 2.5 mh.

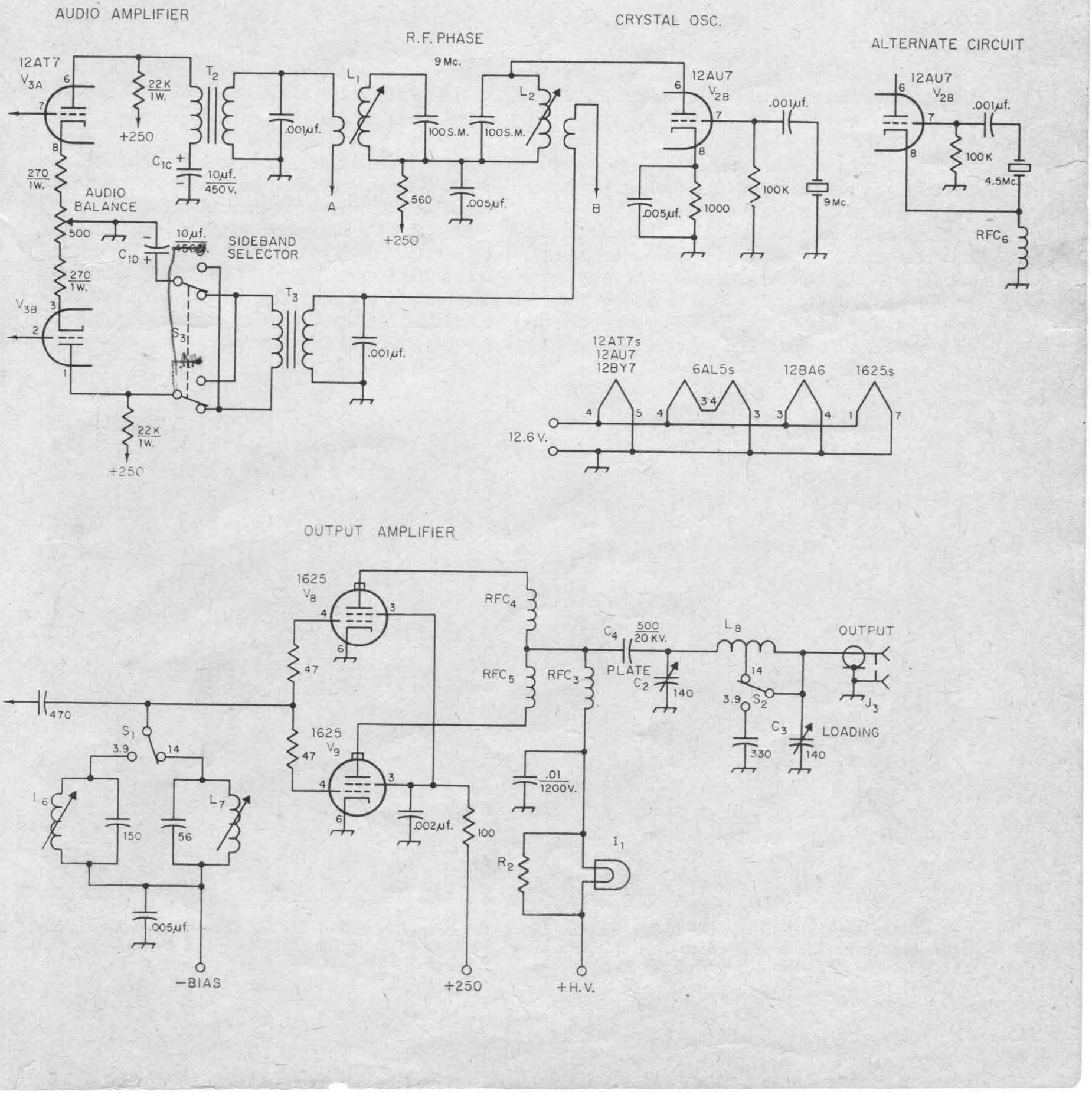
RFC_3 — 1 or 2.5 mh., 300 ma.

RFC_4, RFC_5 — 20 turns No. 22 enam., wound on 3/16-inch form (high-value resistor) and spaced to occupy 7/8-inch winding length.

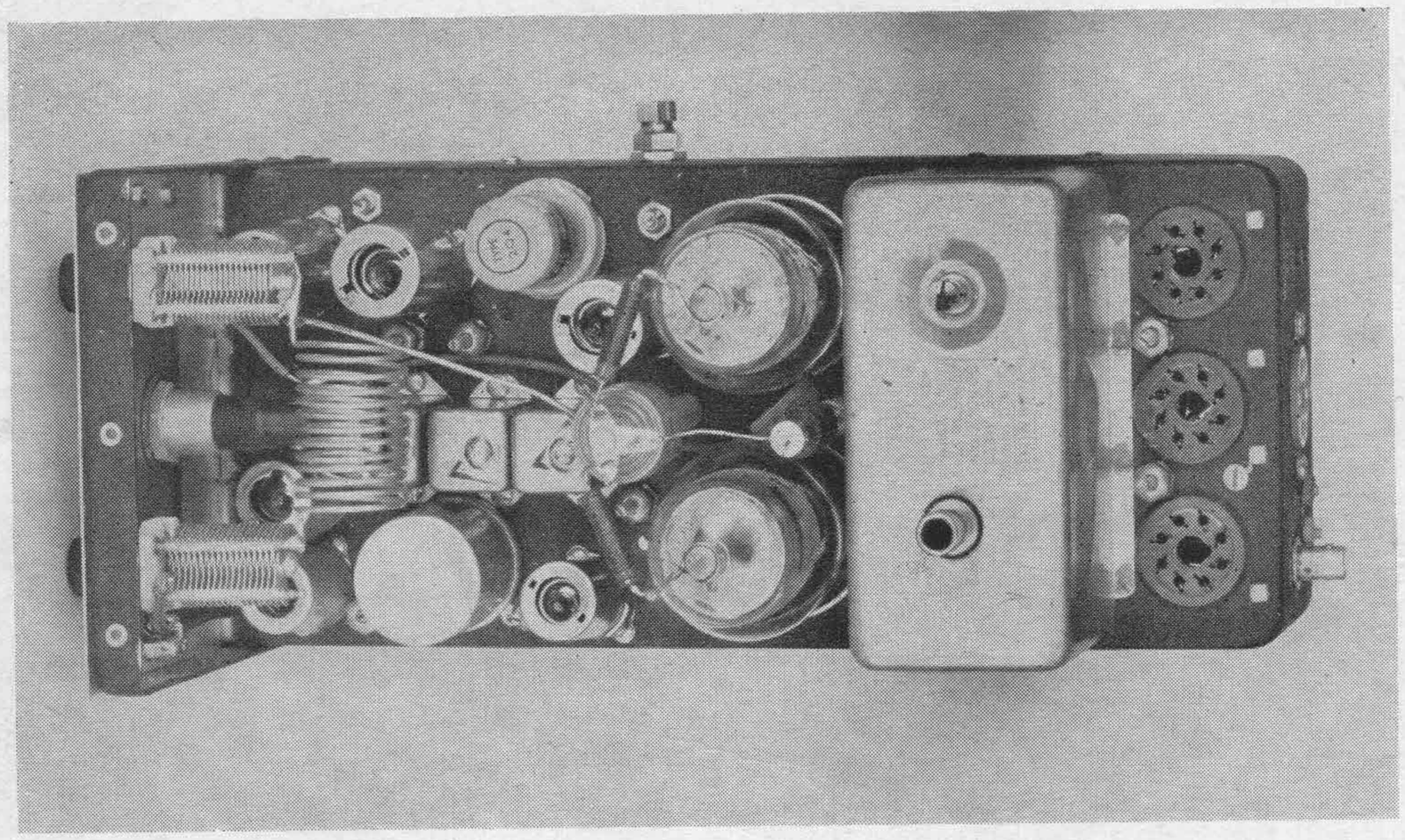
RFC_6 — 30 turns No. 36 d.c.c. jumble-wound on 3/16-inch diameter form.

T_1 — 20,000 to 600-ohm transformer.

T_2, T_3 — 20,000 to 200-ohm transformer. (Suitable compact transformers are often advertised in *QST* Ham Ads.)



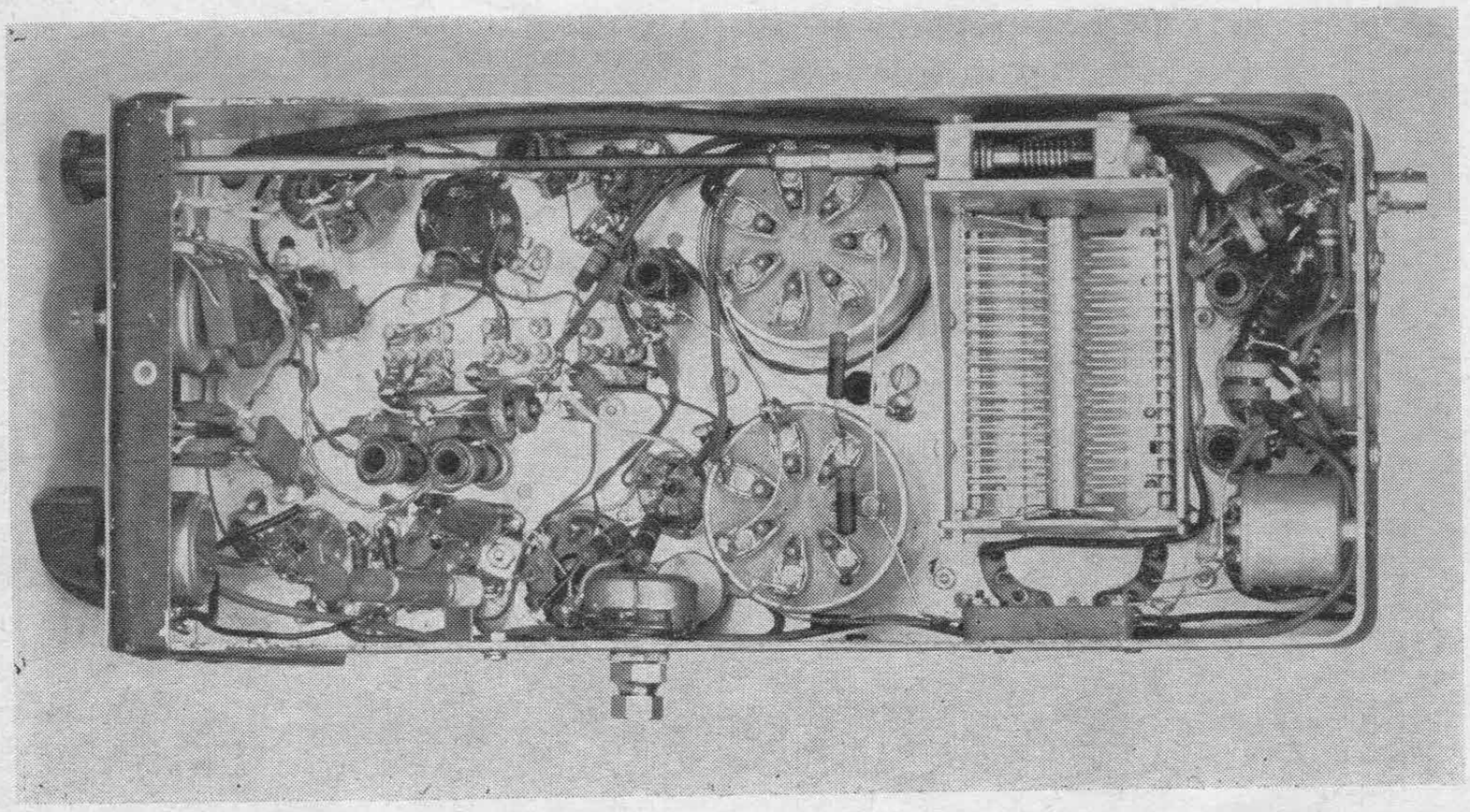
The 14-Mc. version differs from the 2-band exciter in only a few respects. This view shows V_7, V_{10} and V_{11} removed from their sockets; the coil adjustment screw visible between the V_{10} and V_{11} sockets is L_7. This coil is link-coupled to a similar coil at the other L_7 location shown in another photograph.



W2EWL unit uses a 2-watt W.E. pilot lamp mounted in an insulated fuse holder. A meter could be substituted, of course.

The switch in the V_7 cathode circuit is the most convenient point to turn the exciter on and off. The switch can be one pole of a relay used to key the antenna relay and to disable the receiver, and it can be controlled by the push-to-talk switch. You won't find it in the photographs because it isn't there. In a mobile installation it is usually outrigger; in a home installation it will probably be in the voice-control circuit.

The bias for the output stage is best furnished by a small battery; the value of the bias voltage will depend upon the plate voltage that is used. The output stage can be driven into Class AB_2 operation, or it can be operated in Class AB_1 with less output but better linearity.



A view under the chassis of the 14-Mc. exciter. The only significant difference between this unit and the two-band exciter is the absence of the bandswitches, the change in size of L_8, and the 4-turn link coupling between an L_7 in the plate circuit of V_7 and an L_7 in the grid of V_8V_9.

Construction

Construction is started by the removal of all of the original wiring of the BC-458 except the 1626 oscillator circuit. The two sockets adjacent to the 1626 are retained, for V_{11} and V_7, and the two 1625 sockets are left on the chassis. The original screen by-pass capacitor for the 1625s is retained. All of the other components are removed from the chassis but retained; they may come in handy at some future date. (The output loading coil and wheel can be used with a base-loading coil on 75.) The knob and shaft that controlled the link coupling in the original unit are used to make up the flexible coupling to the v.f.o. tuning capacitor (see photos).

The next step is the drilling of the new holes for sockets, transformers, coils and potentiometers. Although larger transformers can be crowded into the available space, the small transformers shown in the photographs are very convenient.[2] Holes are also required for the insulator that supports C_4, for the mounting of RFC_3, and for the four-section electrolytic capacitor, C_1.

A new panel of sheet aluminum is used over the old panel. The tuning capacitors C_2 and C_3, the pilot lamp I_1 and the band-change toggle S_2 are mounted on this panel above the level of the chassis deck. On the same panel, below the level of the deck, you will need holes for the two carrier balance potentiometers, the gain control, the microphone jack J_1, the sideband selector switch (toggle) and the v.f.o. tuning.

The ratio potentiometer is mounted on the left-hand side of the chassis (viewed from the front), and the audio-balance potentiometer is mounted on the deck near V_3 and the audio phase-shift network. A CTC "Minipot" (¾-inch diameter) will fit more conveniently here than the standard controls. S_1 is mounted on the right-hand side of the chassis.

At the rear of the chassis, a regular octal socket can be substituted for the original power socket, and a UG-290/U receptacle is added (J_3). The socket for the 9-Mc. crystal can be mounted on a small bracket on the side of the chassis, under the V_2 socket.

Oscillator Wiring

The numbers shown on L_9 in Fig. 1 represent the numerical order of the terminals from the v.f.o. assembly, reading from the rear to the front. The wire from Terminal 1 will have been removed, and the wires from 2 and 3 will be left as is. The black wire from 4 should be grounded to the chassis. The white wire from Terminal 5 ("hot" heater lead) is left connected to the .006-μf. fixed capacitor and the "hot" side of the 12.6-volt heater circuit. The black lead from 6 to the neutralizing capacitor is removed, and the lead from 7 is carried over to Pin 5 of the V_7 socket.

On the oscillator socket, V_{10}, the red lead at Pin 3 that ran to the tuning-eye socket is removed, and the red lead from Pin 4 is run to Pin 5 of the V_{11} socket (old crystal socket). This is the pin to which R_1 is connected; the value of R_1 will be 5000 ohms, 5 watts, if a 250-volt supply is used.

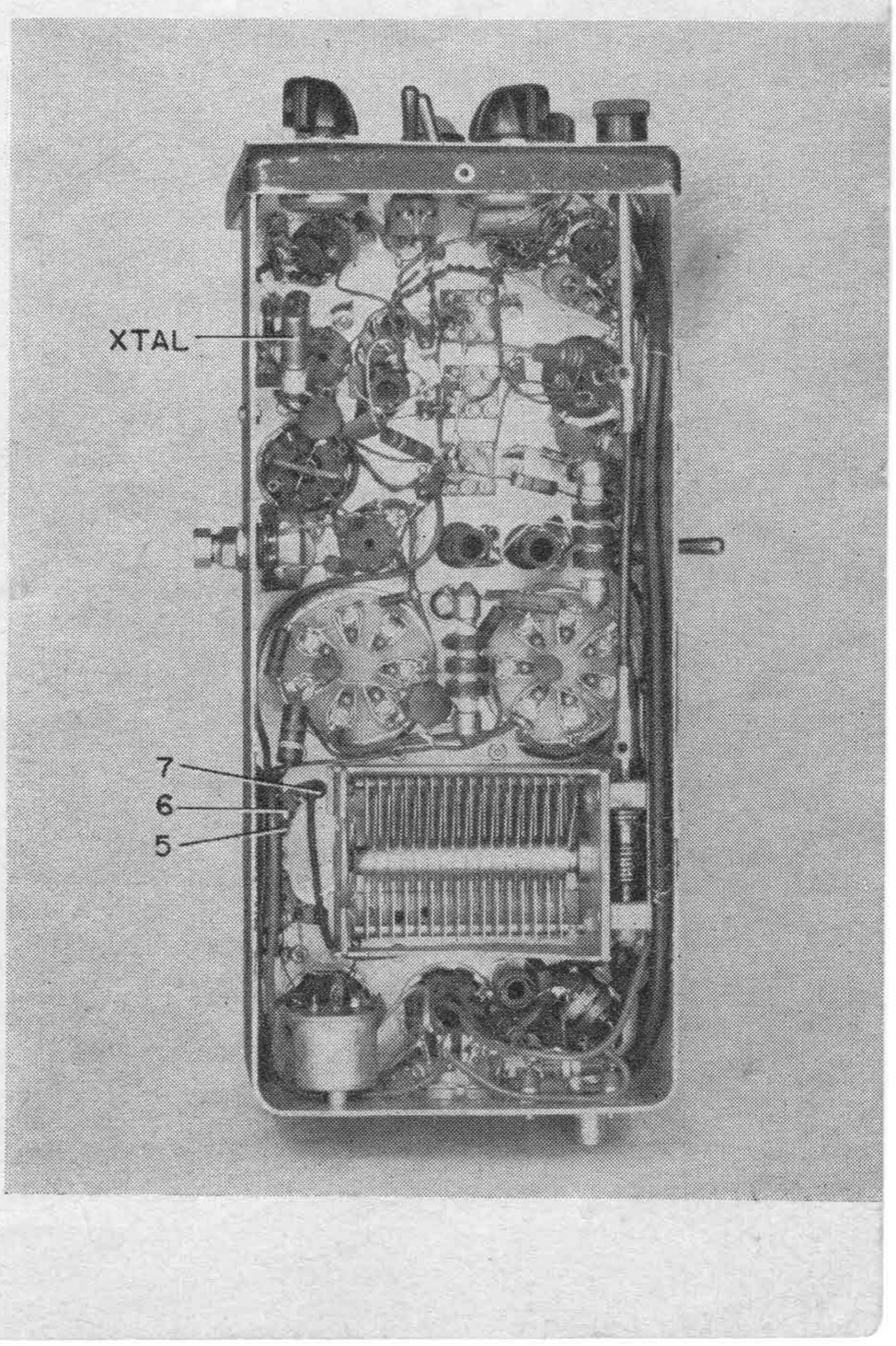
Other Wiring

Not much need be said about the rest of the wiring, since everyone has his own pet tricks. In the construction of the coils L_1 through L_5, the link windings are wound over the "cold" ends (grounded end) with the same wire that is used for the twisted link lines. The single exception is the 1-turn link winding of L_3, and this winding should be dead center on L_3.

Adjustment

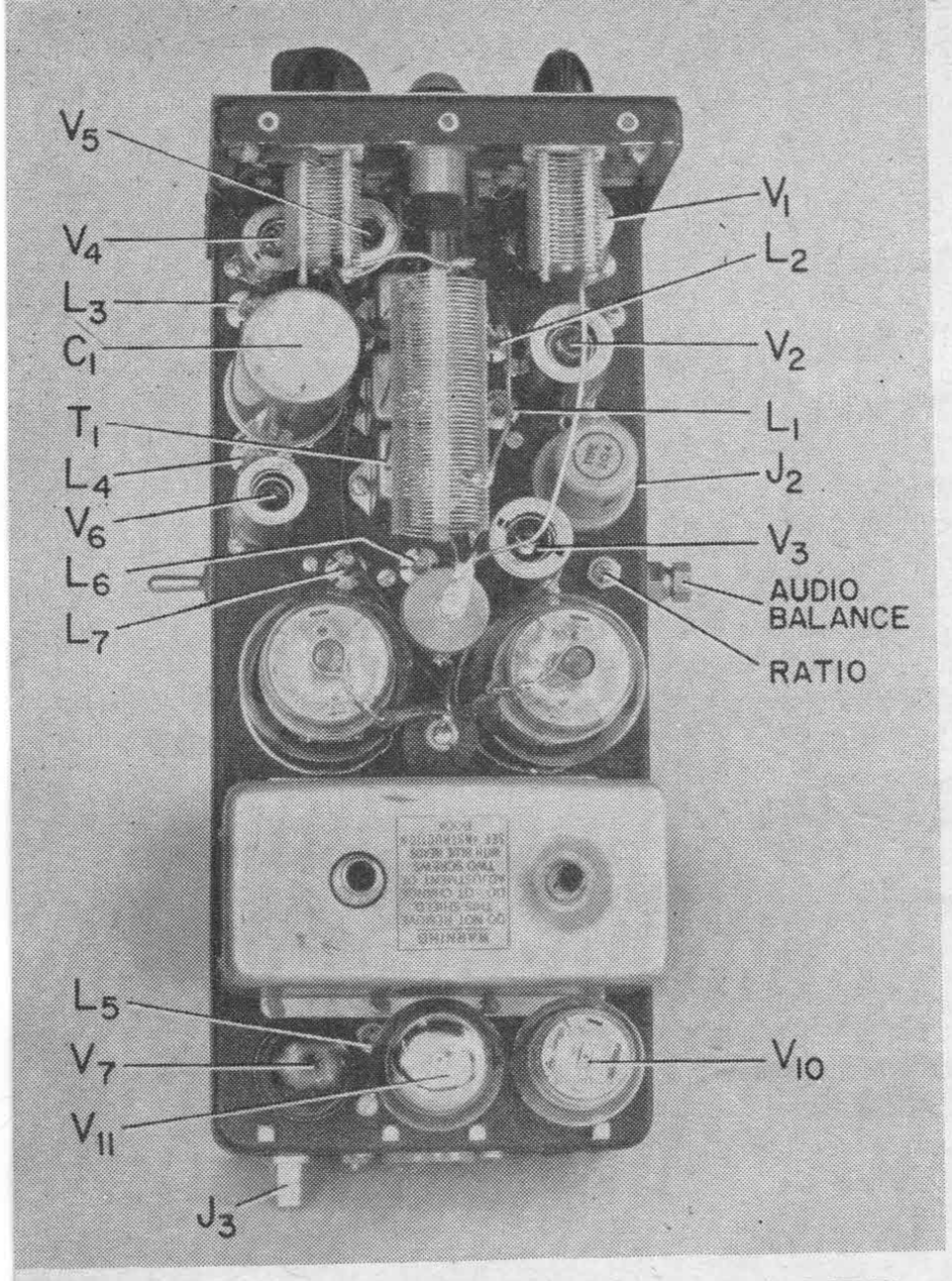
As in any transmitter, the initial adjustment is a step-by-step process. To do a good job with this unit, you should have an audio oscillator and a simple oscilloscope, which you may be able to borrow if you don't have them in your shack. You will also need a receiver and, if you run into any troubles, a v.t.v.m. or other test meter.

When the wiring has been completed and you have determined that the tube heaters light up when 12.6 volts has been applied, remove V_8 and V_9 from their sockets and connect the 250-volt



View under the chassis of the two-band "W2EWL Special." The v.f.o. control shaft at the right is made from the original coupling control of the BC-458.

[2] Suitable transformers are sold by Lafayette Radio, New York City, for transistor applications.



Top view of the two-band exciter. The B & W Phase Shift network is in the light-colored "tube" plugged in J_2.

source. Check the oscillation of the v.f.o. by listening on the receiver tuned to 5.3 Mc. If a 9.1-Mc. crystal is used, the v.f.o. must tune 5.1 to 5.3 Mc. to cover 3.8 to 4.0 Mc. and 14.2 to 14.4 Mc. The tuning range of the v.f.o. can be shifted with the trimmer capacitor and the tuning slug. If the transmitter is to be built for one-band operation, a crystal frequency can be selected that will require no modification of the BC-458 range.

With the v.f.o. working, plug in the crystal and check for oscillation by listening on the receiver. Some adjustment of the slug in L_2 may be required before the stage oscillates.

Next feed in a 1200-cycle signal at the microphone jack, using a very low-level signal. Peak L_3, L_4 and L_5 for maximum signal. This can be checked with a small pick-up loop connected to the receiver through a length of shielded wire. The tuning of L_6 and L_7 and the output amplifier tuning controls can now be checked after the high-voltage supply is connected and the 1625s are plugged in. The correct operating bias must also be added, and it is hardly necessary to point out that the tubes should be plugged in while the power supplies are turned off, if you want to get on with your s.s.b. career. A 60-watt lamp can be used for a dummy load during initial tests, and the pick-up loop for the receiver can be placed near the lamp.

Now turn off the audio signal and adjust the two carrier-balance potentiometers for minimum output. Next turn on the audio and adjust the ratio and audio-balance controls for minimum ripple on the scope pattern. It will undoubtedly be necessary to adjust L_1 before the ripple can be reduced to a small value, and you will find that you have to go through these adjustments several times before you can get the ripple down. Be sure to keep the audio at a low level so as not to saturate a stage somewhere along the line. The initial sideband alignment checks are best made at 9 Mc., using the output of V_6 link-coupled to a 9-Mc. tuned circuit connected to the vertical plates of the oscilloscope.

Check each sideband position, because in an ideal exciter they should both give the same minimum-ripple pattern. If you have an r.f. probe for your v.t.v.m., you can measure the r.f. voltages at the arms of the carrier balance controls and try to get the values within 10 or 15 per cent of each other. This is done by the tuning of L_1 and L_2 which will require further monitoring on the scope for minimum ripple.

Your objective is to minimize the ripple on the scope pattern and to have it similar for either position of the sideband selector switch. Once that has been done, you can connect the microphone and, whenever you need a single tone for tuning C_2 and C_3, you can unbalance one of the carrier balance controls temporarily. To run two-tone test patterns for checking the output-amplifier performance, remove V_4 or V_5 from its socket and use a low-level audio tone into J_1.

The 1625 bias will depend upon the plate and screen voltage. A fair rule of thumb is to adjust the bias so that the idling plate current (no signal) for the two tubes gives around 35 to 40 watts input for the two tubes. With 750 volts on the plates and 250 on the screens, you can start at a bias of −30 and work down. With higher plate and screen voltages, it will be necessary to start proportionately higher.

Mobile Operation

While the unit is an excellent one for home-station use and "getting your feet wet" in s.s.b., it was designed for mobile operation. The most common question you run into about mobile operation is "What do you use for a receiver" and "Isn't it hard to tune in s.s.b. in motion?" The answer to the first question is "Use a crystal-controlled converter into a BC-453 (190 to 550 kc.)." The answer to the second question is "No, not with a good tuning rate in the receiver," (which the converter/BC-453 combination has).

Voice-controlled break-in? Who needs it in mobile work? The push-to-talk switch is plenty good enough.

6.3-Volt Operation

The tubes specified in the schematic are for 12-volt heater operation, and the unit has been operated in a car with a 12-volt battery. For 6-volt mobile operation, it is suggested that one or two 6146s be substituted for the two 1625 output tubes. The other parts of the circuit remain the same, except that the heater wiring must be revised. A 6BA6 would be used at V_6 and a 6V6 at V_7.