G-E TUBES HAM NEWS

NOVEMBER-DECEMBER, 1961

THE LWM-3

— A BANDSWITCHING MOBILE SSB TRANSCEIVER

By W. C. Louden, W8WFH, and A. F. Prescott, W8DLD

PART I — Design and Electrical Details

G-E HAM NEWS is proud to present a complete bandswitching SSB/CW transceiver which — though primarily designed for mobile service — is also well suited for operation from a fixed location too.

The LWM-3 tunes eleven 200-kilocycle wide segments in its over-all range of 3.5 to 30 megacycles. These ranges may be chosen by plugging the proper crystals into the high frequency section which is crystal controlled.

The LWM-3 is a project which the experienced radio amateur can construct and have the equivalent of fine commercial equipment in performance and operating convenience.

Design and electrical details of this 23-tube transceiver are covered in this issue, and the complete mechanical and construction details, and tuneup information, are given in the January-February, 1962 issue of G-E HAM NEWS.

The LWM-3 is a MOBILE SSB and CW transceiver covering 3.5 to 30 megacycles, and delivering 5 watts PEP output. It was designed to drive an easy-to-drive linear amplifier.[1] It features:

1. Transceive operation — no zeroing of the transmitter to the received frequency;
2. 2.1-kilocycle filter for high selectivity — unwanted sideband down 40 decibels;
3. Double conversion circuit with good rejection of spurious signals;
4. Voice-controlled (VOX) break-in and anti-vox circuits.

Plus features include the following innovations:

1. Ultra stable VFO using Command Set transmitter tuning capacitor and packaged oscillator construction for rigidity;
2. Slug tuning unit from broadcast auto radio — modified for ganged exciter tuning control;
3. Custom made slow-tuning rate dial for VFO;
4. Cabinet which is inexpensive and easy to fabricate;
5. Balanced first mixer in transmitter featuring the inexpensive G-E 6AR8 sheet-beam tube to minimize spurious frequencies;
6. Standard IF transformers — slightly modified to perform special tasks;
7. Mobile mount that facilitates "slip in — slip out" operation in the car;
8. Good ideas on circuit board component mounting.

W8WFH DEMONSTRATES here the operation of his new LWM-3 transceiver in his automobile. The complete unit and mounting bracket were designed and built by him and A. F. Prescott, W8DLD. The LWM-3 is the latest in a series of projects described by these well-known authors in **G-E HAM NEWS**. W8WFH drives a pair of GL-4D21/4-125-A's in a linear amplifier in his station wagon. Power is supplied by a 3-phase AC alternator system and high-voltage stepup transformers, as previously described in **G-E HAM NEWS.**

Basically the LWM-3 was designed for mobile operation. All the "most-used" controls were placed on the left side of the front panel to minimize the distance a driver must reach when tuning and operating the unit. The tubes and associated circuitry were positioned for this placement of the controls.

The size of the unit was reduced to a minimum to prevent using front seat leg room needed by passengers. In fact, three people can still sit in the front seat if the one in the cener sits at an angle with his feet to the right of the transceiver. "VOX" has worked out well through the use of a close-talking reluctance microphone which minimizes background noise pickup.

The 5 watts peak power output is more than adequate to drive the "Mobile Linear Amplifier" even at 28 megacycles. An intermediate amplifier stage with higher power was not needed, and was not included to achieve higher over-all efficiency, which is of prime importance for mobile operation.

THE RECEIVER SECTION of the LWM-3 transceiver is shown in black in the block diagram, Fig. 1. Several tubes and other key components in the circuit also function when the transceiver is operating as a transmitter. These dual-function stages are colored in red on the block diagram, with the signal paths on "*transmit*" also in red.

(continued on page 2)

FRONT-PANEL VIEW of the beautifully constructed LWM-3 transceiver. All controls used during normal operation are at the left, easily accessible from the driver's seat. This model has been seen by thousands of radio amateurs at meetings and conventions during 1961. Panel has brushed aluminum finish.

IN THIS ISSUE

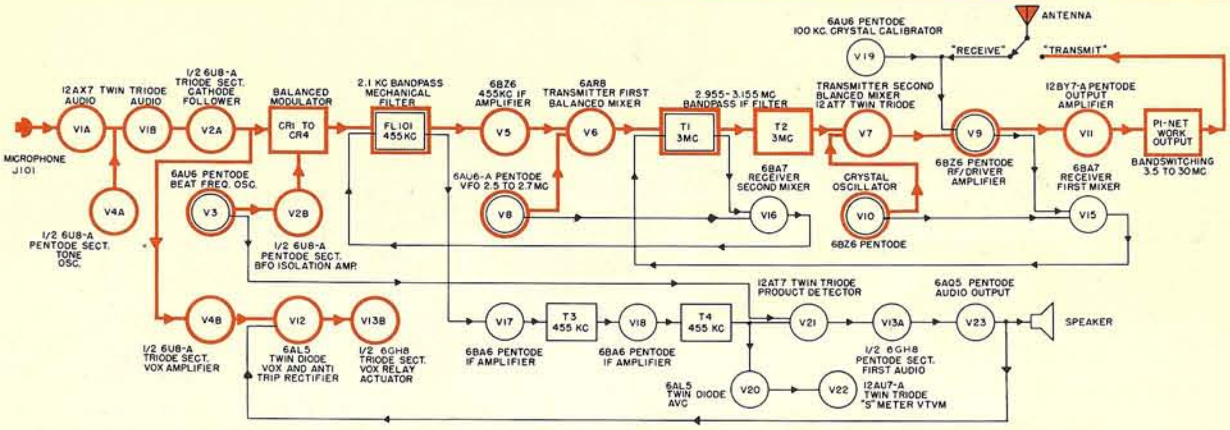


FIG. 1. COMPLETE BLOCK DIAGRAM of the LWM-3 transceiver. The diagram is color coded to show: (1) circuits which operate only on receive, and inoperative on transmit, are in solid black lines; (2) circuits which operate both on receive and transmit in solid black and red lines: and (3) circuits which operate only on transmit in solid red lines. The schematic diagram number is marked next to each tube and component.

(continued from page 1)

A 6BZ6 remote-cutoff pentode (V_9) serves the dual purpose of tuned RF amplifier for the receiver, and as the driver for the output amplifier on *transmit*. The amplified incoming signal is then mixed in a 6BA7 pentagrid converter (V_{15}) with the signal from the crystal oscillator (V_{10}), a 6BZ6 pentode, resulting in an intermediate frequency signal between 2.955 and 3.155 megacycles.

This IF signal then passes through passband tuned circuits in T_1 into a second 6BA7 pentagrid converter (V_{16}), where the signal is mixed with the 2.5 to 2.7-megacycle VFO signal from the tunable oscillator (V_8). The difference signal in the output of the second mixer in the 450 to 460-kilocycle range, is then fed through the 2.1-kilocycle wide mechanical filter (FL_{101}). This second IF signal is amplified in two 6BA6 remote-cutoff pentodes (V_{17} and V_{18}).

Demodulation of SSB signals is accomplished with a 12AU7-A twin triode (V_{21}), which functions as a product detector. A 6AU6 crystal controlled beat frequency (BFO) oscillator (V_3) provides the inserted carrier for the product detector. Two crystals, Y_1 and Y_2, place the oscillator on the correct frequencies for selection and reception of upper or lower sidebands. After detection, the audio signal is amplified in a 6GH8 pentode section voltage amplifier (VA_{13A}) and a 6AQ5 beam power audio output stage (V_{23}).

THE TRANSMITTER SECTION of the LWM-3 utilizes a 12AX7 twin triode as two stages of audio amplification (V_{1A} and V_{1B}) from a high-impedance microphone input (J_{101}). The audio signal is then fed into a balanced modulator (four 1N34-A diodes) through the triode section of a 6U8-A (V_{2A}) in a cathode follower circuit. The same BFO (V_3) used for the receiver drives a 6U8-A pentode section isolation amplifier (V_{2B}) to supply the carrier to the balanced modulator. Crystals Y_1 and Y_2 again provide selection of upper or lower sideband.

The output of the modulator is a double sideband suppressed carrier signal, the carrier having been balanced out in the modulator. This signal passes through the 2.1-kilocycle bandwidth mechanical filter (FL_{101}) at 455 kilocycles to remove one sideband. The resulting single sideband signal is then amplified in a 6BZ6 pentode (V_5) before being applied to a 6AR8 sheet beam tube (V_6).

The 6AR8 mixes this SSB signal with the signal from the VFO (2.5 to 2.7 megacycles), resulting in a signal in the 2.955 to 3.155-megacycle range, depending upon the frequency to which the VFO is set. After passing through the bandpass filter (T_1 and T_2), the signal is mixed with the signal from the 6BZ6 pentode crystal oscillator (V_{10}) to arrive at the desired amateur band output signal frequency.

Then the signal is amplified by the 6BZ6 RF amplifier (V_9), and this stage, in turn, drives the 12BY7-A beam pentode (V_{11}) output amplifier. Thus, the RF amplifier, VFO, BFO, and the crystal oscillator tubes, plus the 2.1-kilocycle wide mechanical filter and the 2.955 to 3.155-megacycle bandpass filter, all serve dual purposes in the LWM-3 and function both for reception and transmitting.

Still other circuits in the LWM-3 transceiver include automatic volume control (AVC) (V_{20}), an "S" meter circuit (V_{22}), and a 100-kilocycle crystal calibrator (V_{19}) to provide precise frequency markers from which to adjust the tuning dial pointer.

Most of the circuit switching between *receive* and *transmit* is performed by applying a minus 65 volts — obtained from the external power supply — to the tubes which are unused in each function, biasing these stages to cutoff condition. This is simpler than transferring such functions through relay contacts or other mechanical means.

The voice-controlled break-in (VOX) circuitry (V_{4B}, V_{12}, and V_{13B}) actuates three relays during *transmit* which apply and remove a minus 65 volts to appropriate circuits. Plate and screen voltage is applied to V_{2A} and V_5 only during *transmit*. One of the control relays also transfers the antenna from the input circuit of V_9 to the output circuit of V_{11} during *transmit*.

THE SCHEMATIC DIAGRAMS of the LWM-3 transceiver have been divided into sections according to major function to facilitate reference. Major components in the transceiver are identified in the photo on page 3.

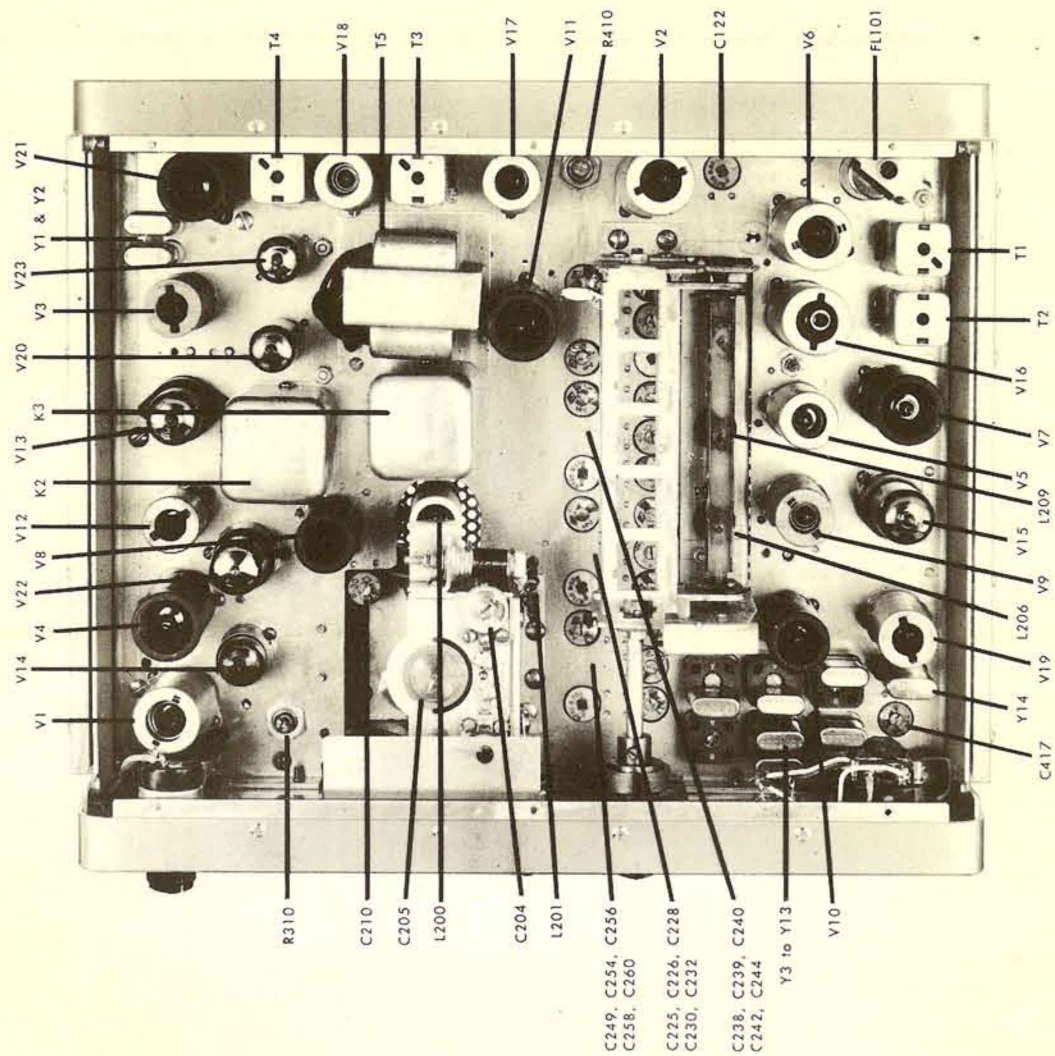
The transmitter schematic diagram, Fig. 2, contains the circuits of the two key oscillators, the VFO (V_8) and the high-frequency crystal oscillator (V_{10}). A description of these circuits follows.

The heart of any mobile communications unit is the tunable oscillator (VFO), and therefore the design of the LWM-3 was built around this unit. It was realized that stability was the prime objective and small size would necessarily be the second. From previous experience with mobile VFO's the LWM-3 VFO was designed to withstand shock and impact testing as well as vibration and thermal drift.

A series-tuned Colpitts (Clapp) circuit using the Harrington XL-1 coil (L200) and a Command Set transmitter tuning capacitor (C205) resulted in the desired frequency stability after a series of preliminary tests. All major frequency determining components were bolted directly to the capacitor frame to eliminate relative movement of parts. A temperature compensating capacitor (C204) in conjunction with a zero drift (C203) is used to compensate the VFO for the temperature rise within the transceiver cabinet during operation.

The oscillator output is divided by a 470-microhenry coil (L202) in series

[1]"MOBILE LINEAR AMPLIFIER," G-E HAM NEWS, November-December, 1960 (Vol. 15, No. 6). This bandswitching amplifier has two GL-4D21/4-125-A tetrodes in parallel and covers 3.5 to 30 megacycles.
[2]Jackson, "Coils for the HF Crystal Filter," QST, June, 1960, page 63. This text says:
" — in selecting matched germanium and silicon diodes, the normal ohmmeter reading does not seem to be accurate enough, but the forward current flow through a diode from a 1½-volt flashlight battery source will show up minute differences in the forward resistance of various diodes. Out of a group of 20 I found four in which the current flow varied only 5 percent. Used in a ring modulator, these provided approximately 40 db. of carrier suppression with no attempt made at balancing the modulator."



TOP VIEW OF THE LWM-3 showing the location of major components and the tubes in the unit. Packaged VFO is large assembly at left-center behind panel. Crystals which select the 200-kilocycle tuning segments are at right. Mechanical actuator for ganged slug-tuned coils in the RF amplifier/driver stage (V_9) is at right-center; was originally a push button tuning mechanism from an auto radio. Detail views of the bottom will be published in PART II of this article. All 23 tubes (count 'em) are clearly visible on the chassis. Note enclosed relays K_2 and K_3.

with a 12-microhenry RF coil (L203), to provide between 1.2 and 1.5 volts RF for the first transmitter mixer (V_6) and second receiver mixer (V_{16}).

The crystal oscillator is a standard electron coupled Pierce circuit which uses fundamental crystals. The output circuit is tuned to the marked frequency of crystals in the range from 3.5 to 12 megacycles. Above this the second harmonic of the crystal is obtained in the oscillator plate circuit, pretuned to each crystal that is selected by the bandswitch (S_{2A}).

The plate coil, L212, could be gang tuned with the RF amplifier and possibly eliminate some of the trimmer capacitors selected by S_{2B}. The series plate resistor (R225) can be adjusted so that the oscillator will provide 2.0 volts RF for the transmitter second mixer (V_7), and the receiver first mixer (V_{15}). The value of 4700 ohms for R225 gave the correct voltage in this unit.

The 6AR8 sheet beam tube (V_6) in the transmitter first mixer has the RF signal from the VFO applied to the control grid, and the 455-kilocycle SSB signal from the generator section applied to one beam deflection plate (see "D"). No balancing voltage controls were found necessary for the deflection electrodes of the 6AR8 to obtain satisfactory rejection of the VFO signal in the output. Several 6AR8 tubes with unbalance were substituted in the circuit to confirm this fact.

A Miller type 6205 4.5-megacycle ratio detector transformer was used for the balanced output transformer. This transformer has a tertiary winding which must be disconnected by unsoldering its connection to pin 6. An additional transformer (T_2), a Miller type 6203 4.5-megacycle IF transformer, is used to obtain the desired bandwidth to cover 3.155 to 2.955 megacycles with high attenuation outside this range. The secondary of T_2 is used as a parallel tuned trap to help attenuate unwanted frequencies.

The output of the bandpass IF amplifier is connected to a second balanced mixer — a 12AT7 (V_7) twin triode — of conventional design. Both mixers are biased to cutoff when the transceiver is in the receive function.

The grid and plate circuits of the 6BZ6 pentode RF amplifier (V_9) are slug-tuned circuits with various capacitors switched in parallel to resonate at the various amateur band segments selected by the bandswitch. The plate circuit is also the grid circuit of the 12BY7-A pentode final amplifier (V_{11}). Bridge neutralization is used and a Pi-type output network with 50-ohm output impedance is band switched in the plate circuit.

Since the 12BY7-A is operating class A, a Pi output tank is quite inefficient but it is a simple unit to switch, and provides sufficient RF output to drive W8WFH's mobile linear amplifier. A 1N34A diode (CR_6) voltmeter circuit is provided across the 50 ohm output to facilitate tuneup procedures.

THE RECEIVER SECTION schematic diagram is shown in Fig. 3. This diagram contains the AVC, "S" meter and crystal calibrator functions. The 6BZ6 pentode RF amplifier for the receiver (See V_9 in Fig. 2) — also the RF driver stage in the transmitter — receives the signal from the antenna through connection "W" and the antenna transfers contacts on relay K_1, in the VOX AND CONTROL CIRCUITS schematic diagram, Fig. 5. The plate circuit of V_9 then runs to the 6BA7 pentagrid first receiver mixer (V_{15}) in Fig. 3 through connection "U."

(continued on page 6)

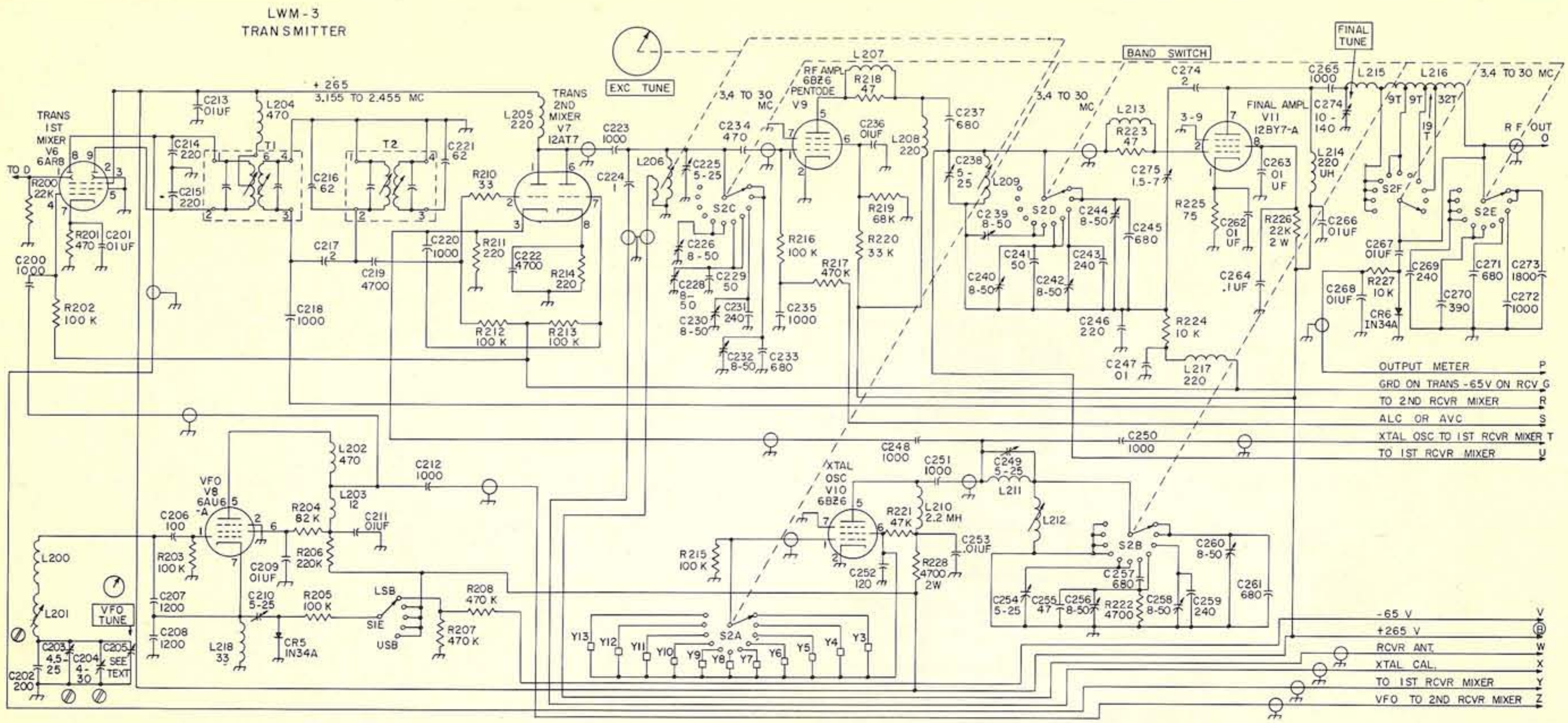


TABLE I — COIL TABLE

L_{100}, L_{102}, L_{205}, L_{208}, L_{214}, L_{217}, L_{400}....220-uh RF coil (J. W. Miller 4646-E).

L_{101}, L_{210}, L_{401}....2-Mh. RF coil (J. W. Miller 4666-E).

L_{103}....480 — 800-uh adjustable RF coil (Cambion L56-CN2L, or J. W. Miller No. 4514-1).

L_{200}....18-uh VFO coil; 52 turns, No. 24 tinned wire, wound 28 TPI, 1⅞ inches long, on ¾-inch diameter grooved ceramic coil form (Harrington Electronics No. XL-1 coil).

L_{201}....4 — 6-uh slug-tuned coil; 22 turns, No. 24 Formex wire close wound on ⅜-inch diameter form (Cambion LS-5 blank form).

L_{202}, L_{204}....470-uh RF coil (J. W. Miller No. 4649-E).

L_{203}....12-uh RF coil (J. W. Miller No. 4624-E).

L_{206}....1.0 — 3.0-uh slug-tuned coil; 18 turns No. 26 Formex wire spacewound 1 inch long on 0.354-inch diameter fiber form;[3] 3 turns No. 26 interwound at grounded end turn spacing decreases from ⅛ inch to 1/32 inch (similar to Collins Radio Co. No. 544-9715-002 coil).

L_{207}, L_{213}....6 turns No. 26 Formex wire on 47-ohm, ½-watt composition insulated resistor.

L_{209}....0.5 — 3.0-uh slug-tuned coil; 13 turns, No. 26 Formex wire, space wound 1 inch long on same form as L_{206}; turn spacing decreases from ⅛ inch to 1/32 inch at lower end (similar to Collins Radio No. 544-3135-002).

L_{211}....0.3-uh, 5 turns, No. 20 tinned wire, ½-inch diameter, 5/16-inch long, 16 TPI (B & W 3003 Miniductor).

L_{212}....0.8 — 1.5-uh slug tuned coil; 10 turns No. 24 Formex wire closewound on ¼-inch diameter ceramic form (Cambion LS-6).

L_{215}....0.6-uh, 8 turns, No. 20 tinned wire, ½-inch diameter, ½-inch long, 16 TPI (B & W 3003 Miniductor).

L_{216}....12-uh total, 64 turns No. 24 tinned wire, ½-inch diameter, 2 inches long, 32 TPI, tapped at 9 (21 Mc.), 18 (14 Mc.) and 32 (7 Mc.) turns from L_{215} end (B & W 3004 Miniductor).

L_{218}....33-uh RF coil (J. W. Miller No. 4628-E).

L_{301}, L_{302}....1.2-uh, 12 turns No. 24 Formex wire closewound on ¼-inch diameter ferrite core.

[3]Forms for L_{206} and L_{209} are impregnated paper fiber, 0.354-inch outside diameter, 0.260-inch inside diameter, 1¾ inches long, tuned with ¼-inch diameter ferrite slugs 1¼ inches long with flexible drive rod (similar to Collins Radio Part No. 288-2509-00). Coil forms and tuning slugs are available from Jeff-tronics, Unlimited, 4722 Memphis Avenue, Cleveland 9, Ohio.

FIG. 2. "TRANSMITTER" SECTION schematic diagram, showing the tunable oscillator (V_8) (VFO), high-frequency crystal controlled oscillator (V_{10}), and RF amplifier (V_9) circuits which operate both on receive and transmit. The two transmitter mixers (V_6 and V_7), and the final amplifier (V_{11}) operate only on transmit. The BANDSWITCH (S_2) is shown in the highest frequency position.

IN ALL SCHEMATIC DIAGRAMS, resistances are in ohms, tolerance ± 10 percent, ½-watt power rating, unless otherwise noted. Capacitances marked "UF" are in microfarads, disc ceramic type unless otherwise described in the PARTS LIST. Capacitances not marked "UF" are in micro-microfarads (mmf), and mica type unless otherwise noted. Inductances are in microhenries unless otherwise described in PARTS LIST. Connections which run between schematic diagrams Figs. 2, 3, 4, and 5 are coded with letters "A" through "II" where they enter and leave each diagram. Only two inter-diagram connections are coded with each letter, except code letters in circles, which have three or more connection points. Components connected to panel controls are identified with the control title in a rectangular box.

TABLE II — PARTS LIST

C_{122}, C_{226}, C_{228}, C_{230}, C_{232}, C_{239}, C_{240}, C_{242}, C_{244}, C_{256}, C_{258}, C_{260}, C_{417}....8 — 50-mmf midget variable ceramic.

C_{202}....200-mmf NPO ceramic (two 100-mmf NPO's).

C_{203}....4.5 — 25-mmf midget variable ceramic (Erie TS-C).

C_{204}....4 — 30-mmf midget variable ceramic (Erie 557-F).

C_{205}....5 — 25-mmf double bearing variable (Front tuning capacitor from 2.1 — 3-Mc. Command Set transmitter).

C_{206}....100-mmf NPO ceramic (Erie TCO-100).

C_{207}, C_{208}....1200-mmf silvered mica, 500 volts working.

C_{210}, C_{225}, C_{238}, C_{249}, C_{254}....5—25-mmf midget variable ceramic.

C_{214}, C_{215}....200-mmf silvered mica, 500 volts working.

C_{216}, C_{221}....62-mmf silvered mica, 500 volts working.

C_{229}, C_{241}, C_{255}....50-mmf, 500-volt silvered mica.

C_{231}, C_{242}, C_{259}....240-mmf, 500-volt silvered mica.

C_{233}, C_{245}, C_{261}....680-mmf, made from a 330 and a 390-mmf, 500-volt silvered mica in parallel.

C_{269}....240-mmf silvered mica, 500 volts working.

C_{270}....390-mmf silvered mica, 500 volts working.

C_{271}....680-mmf silvered mica, 500 volts working.

C_{272}....1000-mmf silvered mica, 500 volts working.

C_{273}....1800-mmf silvered mica, 500 volts working.

C_{274}....10 — 140-mmf midget air variable with 1/4-inch diameter shaft (Hammarlund APC-B-140, of HF-140).

C_{275}....1.5 — 7-mmf midget variable ceramic (Erie 557-A).

CR_1, CR_2, CR_3, CR_4....matched set of 1N34A germanium diodes.

FL_{101}....455-Kc. mechanical filter, 2.1-Kc. bandwidth (Collins F-455 J21).

I_1....6.3 volt, 0.25-ampere pilot lamp (G. E. No. 46).

J_1, J_2....chassis type midget coaxial cable connectors.

J_3....midget phono type 1-pin jack.

J_{101}....midget 3-way phone jack (Mallory SCA-2B).

K_1....4 pole, double throw midget relay, 10,000-ohm DC coil (P & B GB-17D).

K_2, K_3....4 pole, double throw midget enclosed relay, 110-volt DC coil (P & B MG-17DP, or Phil-Trol 9DC-115-4C).

L....See TABLE I — COIL TABLE, for specifications of all coils.

M_{401}....0 — 1-Ma. DC midget panel meter (Lafayette).

P_{301}....24-pin midget type male connector with chassis mounting flange (Amphenol 26 — 4101 — 24P).

R_{117}, R_{118}, R_{435}....500,000-ohm potentiometer (IRC Q13-133).

R_{132}....100-ohm **Trimit** 10-turn potentiometer (Bourns 273).

R_{306}....50,000-ohm potentiometer (IRC Q11-123).

R_{310}....10,000-ohm potentiometer (IRC Q11-116).

R_{410}....2,500-ohm potentiometer (Clarostat A47-2500-S).

R_{425}....75,000-ohm potentiometer (Clarostat A47-75K-V).

R_{433}....500-ohm **Trimit** 10-turn potentiometer (Bourns 273).

R_{435}....500,000-ohm audio taper potentiometer.

S_1....6 pole, 5-position three section phenolic insulated miniature tap switch (Centralab PA-1020).

S_2....7 pole, 11-position, seven section, miniature ceramic insulated tap switch (Centralab PA-302 Index and seven PA-1 2 — 12-position non-shorting 30-degree wafers).

S_3....Double pole, double throw midget slide switch.

T_1....4.5-megacycle Ratio Detector type IF transformer with tertiary winding disconnected (J. W. Miller 6205).

T_2....4.5-megacycle input or interstage television IF transformer (J. W. Miller 6203).

T_3....455-kilocycle input type IF transformer; secondary detuned and not used (J. W. Miller 12-C1).

T_4....500-kilocycle output type IF transformer.

T_5....Audio output transformer, 5000-ohm primary, 4-ohm secondary, 5 watt power rating (Stancor A-3877).

V_1 to V_{23}....General Electric receiving tubes, types as marked on schematic diagrams.

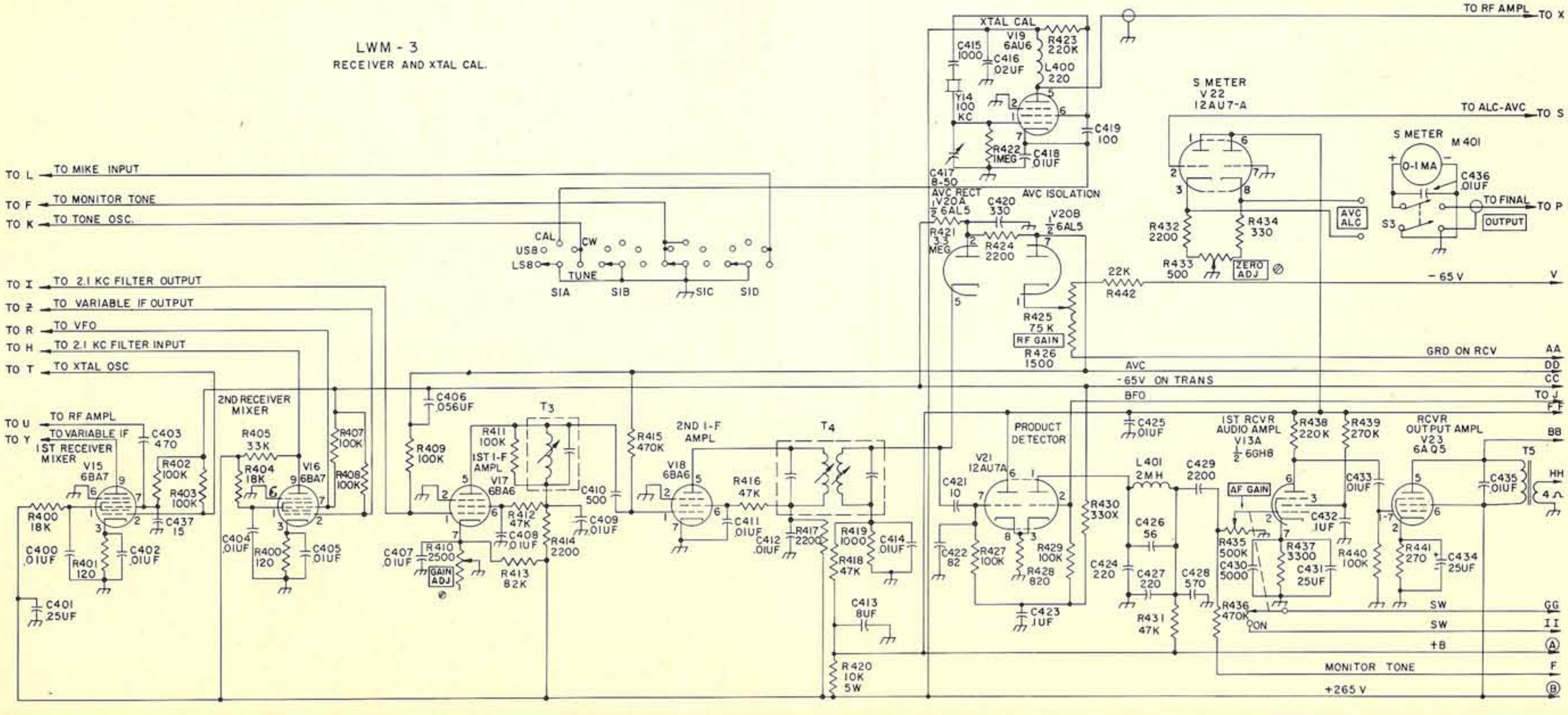
Y_1....Quartz crystal, 453.9 kilocycles, FA-5 type holder.

Y_2....Quartz crystal, 456.4 kilocycles, FA-5 type holder.

Y_3 to Y_{13}....Quartz crystals, see TABLE III — CRYSTAL CHART, for frequencies.

Z_{301}....11-volt, 1-watt Zener diode (G. E. Z4X11B).

FIG. 3. RECEIVER SECTION schematic diagram for the LWM-3. All circuits in this section operate only on **receive**, except the "S" meter amplifier (V_{22}), which also functions as an ALC voltage indicator on **transmit**.



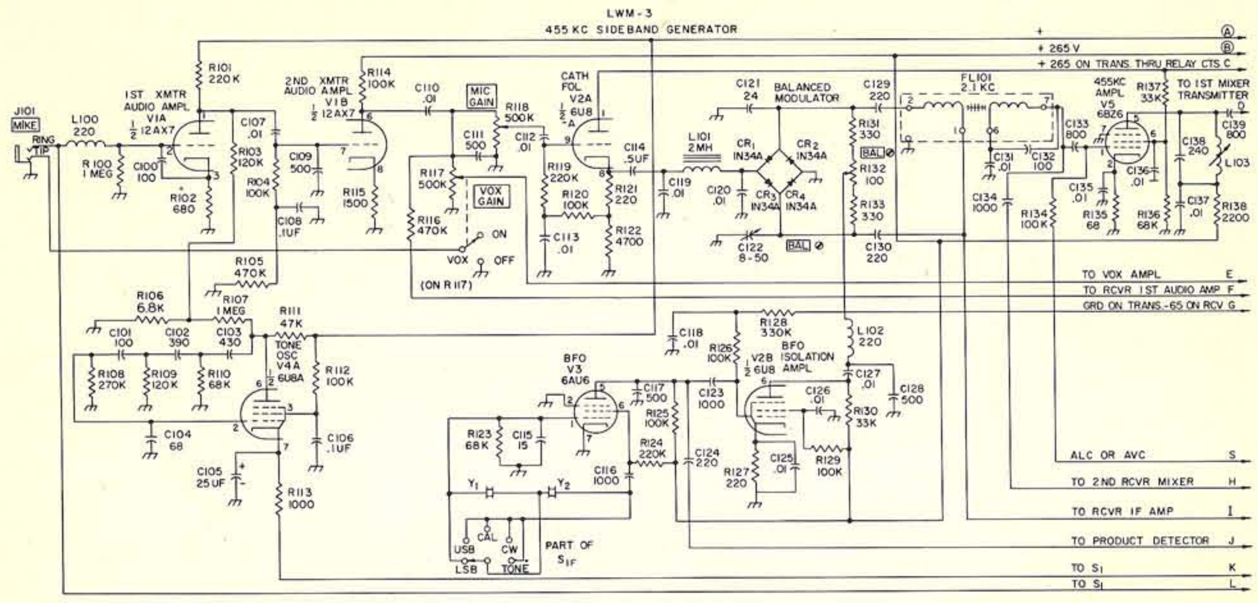


FIG. 4. SSB GENERATOR schematic diagram, showing the transmitter audio section (V_1, V_{2A} and V_{4A}), and BFO isolation amplifier (V_{2B}), diode balanced modulator (CR_1 to CR_4), and 455-kilocycle amplifier (V_5), which operate only on transmit. The BFO (V_3) and mechanical filter (FL_{101}) operate both on receive and transmit.

(continued from page 3)

A signal from the high-frequency crystal oscillator (V_{10} on Fig. 2) through connection "T" is mixed with the received signal to obtain a signal in the bandpass first IF range, 2.955 to 3.155 megacycles.

This IF signal then runs back through connection "Y" to Fig. 2 and through transformer T_1. From T_1, the signal runs back through connection "R" to Fig. 3 — transformer T_2 is not used for reception — to the signal grid of the 6BA7 second mixer (V_{16}).

The VFO signal from V_8 in Fig. 2 is fed into V_{16} through connection "Z," converting the first IF signal down to approximately 455 kilocycles. This signal then exits to Fig. 4 through connection "H" to the 455-kilocycle mechanical filter (FL_{101}). From FL_{101} the signal returns to Fig. 3 through connection "I" and runs through a conventional two-stage IF amplifier.

At the output of the 455-kilocycle IF strip, the full output voltage is applied to the 6AL5 twin diode AVC Rectifier (V_{20}). Through a capacitive voltage divider made up of C421 and C422, part of the IF voltage is applied to the 12AU7-A twin triode product detector (V_{21}). A conventional first audio — 6GH8 pentode section (V_{13A}), and 6AQ5 power pentode second audio amplifier (V_{23}) is used.

A 12AU7-A twin triode (V_{22}) in a balanced VTVM circuit is used with a 0–1 milliameter (M_{301}) to read the AVC voltage on *receive* or ALC voltage on *transmit*. The same meter is used as an output meter on *transmit* through a DPDT slide switch (S_3) on the front panel. A 6AU6-A pentode (V_{19}) tube in a 100-kilocycle crystal oscillator is used to calibrate the receiver.

THE SSB GENERATOR section, including the audio circuits, is shown in the schematic diagram of Fig. 4. Connections which run from one schematic diagram to another are identified with the same code letter where they leave one diagram and enter the other.

Input from a high-impedance microphone (J_{101}) runs through a two-stage audio amplifier using a 12AX7 twin triode (V_1). A cathode follower stage — the triode section of a 6U8-A (V_{2A}) — feeds the audio signal into a diode balanced modulator. The audio stages have coupling and shunting capacitors which shape the frequency response to the 300–3,000-cycle speech range.

The MICROPHONE GAIN control (R_{118}) is between the 12AX7 and the 6U8-A. Audio voltage for the VOX system is tapped off at this point through the VOX GAIN control (R_{117}). It runs to the VOX section on Fig. 5 through connection "E." A 6U8-A pentode section (V_{4A}) functions as a tone oscillator to provide an audio signal for tuneup purposes.

The audio signal from V_{2A} feeds into a ring type diode balanced modulator with four 1N34A germanium diodes. These were selected to have nearly identical forward resistance using the method suggested by W3NMP.[2] Some juggling of C121 may be necessary to make the modulator null out the carrier within the adjustment range of C122. A miniature Bourns Trimit, 10 turn potentiometer (R132) was found to provide good carrier null and to hold its adjustment with mobile vibration.

The 6AU6-A BFO crystal oscillator (V_3) provides a signal of either 453.9 or 456.4 kilocycles, depending upon whether crystal Y_1 or Y_2 is connected, through a 6U8-A pentode section (V_{2B}) isolation amplifier to the balanced modulator. The output of the modulator, a pure 455-kilocycle DSB signal, is connected to the 2.1-kilocycle bandwidth mechanical filter.

Output of the filter is amplified by a 6BZ6 pentode (V_5) to increase the level to several volts RF for the 6AR8 balanced mixer (V_6). The signal patch to V_6 runs through connection "D" to the left side of Fig. 2.

THE VOX and other control functions in the LWM-3 transceiver are combined in one schematic diagram, Fig. 5. The audio signal from the microphone, amplified by V_1 in Fig. 4, is transferred to the VOX circuit through connection "E." This signal is further amplified in a 6U8-A triode section (V_{4B}). It is applied to one diode of a 6AL5 (V_{12A}), rectified and charges capacitor C_{308} positive. This positive charge causes the 6GH8 triode section (V_{13B}) relay actuator stage to conduct more plate current, energizing relay K_1. In the absence of audio voltage, C_{308} discharges slowly through R_{305} and R_{307}, causing V_{13B} to conduct less current and deenergizing K_1.

An anti-trip circuit to prevent speaker noise from triggering the VOX circuit obtains an audio signal from 6AQ5 audio amplifier (V_{23}) in Fig. 4 through connection "BB." This signal is rectified in diode V_{12B} and develops a negative voltage which counteracts the positive voltage developed when noise from the speaker is picked up by the microphone, and which otherwise would actuate the VOX circuit.

An Automatic Load Control (ALC) circuit is incorporated into the transceiver by which an RF voltage from an external linear amplifier is fed into

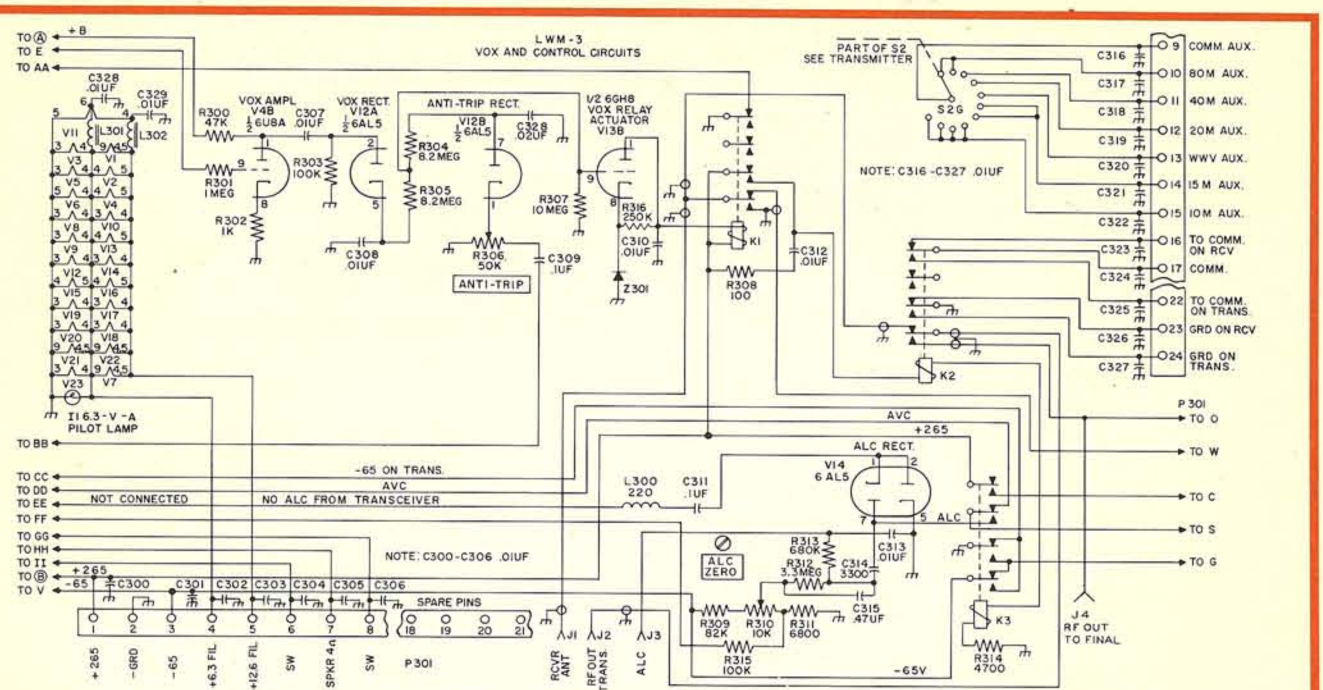


FIG. 5. VOX AND CONTROL CIRCUIT schematic diagram. The heater circuit for all 23 tubes is shown at the left side of this diagram. All tubes in this section operate only on transmit. Antenna transfer and power control circuits are in the upper right hand corner of the diagram. All sets of contacts on control relays are shown in their de-energized, or receive, position. Connection is made to J_4 to drive a linear amplifier from the LWM-3 transceiver.

a time constant network and V_{14} through J_3. This voltage is applied to the 6BZ6 driver amplifier (V_9 in Fig. 2), and the 6BZ6 455-kilocycle IF amplifier (V_5).

One set of SPDT contacts on relay K_2 in the LWM-3 transceiver transfers the antenna from the receiver to the transmitter when it is energized. The antenna connection from K_2 to the receiver also runs through a set of SPDT contacts on K_1. These contacts remove the antenna from the receiver and ground its input during *transmit.*

No external antenna transfer relay or T-R switch is thus required when the LWM-3 is operated directly into an antenna suitable for transmitting. However, when the LWM-3 is used to drive a linear amplifier, a coaxial cable should be run from the *receiver* connection on the antenna transfer relay or T-R switch for the linear to J_1 in Fig. 5. Or, if a separate receiving antenna is used, connect it to J_1.

MOST EXTERNAL CONNECTIONS from the LWM-3 run through a 24-pin plug (P_{301}) on the rear of the chassis. In addition to the power connections on pins 1 through 8, provision has been made to control some external functions from within the LWM-3. The connections from pins 9 through 15 run through a section of the bandswitch (S_{2G}). This circuit can be used to control external functions — linear amplifiers, etc. — for each band.

Pins 16, 17 and 22 connect to SPDT contacts on K_2, permitting control of an external function on either *transmit* or *receive.* Also, pins 23 and 24 connect to another set of SPDT contacts on K_2 which have the movable contact arm grounded, permitting external circuitry to be grounded in either position of K_2. All pins on P_{301} are bypassed to the chassis by capacitors C_{300} to C_{306}, and C_{316} to C_{327}) to prevent RF leakage outside the LWM-3 enclosure.

The LWM-3 requires 265 volts DC (not less than 240, or over 275 volts is recommended) at about 200 milliamperes, and minus 65 volts at 10 milliamperes for bias. The tube heaters are arranged in a series-parallel circuit for either 6.3 or 12.6-volt operation. A 12.6-volt, 4-ampere source can be connected to pins 2 and 5 on P_{301}; or, a 6.3-volt 8-ampere source should be connected to pins 2 and 4, and pin 5 should be connected back to pin 2, thus placing all heaters in parallel.

Information on an AC power supply for the LWM-3 will be covered in PART II in the next issue. This supply — or a mobile power supply — can be turned on and off through connections to pins 6 and 8 on P_{301}. These connections run through "GG" and "II" to Fig. 3, the receiver diagram, where they terminate in S_{401}, a switch mounted on potentiometer R_{435}, the AF GAIN control.

CRYSTAL LATTICE FILTER —

Although the LWM-3 transceiver as designed, described and constructed uses a *Collins* F-455J21 mechanical filter, it is possible to substitute a crystal lattice filter for it. The crystal lattice filter usually will not have the sharp selectivity of the mechanical filter, and thus the selectivity on *receive,* and unwanted sideband attenuation on *transmit,* will not be as good.

A representative circuit for a full lattice filter is shown in Fig. 6. Inexpensive war surplus type FT-241-A crystals can be used in a 455-kilocycle filter of this type. Refer to the "Filter System" chapters in the sideband handbooks for complete information on circuits, construction and, most important, proper alignment of crystal lattice filters.

MECHANICAL DETAILS —

Complete mechanical and constructional details on the LWM-3 will be published in PART II of this article in the January-February, 1962 issue of *G-E HAM NEWS.*

Now that you've covered the design and electrical details, start collecting parts and be ready to start construction when the next issue is out!

FIG. 6. FULL CRYSTAL LATTICE FILTER schematic diagram. This type of filter can be substituted for the Collins mechanical filter in the SSB GENERATOR schematic diagram, Fig. 3. Certain circuit changes may be necessary, as described in the chapters on filter systems in handbooks on single sideband.

FINAL REMINDER—1961 EDISON AWARD NOMINATIONS CLOSE JANUARY 3, 1962

Nominating letters for the 1961 Edison Radio Amateur Award must be postmarked not later than January 3, 1962.

Please remember that the judges will consider only candidates whose names are submitted in writing by you and others. There is no other source for Edison Award nominations.

Therefore, between now and January 3, canvass in your mind the activities of amateurs you know, in order to make sure no deserving OM or YL fails to be represented. If you uncover such a candidate, by all means send in his name promptly.

Write to Edison Award Committee, General Electric Co., Electronic Components Division, Owensboro, Ky.

HERE ARE TYPICAL ACTIVITIES THAT CAN QUALIFY FOR THE AWARD:

- Emergency communications work in a disaster, such as a flood, hurricane, tornado, or explosion.
- Helping amateurs and others with their specialized problems, through professional knowledge and experience.
- Community service in organizing mobile and fixed communications to promote the success of fund drives and other public events.
- Helping disabled or physically handicapped persons.
- Relaying messages from remote points for the benefit of isolated servicemen and civilians.
- Designing and constructing radio equipment for use by persons in remote parts of the world, who do not have access to regular commercial communication channels.
- Civil-defense organization work; weather reporting; radio assistance to state or local traffic and police authorities; cooperation in forest-fire prevention and control.
- Teaching basic electronics to young people.

RULES OF THE AWARD

WHO IS ELIGIBLE? Any man or woman holding a radio amateur's license issued by the F.C.C., Washington, D.C., who in 1961 performed a meritorious public service in behalf of an individual or group. The service must have been performed while the candidate was pursuing his hobby as an amateur within the limits of the United States.

RECIPIENT OF THE AWARD will receive the Edison trophy in a public ceremony in Washington, D.C. Expenses of his trip to that city will be paid.

$500 GIFT. Recipient will be presented with a check for this amount in recognition of the public service which he has rendered as a radio amateur.

WHO CAN NOMINATE? Any individual, club, or association familiar with the public service performed.

HOW TO NOMINATE. Include in a letter a full description of the service performed, as well as the candidate's name, address, and call letters. Your letter of nomination must be postmarked not later than January 3, 1962.

BASIS FOR JUDGING: All entries will be reviewed by a group of distinguished and impartial judges. Their decisions will be based on (1) the greatest benefit to an individual or group, (2) the amount of ingenuity and sacrifice displayed in performing the service.

EDISON AWARD JUDGES WILL BE:

E. ROLAND HARRIMAN, Chairman, The American National Red Cross.

ROSEL H. HYDE, Commissioner, Federal Communications Committee.

GOODWIN L. DOSLAND, President, American Radio Relay League.

Recipient of the Award will be announced on or before Thomas A. Edison's birthday, February 11, 1962.

Employees of the General Electric Company may nominate candidates for the Edison Radio Amateur Award, but are not permitted to receive the Award.

Season's Greetings to All!

—Lighthouse Larry

G-E HAM NEWS is available free from authorized **G-E Tube** distributors. Some distributors mail copies locally to their customers.

A low-cost direct-mail subscription plan is available to persons residing in the United States and its possessions (including APO and FPO numbers).

Subscription rates are:

One Year (6 issues)	$1.00
Two Years (12 issues)	$2.00
Three Years (18 issues)	$3.00
Five Years (30 issues)	$4.00

Enclose check or money order for U. S. currency for the proper amount above made payable to "General Electric Company."

Residents of Canada may subscribe to **G-E HAM NEWS** for $1.00 per year from the Canadian General Electric Company, Ltd., Electronic Tube Marketing Section, 189 Dufferin Street, Toronto 3, Ontario, Canada. Enclose check or money order made payable to: "Canadian General Electric Company, Ltd."

Distribution of **G-E HAM NEWS** in more than 40 foreign countries is handled through the International General Electric Company. A listing of outlets is available from the **G-E HAM NEWS** office. Or, write to: Customer Inquiry Section, International General Electric Company, 159 Madison Avenue, New York 16, New York, U. S. A.

TUBES

HAM NEWS

***presents* HOW-TO-DO-IT IDEAS *from the 999 radio amateurs at* GENERAL ELECTRIC**

A bi-monthly publication of the RECEIVING TUBE DEPARTMENT
Owensboro, Kentucky, U. S. A. • Editor — E. A. Neal, W4ITC

NOVEMBER-DECEMBER
1961
VOL. 16, NO. 6

DENVER COLO.

Bulk Rate
U. S. POSTAGE
PAID
Permit No. 37

OTIS C. SMITH WØBFN
DUNLAP ROUTE
HEMINGFORD, NEBRASKA

RETURN POSTAGE GUARANTEED