



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 band-switching 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 side-band 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.

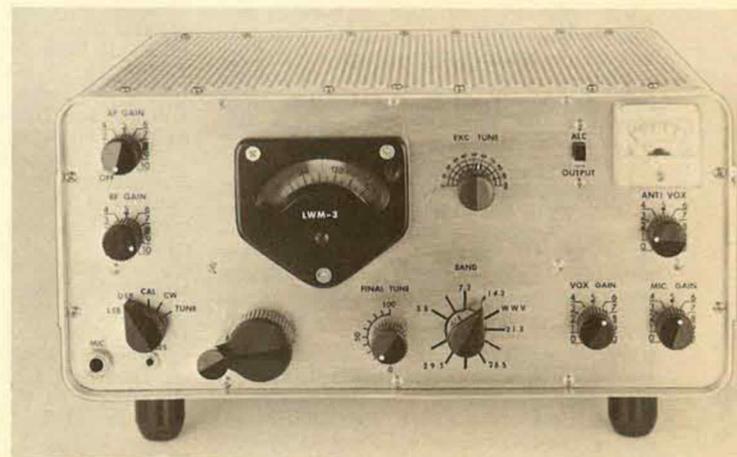
Basically the LWM-3 was designed for mobile operation. All the "most-used" controls were placed on the left side of the front panel to minimize the distance a driver must reach when tuning and operating the unit. The tubes and associated circuitry were positioned for this placement of the controls.

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 center 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

The LWM-3 — A BANDSWITCHING MOBILE SSB TRANSCEIVER...page 1
FINAL REMINDER — 1961 Edison Award Nominations.....page 8

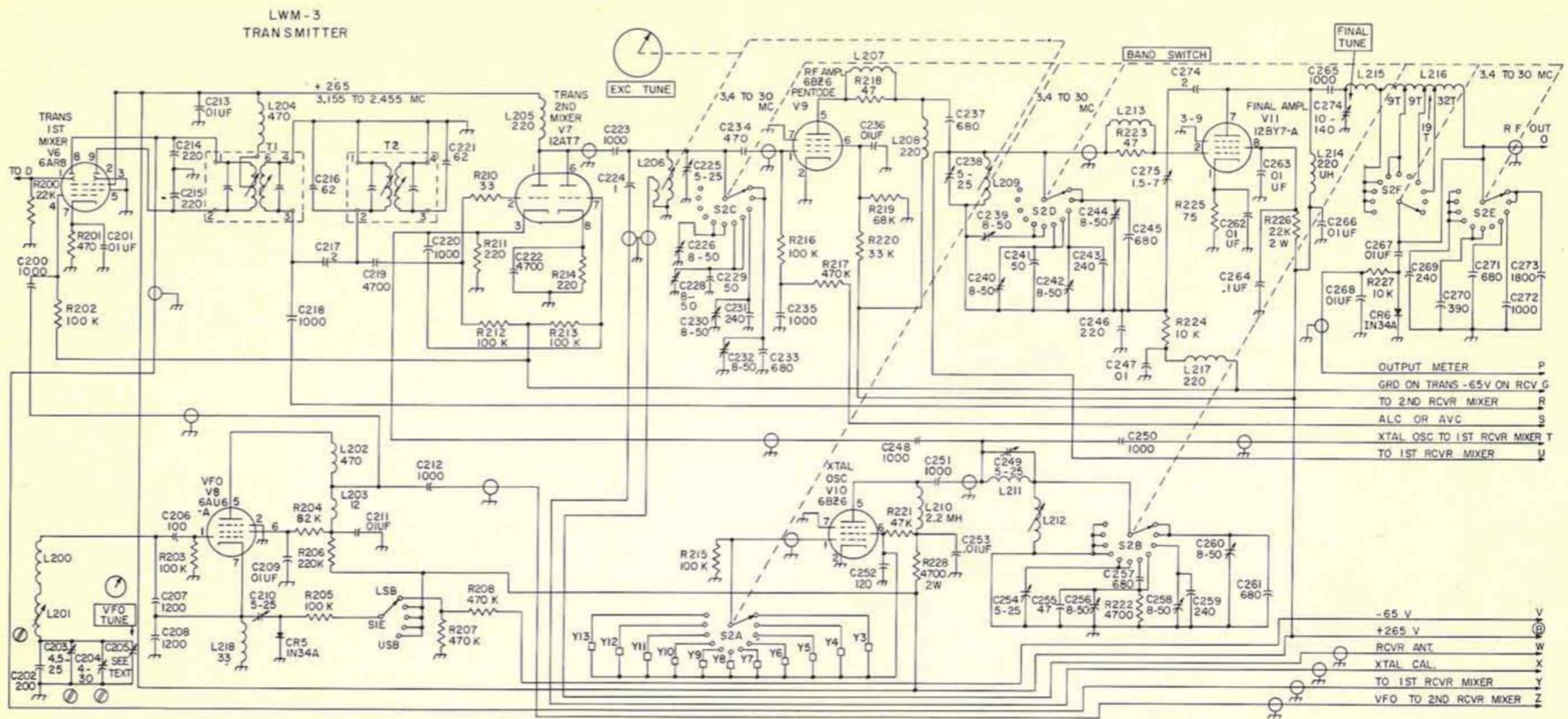


TABLE I — COIL TABLE

turn spacing decreases from 1/8 inch to 1/32 inch at lower end (similar to Collins Radio No. 544-3135-002).

FIG. 2. "TRANSMITTER" SECTION schematic diagram, showing the tunable oscillator (V8) (VFO), high-frequency crystal con-

TABLE II — PARTS LIST

C₁₂₂, C₂₂₆, C₂₂₈, C₂₃₀, C₂₃₂, C₂₃₉, C₂₄₀, C₂₄₂, C₂₄₄, C₂₅₆, C₂₅₈, C₃₀₉, C₃₁₇....8 — 50-mmf midget variable ceramic.
 C₂₀₂....200-mmf NPO ceramic (two 100-mmf NPO's).
 C₂₀₃....4.5 — 25-mmf midget variable ceramic (Erie TS-C).
 C₂₀₄....4 — 30-mmf midget variable ceramic (Erie 557-F).
 C₂₀₅....5 — 25-mmf double bearing variable (Front tuning capacitor from 2.1 — 3-Mc. Command Set transmitter).
 C₂₀₆....100-mmf NPO ceramic (Erie TCO-100).
 C₂₀₇, C₂₀₈....1200-mmf silvered mica, 500 volts working.
 C₂₁₀, C₂₂₅, C₂₃₅, C₂₄₉, C₂₅₄....5—25-mmf midget variable ceramic.
 C₂₁₄, C₂₁₅....200-mmf silvered mica, 500 volts working.
 C₂₁₆, C₂₂₁....62-mmf silvered mica, 500 volts working.
 C₂₂₉, C₂₄₁, C₂₅₅....50-mmf, 500-volt silvered mica.
 C₂₂₄, C₂₄₂, C₂₅₉....240-mmf, 500-volt silvered mica.
 C₂₃₃, C₂₄₅, C₂₉₁....680-mmf, made from a 330 and a 390-mmf, 500-volt silvered mica in parallel.
 C₂₆₉....240-mmf silvered mica, 500 volts working.
 C₂₇₀....390-mmf silvered mica, 500 volts working.
 C₂₇₁....680-mmf silvered mica, 500 volts working.
 C₂₇₂....1000-mmf silvered mica, 500 volts working.
 C₂₇₃....1800-mmf silvered mica, 500 volts working.
 C₂₇₄....10 — 140-mmf midget air variable with 1/4-inch diameter shaft (Hammarlund APC-B-140, of HF-140).
 C₂₇₅....1.5 — 7-mmf midget variable ceramic (Erie 557-A).

CR₁, CR₂, CR₃, CR₄....matched set of 1N34A germanium diodes.
 FL₁₀₁....455-Kc. mechanical filter, 2.1-Kc. bandwidth (Collins F-455 J21).
 I₁....6.3 volt, 0.25-ampere pilot lamp (G. E. No. 46).
 J₁, J₂....chassis type midget coaxial cable connectors.
 J₃....midget phono type 1-pin jack.
 J₁₀₁....midget 3-way phone jack (Mallory SCA-2B).
 K₁....4 pole, double throw midget relay, 10,000-ohm DC coil (P & B GB-17D).
 K₂, K₃....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.
 M₄₀₁....0 — 1-Ma. DC midget panel meter (Lafayette).
 P₂₀₁....24-pin midget type male connector with chassis mounting flange (Amphenol 26 — 4101 — 24P).
 R₁₁₇, R₁₁₈, R₁₃₅....500,000-ohm potentiometer (IRC Q13-133).
 R₁₃₂....100-ohm Trimit 10-turn potentiometer (Bourns 273).
 R₃₀₆....50,000-ohm potentiometer (IRC Q11-123).
 R₃₁₀....10,000-ohm potentiometer (IRC Q11-116).
 R₄₁₀....2,500-ohm potentiometer (Clarostat A47-2500-S).
 R₄₂₅....75,000-ohm potentiometer (Clarostat A47-75K-V).
 R₄₃₃....500-ohm Trimit 10-turn potentiometer (Bourns 273).
 R₄₃₅....500,000-ohm audio taper potentiometer.
 S₁....6 pole, 5-position three section phenolic insulated miniature tap switch (Centralab PA-1020).
 S₂....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).
 S₃....Double pole, double throw midget slide switch.
 T₁....4.5-megacycle Ratio Detector type IF transformer with tertiary winding disconnected (J. W. Miller 6205).
 T₂....4.5-megacycle input or interstage television IF transformer (J. W. Miller 6203).
 T₃....455-kilocycle input type IF transformer; secondary detuned and not used (J. W. Miller 12-C1).
 T₄....500-kilocycle output type IF transformer.
 T₅....Audio output transformer, 5000-ohm primary, 4-ohm secondary, 5 watt power rating (Stancor A-3877).
 V₁ to V₂₃....General Electric receiving tubes, types as marked on schematic diagrams.
 Y₁....Quartz crystal, 453.9 kilocycles, FA-5 type holder.
 Y₂....Quartz crystal, 456.4 kilocycles, FA-5 type holder.
 Y₃ to Y₁₃....Quartz crystals, see TABLE III — CRYSTAL CHART, for frequencies.
 Z₃₀₁....11-volt, 1-watt Zener diode (G. E. Z4X11B).

LWM - 3
RECEIVER AND XTAL CAL.

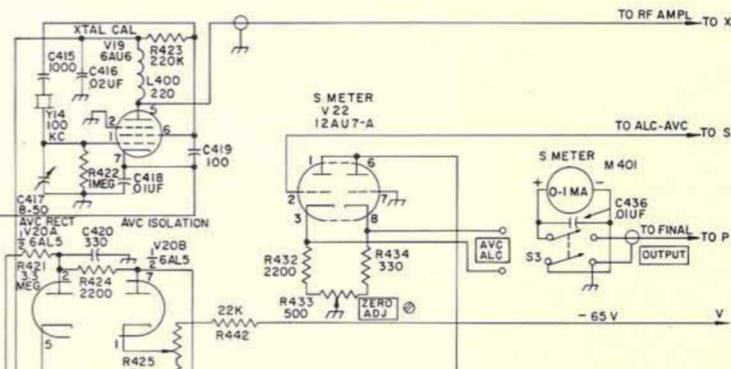
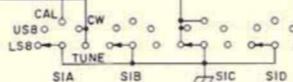
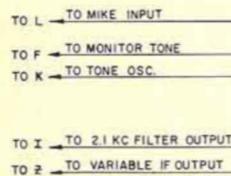


FIG. 3. RECEIVER SECTION schematic diagram for the LWM-3. All circuits in this section operate only on receive, except the "S" meter amplifier (V₂₂), which also functions as an ALC voltage indicator on transmit.

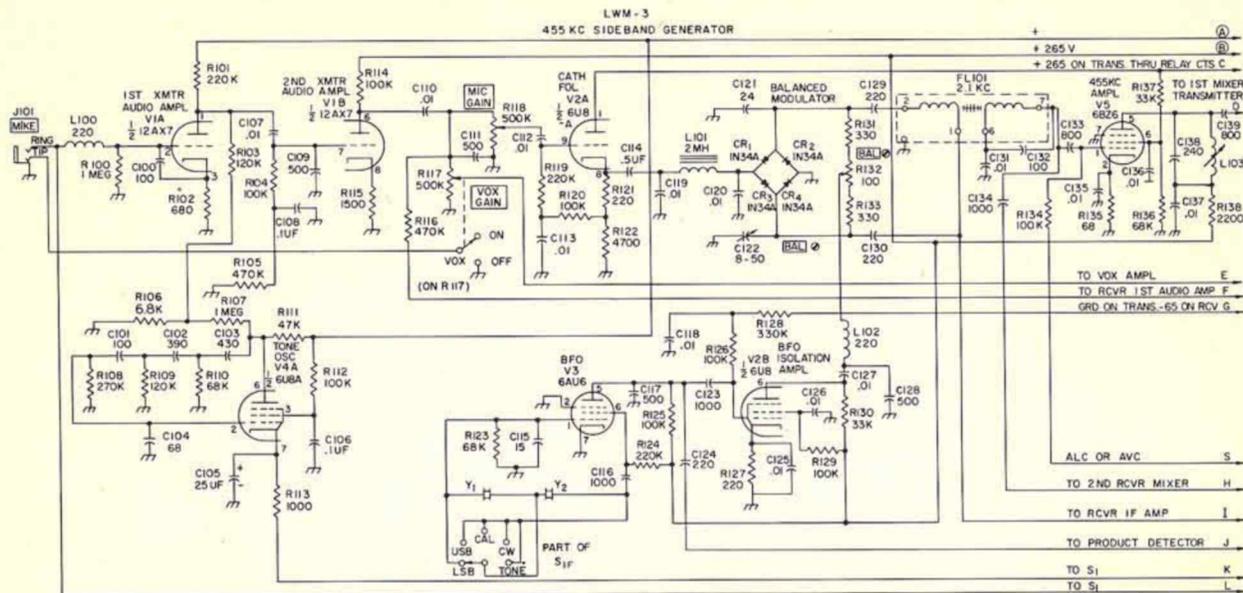


FIG. 4. SSB GENERATOR schematic diagram, showing the transmitter audio section (V_1 , V_{2A} and V_{4A}), and BFO isolation amplifier (V_{2B}), diode balanced modulator (CR_1 to CR_4), and 455-kilocycle amplifier (V_5), which operate only on transmit. The BFO (V_3) and mechanical filter (FL_{101}) operate 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 milliammeter (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 (R_{132}) 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 de-energizing 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

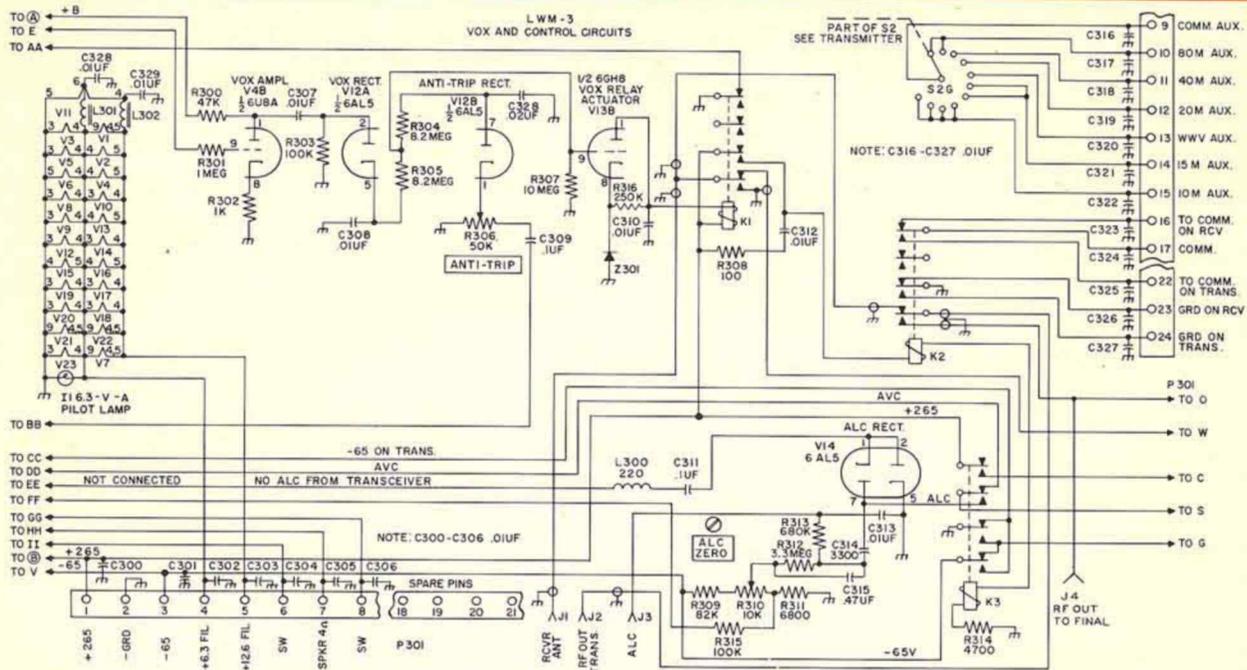


FIG. 5. VOX AND CONTROL CIRCUIT schematic diagram. The heater circuit for all 23 tubes is shown at the left side of this diagram. All tubes in this section operate only on transmit. Antenna transfer and power control circuits are in

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_1 to drive a linear amplifier from the LWM-3 transceiver.

a time constant network and V_{11} through J_5 . 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_{20}). 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_{101} , a switch mounted on potentiometer R_{455} , 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!

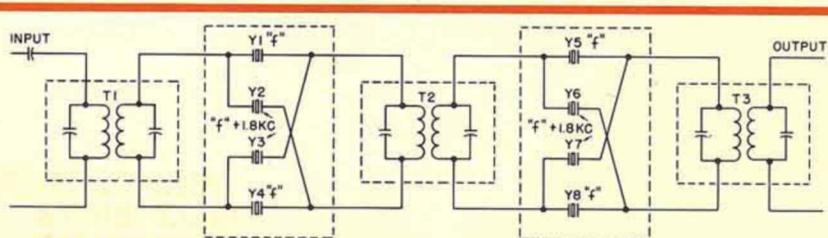


FIG. 6. FULL CRYSTAL LATTICE FILTER schematic diagram. This type of filter can be substituted for the Collins mechanical filter in the SSB GENERATOR schematic diagram, Fig. 3. Certain circuit changes may be necessary, as described in the chapters on filter systems in handbooks on single sideband.



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 Commission.

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

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A bi-monthly publication of the RECEIVING TUBE DEPARTMENT
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NOVEMBER-DECEMBER

1961

VOL. 16, NO. 6

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