SPECIAL REPORT ON VHF SSB

G-E TUBES HAM NEWS

JULY-AUGUST, 1962

Presenting a 2-part series on VHF Sideband Equipment

PART I . . . In This Issue:

A COMPLETE 20-WATT, 144-MC. SSB EXCITER

By David W. Bray, K2LMG

PART II — In the September-October, 1962 Issue:

A 144-MC. DIRECT SSB GENERATOR & HETERODYNING SSB SIGNALS TO 144 MC.

By James V. O'Hern, W2WZR

Interest in SSB on the VHF amateurs bands — principally 50 and 144 megacycles — is growing rapidly. This two-part series in *G-E HAM NEWS* has been prepared by two long-time experimenters with VHF SSB techniques — and proven in hundreds of tests over a rugged 40-odd mile path between their stations. There's a *wealth* of good ideas in their circuits, choices of frequency conversion, and construction techniques. You'll find it's easy to modify or add to your present equipment and try VHF Single Sideband!

K2LMG DISPLAYS his 20-watt, 14-tube, 144-megacycle SSB exciter. Dave is a consulting engineer in the Advanced Radar and ECM Engineering group at General Electric's Advanced Electronics Center at Cornell University, Ithaca, New York. He has been with General Electric for 13 years and has participated in developing a number of advanced electronics, radar and weapons control systems. He is the author of articles in *QST* on measuring VHF station performance, and measuring antenna patterns using the sun. K2LMG since 1957, Dave is a senior member of IRE.

INTRODUCTION — It is not necessary to extol the advantages of single or double sideband on the high frequency amateur radio bands, but on the VHF bands where there is no QRM, just steady receiver noise, many people do not realize the advantages of single or double sideband. These advantages can largely be summed up as follows:

1. In order to achieve high power output with an amplitude modulated signal, a large audio amplifier of at least one-half the total input power to the transmitter is required. For one kilowatt transmitter this audio power output is extremely difficult and costly to achieve. However, a single sideband exciter of only 6 watts output is capable of driving a pair of 250-watt class beam pentode tubes in a linear amplifier to full 1200 watt peak effective input. If this same amplifier was used to amplify an amplitude modulated signal one finds that its efficiency is so poor that an amplifier which is capable of putting out 800 watts of SSB RF power delivers approximately 200 watts. Thus single and double sideband provide a simple means of producing a high power RF signal.
2. By theory and experimentation it has been shown that CW has a 17 db. advantage over amplitude modulation. That is; a transmitter capable of transmitting one kilowatt input fully amplitude modulated has the same transmitting range as a 20-watt transmitter which is operated on CW. This is all well and good if you want to use CW. However, it has also been shown that a single sideband emission is nearly as effective as CW. Actual tests on the 144-megacycle band have shown that, even though not exactly predicted by theory, a single sideband signal can be copied with the same ease as CW when the distance between stations is such that the signal strength of the received signal is very weak. Under these same conditions an amplitude modulated signal is indistinguishable. Therefore, single or double sideband do provide two very obvious advantages in the VHF bands: (1) equipment simplicity, and (2) talking power.

This article describes a 144-megacycle exciter which is capable of operating single sideband, double sideband, amplitude modulation and CW. It has a power output of approximately 6 watts which is adequate for local use or to drive a pentode-type kilowatt linear amplifier to full rated output. It also includes a tunable crystal oscillator with good stability and a voice operated control system.

The exciter is a phasing type single sideband generator which provides good carrier suppression and unwanted sideband rejection.

CIRCUIT DESCRIPTION — The Exciter consists of four basic circuits: (1) A phasing type single sideband generator operating on 25 megacycles; (2) a tunable crystal oscillator as the VFO; (3) a RF mixer and amplifier; and (4) a voice operated control circuit.

Each of the separate circuits which make up the Exciter are discussed in detail, and all references are made to the schematic diagram, Figure 1.

FRONT-PANEL VIEW of the complete exciter constructed in an 8x12½x8-inch steel cabinet. All controls used during normal operation are on the front panel. The National MCN dial tunes the VXO over 100-kilocycle segments.

IN THIS ISSUE

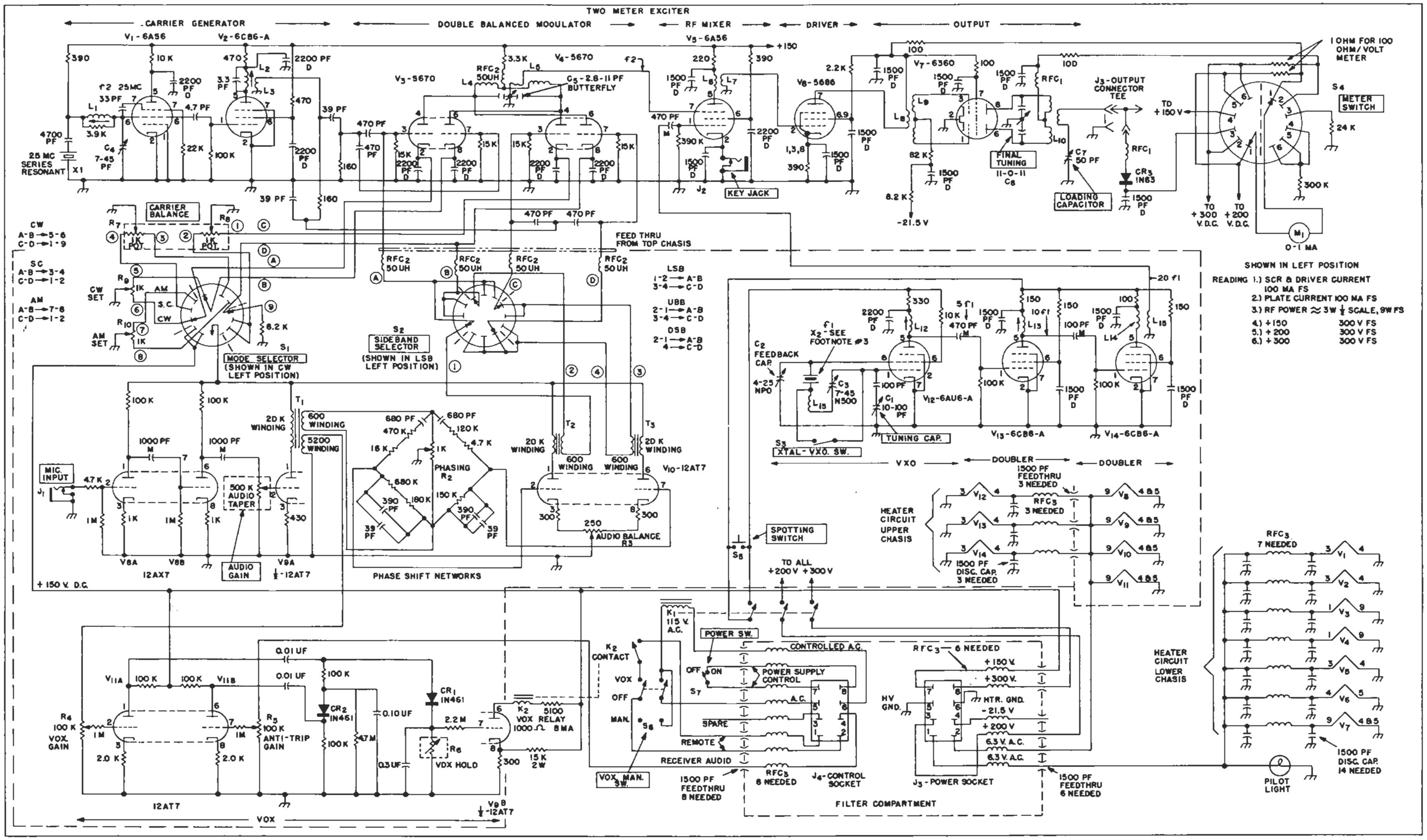


TABLE I — PARTS LIST

C_1......8-100-pf variable, double bearings (Hammarlund MC-100-S).
C_2......4.5-25-pf ceramic trimmer, NPO (Centralab 822-AZ).
C_3, C_4......7-45-pf ceramic trimmer, N-650 (Centralab 822-BN).
C_5, C_6......2.7-10.8-pf per section miniature butterfly variable, 0.013-inch air gap (E. F. Johnson 160-211, type 11MB11).
C_7......3.7-52-pf midget air variable (Hammarlund HF-50 or equal).
J_1, J_2......2-circuit midget closed circuit phone jack.
J3......chassis type coaxial cable connector.
K_1......3-pole, double throw midget relay, 115-volt AC coil.
K_2......Single pole, single throw midget relay, 1,000-ohm, 8-milliampere DC coil (P&B type RS5D or equal).
L......Single layer coils; See TABLE I—COIL DATA, for details.
M_1 ....0-1 DC milliameter, 1½-inch diameter case (G-E type DN1).
R_1......500,000-ohm midget potentiometer, audio taper.

FIG. 1. MAIN SCHEMATIC DIAGRAM for the exciter. The panel controls are identified with rectangular boxes around their names. Resistances are in ohms, ½-watt rating unless otherwise marked. Capacitances are in picofarads (pf), or microfarads (mfd), as marked. Parts needing further identification are described in TABLE I — PARTS LIST, or TABLE II — COIL DATA. Circuits within dashed lines are in the upper sub-chassis section of the exciter.

TABLE II — COIL DATA

R_2, R_7, R_8, R_9, R_{10}......1000-ohm midget potentiometer, linear taper.
R_3......250-ohm midget potentiometer, linear taper.
R_4, R_5......100,000-ohm midget potentiometer, linear taper.
R_6......2.5-megohm midget potentiometer, linear taper.
S_1, S_2......4-pole, 3-position, 1-section rotory tap switch (Mallory 3243J, or equivalent).
S_3......SPDT rotary toggle switch (Arrow-Hart No. 1565-B, or equal).
S_4......2-pole, 6-position, 1-section rotory tap switch (Mallory 3226J; Centralab PA-2003, or equivalent).
S_5......SPST midget push-button switch.
S_6......DPDT 3-position center-off toggle switch.
T_1, T_2, T_3......midget encased audio transformer, 3 windings with impedances of 600, 5200 and 20,000 ohms. (These are the transformers used in the W2EWL Command Set SSB exciter, and are regularly advertised in QST for $1.39 each, 3 for $3.49, by Arrow Electronics, 65 Cortlandt Street, New York 7, N.Y.)
V_1-V_{14}......General Electric receiving tubes, types per Fig. 1.
X_1......Quartz crystal, 25,000 kilocycles, third-overtone type.
X_2......Quartz crystal, 5955 kilocycles; also see footnote 3.

NOTE: All coils wound with enameled wire unless otherwise noted.

L_1......12 turns, No. 28 wire, closewound on ⅜-inch form.*
L_2, L_{12}......35 turns, No. 28 wire, closewound on ¼-inch form.**
L_3......4 turns, No. 28 wire on bypassed end of L_2.
L_4......17 turns, No. 24 wire wound 8½ turns on both sides of L_5, on ¾-inch diameter coil form, no tuning slug.
L_5......3 turns, No. 20 wire at center of form for L_4.
L_6......6½ turns, No. 20 wire, ⅜-inch diameter, spacewound the diameter of wire.
L_7......3½ turns, No. 20 wire, ⅜-inch diameter, spacewound the diameter of wire and spaced ⅛-inch from L_6.
L_8......3 turns, No. 20 wire, ⅜-inch diameter, spacewound the diameter of wire.
L_9......5 turns, No. 20 wire, ⅜-inch diameter, spacewound diameter of wire in two 2½-turn coils spaced ⅜-inch.
L_{10}....6 turns, No. 20 wire, ⅜-inch diameter, spacewound diameter of wire, in two 3-turn coils spaced ⅛ inch apart.
L_{11}....1 turn, No. 20 wire, ⅜-inch diameter, at middle of L_{10}.
L_{13}....7 turns, No. 28 wire, ¼-inch diameter, closewound on ¼-inch diameter form.**
L_{14}....8½ turns, No. 20 wire, ⅜-inch diameter, spacewound the diameter of wire.
L_{15}....2½ turns, No. 20 wire, ⅜-inch diameter, spacewound the diameter of wire (see detail view of VXO for position).
L_{16}....50-75-uh.; 105 turns, No. 33 wire, closewound on ⅜-inch diameter slug-tuned coil form. (Cambion LS-3 coil form with red slug, or LS-3 5-MC. wound coil, green code.)
RFC_1..34 turns, No. 28 wire on $^5/_{32}$-inch diameter molded form with end leads (½-watt resistor for form).
RFC_2..4 chokes required, 50-uh., pi-wound, midget RF chokes National type R-33, 50 uh., or equivalent.
RFC_3..24 chokes required, 5-uh., 34 turns, No. 22 wire, closewound on ¼-inch diameter powdered iron form with end leads (Groyhill No. 28YY1006-6, or equivalent).

*Use Cambion LS-3 phenolic coil form, ⅜-inch diameter, 1⅛ inches long, with white-coded iron tuning slug.

**Use Cambion LSM phenolic coil form, ¼-inch diameter, ¾-inch long with white-coded iron tuning slug.

THE CARRIER GENERATOR is a transitron oscillator (V_1) operating on 25 megacycles. This ocsillator is very stable. It uses the screen grid of a 6AS6 dual-control RF pentode as the plate of the oscillator, and the suppressor grid as the control grid.[1] The suppressor grid electrically follows the screen grid as the electron stream flows but yet controls the flow of electrons, materially contributing to the stability of the oscillator. The stability is also improved by forcing the crystal to run in a series resonant mode. Since this is a low impedance mode an L matching network transforms the low impedance crystal to a higher impedance to develop more voltage at the screen and control grids.

The power output is very low; therefore, it is necessary to follow the oscillator with a 6CB6 pentode (V_2) RF amplifier. Its control grid is coupled very loosely to the transitron oscillator by a 4.7-pf capacitor. The 4.7-pf capacitor and the interelectrode capacitance of the 6CB6 is a capacity divider thereby keeping the load on the oscillator small. The output of the buffer is coupled to the double balanced modulator by a four turn link (L_5) tightly coupled to the plate tank circuit (L_3 & 3.3-pf) of the buffer, providing a low impedance output to drive the rf phase shift network.

THE DOUBLED BALANCED MODULATOR consists of a pair of 5670 twin triodes (V_3 & V_4). Each of the balanced modulators suppresses the carrier and produces a double sideband suppressed carrier signal centered around the carrier frequency.

In order that the balanced modulator can suppress the carrier, the carrier signal is fed to the grids in parallel, and a push-pull audio signal to the grids.

The plates are also in push-pull, to provide cancellation of the audio and RF input signals.

One of the 5670 tubes connected as a balanced modulator is fed from an RF phase shift network which produces a 45 degree leading phase of the carrier. The other balanced modulator is fed from a phase shift network that produces a lag of 45 degrees from the carrier generator. Thus the net result is that the phase of one of the balanced modulators differs from the other balanced modulator by 90 degrees.

In addition, each balanced modulator is fed by two audio signals having a relative phase difference of 90 degrees. The output of the balanced modulators (V_3 & V_4) are fed to a common tank circuit (C_5-L_4) which combines the signals. This addition and cancellation in the output of the two balanced modulators whose carrier is phase shifted by 90° as well as a 90° phase shift of the audio input, produces a single sideband signal in the tank circuit.

AUDIO AMPLIFIER AND PHASE SHIFTER — The major problem with the phasing type single sideband generator is to provide a precise 90 degrees relative phase shift between the two push-pull audio signals required for each balanced modulator. This 90 degree phase shift must be precise across the voice range audio spectrum. In order to provide this phase shift a complicated network must be built. Usually this network is made up of resistance and capacitance values that are not readily available. However, a special phase shift network was developed that could be built out of standard resistor and capacitor values. Note that only the 16,000-ohm resistor has a 5 percent tolerance. All other values have 10 percent tolerance. The sideband suppression provided by this network is at least 30 db. To insure that ths suppression is as good as possible, the actual components used should be close to the specified values.

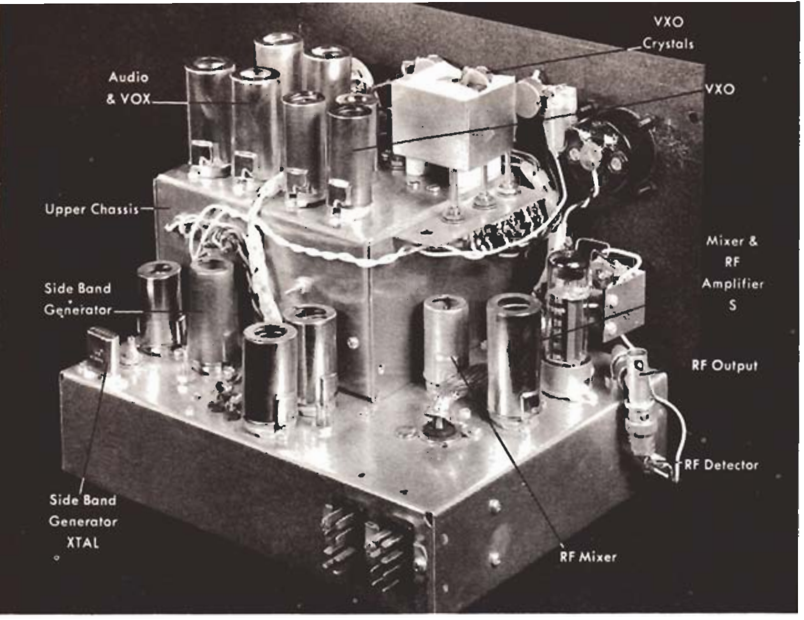
The audio amplifier itself is straight forward. It consists of three twin triode tubes; a 12AX7 and two 12AT7's. The 12AX7 (V_8) functions as a normal two-stage triode amplifier. The output of the second section feeds the first section of the 12AT7 (V_{9A}) which is transformer coupled (by T_1) to both the audio phase shift network and the VOX amplifier. The 600-ohm winding of T_1 feeds the phase shift network and the 5200-ohm winding drives the VOX amplifier.

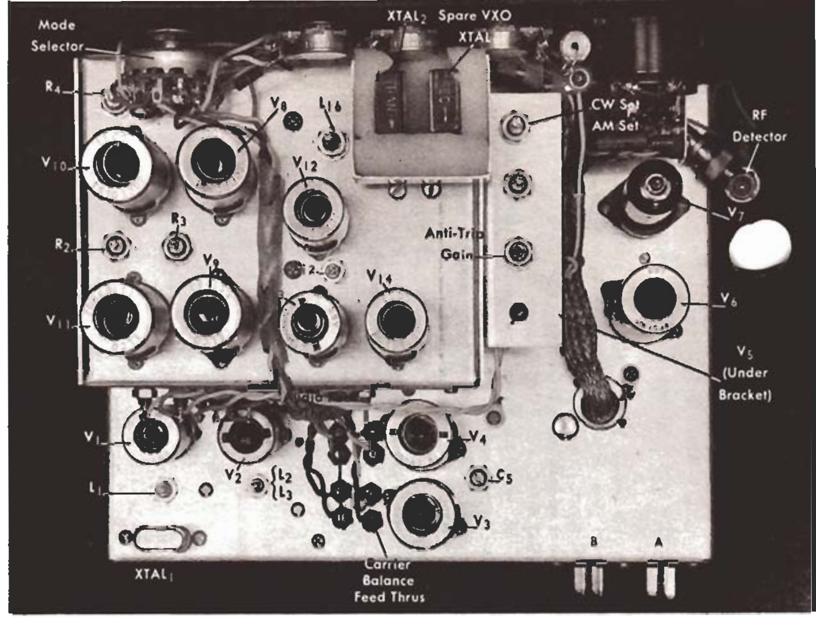
The output of the phase shift network is a push-pull signal and is fed to an amplifier consisting of a 12AT7 (V_{10}) connected in push-pull with a balancing potentiometer (R_3) in the cathodes, and the plate of each connected to a separate output transformer (T_2 and T_3). The 600-ohm windings of each drive the 5670 double balanced modulator tubes.

In order to choose the desired sideband, the output of T_2 and T_3 is connected to a 4-pole, 3-position tap switch (S_2) as shown in Fig. 1. The lower sideband is chosen if transformer leads 1 and 2 from T_2 are connected to modulator grids A and B, respectively, and transformer leads Nos. 3 and 4 from T_3 are connected to modular grids C and D, respectively. To obtain lower sideband leads numbered 1 and 2 are interchanged. To obtain double sideband the modulator grids C and D are connected together in parallel and T_3 lead No. 3 is opened.

VARIABLE CRYSTAL OSCILLATOR — A stable but yet tunable oscillator can be achieved by using a quartz crystal which is "pulled" from its normal operating frequency by a series inductor (L_{15}). As the value of the inductor is changed, the frequency of oscillation will change proportionally.[2] However, since variable inductors are difficult to tune — and particularly in a linear manner — the actual value of the inductance is changed by placing a variable capacitor (C_1) in series with the inductor. A modified Pierce oscillator is achieved by placing the crystal and inductor, and a temperature compensating capacitor, between the screen and control grid of the 6AU6 pentode (V_{12}). The feedback circuit is then provided by the variable capacitor (C_2) and a zero temperature coefficient trimmer capacitor (C_3).

An ideal crystal frequency for 144-megacycle band operation is 5955 kilocycles, since no harmonics fall in the 144-megacycle amateur band and the crystal will pull very nicely at least 100 kilocycles. The 20th harmonic of this crystal is 119.10 megacycles. Mixing this frequency with 25 megacycles then produces a frequency of 144.1 megacycles.[3] To achieve the 20th harmonic the tank circuit in the plate of the oscillator is tuned to the 5th harmonic (29.775 Mc.). This frequency is doubled





REAR VIEW of the complete exciter showing the upper sub-chassis assembled on the main chassis. Upper chassis contains the audio section, phase-shift networks, voice-controlled unit, and the VXO section. Main chassis contains the carrier oscillator, the RF SSB balanced modulator, and VHF mixers and amplifiers, plus control relays.

TOP VIEW, showing the locations of the tubes and other major components on the chassis. Power wiring runs between units in cables, and through feedthrough insulators in chassis. The crystals for the VXO are in the insulated metal container behind the center of the panel. Carrier crystal is in right rear corner of main chassis.

(59.550 Mc.) in the following 6CB6 pentode (V_{13}) stage and again doubled in the second 6CB6 pentode (V_{14}). The 119.1-megacycle output signal drives the control grid of the r-f mixer stage (V_5).

RF MIXER — Very often in single sideband equipment RF mixing is accomplished at a high level in order to avoid a large amount of straight through amplification on the output frequency. However, high level mixing is difficult to accomplish with good mixer stability, and in addition requires the use of relatively high power vacuum tubes in order to obtain the necessary signal level. In order to avoid the difficulties of high level mixing a low level mixer, which seems to have been overlooked in the VHF art, was used. This tube, a 6AS6 (V_5), has the same VHF capabilities as the 6AK5 pentode but yet has a suppressor grid which has sufficient control to act as a good signal grid. Therefore, the 119.1-megacycle signal can be fed directly into the control grid of V_5, and the single sideband signal at 25 megacycles can be fed to the suppressor grid. Using this arrangement the mixer is stable since the cathode is grounded. Bias is provided by self-bias operation of the control grid, and the single sideband signal is fed to a completely separate element of the tube. By tuning the plate of the tube to 144 megacycles and coupling it through a double tuned circuit into the following amplifier stage, a very clean 144-megacycle output signal is produced from this mixer.

RF AMPLIFIER — The first amplifier stage is a 5686 VHF pentode (V_6) operated as a class A amplifier. Double-tuned circuits are used from the mixer into its control grid, and into the following stage. The 5686, even though operated in class A, provides ample drive for the 6360 twin pentode (V_7) output stage, operated class AB1 with a fixed bias of −21.5 volts. The 6360 is operated push-pull and requires no neutralization because of its internal neutralized construction. The output of the push-pull tank is link coupled to the RF output connector. The 6360 operating in class AB1 provides about 6 watts CW output.

To measure the RF output of the exciter, the diode CR_3 and RF choke RFC_1 are mounted in a coaxial cable RF connector, and then plugged into a "Tee" connector in the output cable line, as shown in the rear and top views. A DC connection then runs to the meter control switch, S_4.

VOICE OPERATED CONTROL CIRCUITS — No single sideband transmitter is complete without the voice control circuitry. In this exciter a familiar type voice control circuit is used. The output of the audio amplifier from the 5200 ohm tap of the audio transformer is fed to one-half of the 12AT7 triode (V_{11A}). The output from the 500 ohm tap or loud speaker of the receiver is fed to the other half of the 12AT7 triode (V_{11B}). The output of V_{11A} from the audio channel is then rectified by diode CR_1 and used to charge a 0.3 mfd. capacitor with an adjustable discharge resistor of 2.5 megohms. This operates a control

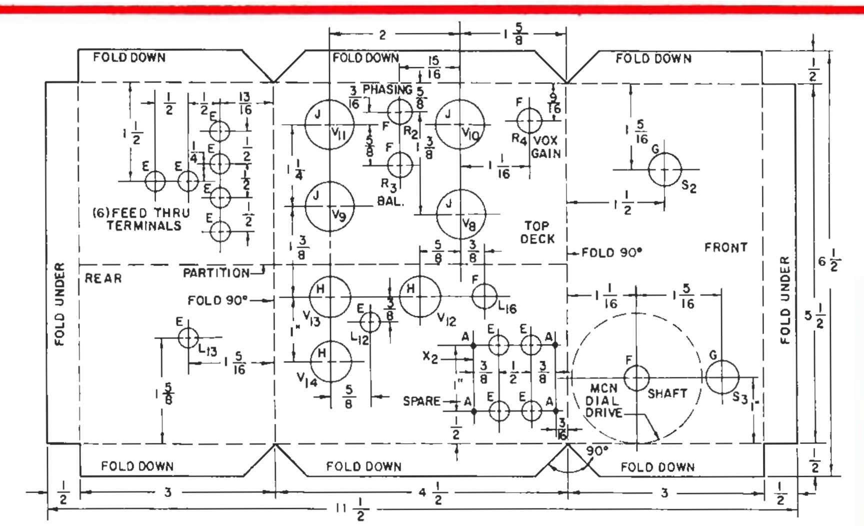


FIG. 2. **LAYOUT DIAGRAM** for the upper sub-chassis unit, showing the overall size of sheet aluminum required. Location of the shield partition across the center of the chassis is indicated by the dashed line. The metal is folded at the dashed lines before drilling holes, sizes of which are given in TABLE III — HOLE SIZE CHART.

TABLE III — HOLE SIZE CHART

"A" drill — No. 31 clears 4-40 screw.
"B" drill — No. 26 clears 6-32 screw.
"C" drill — No. 17 clears 8-32 screw.
"D" drill — No. 9 clears 10-32 screw.
"E" drill — 9/32-inch diameter.
"F" drill — 3/8-inch diameter.
"G" drill — 1/2-inch diameter.
"H" socket punch — 5/8-inch diameter for 7-pin miniature tube socket.
"J" socket punch — 3/4-inch diameter for 9-pin miniature tube socket.
"K" socket punch — 1-1/16-inch diameter for small octal tube socket.
"L" socket punch — 1-1/4-inch diameter for large receiving tube socket.

FOOTNOTES

[1]A technical discussion of the principles of operation of the 6AS6 transitron crystal controlled oscillator will appear in the next issue of G-E HAM NEWS, September-October, 1962 (Vol. 17, No. 5).

[2]Following is a reference listing of articles on the variable crystal oscillator:
"VXO—A Variable Crystal Oscillator," by Herman Shall, W3BWK, QST, January, 1958, page 11;
"VXO-II Variable Frequency Crystal Exciter," by Herman Shall, W3BWK, QST, July, 1959, page 37;
"A V.H.F. Variable Frequency Crystal Exciter," by H. J. Saborsky, W3KXI, QST, November, 1960, page 27.

[3]To cover 144-148 megacycles with the exciter, crystal frequencies between 5950 and 6150 kilocycles may be used in the VXO. The 24th harmonic of crystals between 6000 and 6150 kilocycles falls within the 144-148 megacycle band, but does not cross the exciter output frequency.

relay tube, also one half of a 12AT7 (V_{9B}) with a 1,000-ohm, 8 ma. plate relay. To provide anti-trip, the output of the receiver amplifier (V_{11B}) is rectified by a negatively connected diode (CR_2) and also charges a long time constant circuit. This circuit back-biases the audio amplifier (V_{11A}) channel so that any output from the loudspeaker cancels the signal from the audio amplifier channel by not allowing diode CR_1 to conduct.

In addition to the choice of lower, upper and double sidebands on S_2, by adding a mode selector switch (S_1), the exciter can be placed in an AM or CW mode of operation. To provide AM, one of the double balanced modulators is simply unbalanced. This increases the carrier from its normal cancellation amplitude to any desired value. So that specific carrier level can be set, S_1 transfers one of the balanced modulator carrier balance potentiometers (R_7) to a new potentiometer (R_{10}) which is set at the desired AM carrier amplitude. In practice, only a small amount of carrier is required to make speech very intelligible. Therefore, if a high-power linear amplifier is used to follow this exciter most of the benefits of single sideband can be achieved by inserting a small amount of carrier so that the output modulation is 400 to 500 percent. The carrier output is then small enough to cause little increase in plate dissipation in the linear amplifier tubes, but will be very readible on those 144-megacycle receivers which cannot receive single sideband due to the lack of a B.F.O.

In the AM mode the use of only one sideband — upper or lower — is not detrimental to reception. Normal AM can be accomplished by throwing the exciter into the double sideband mode.

For CW, unbalancing one of the balanced modulators through R_9 to an extent which drives the linear applifier to full output provides a CW carrier. Keying is accomplished in the cathode of the RF mixer (V_5) through J_2. In addition to unbalancing the carrier, it is also desirable in the CW mode to disconnect the output of the audio amplifier. This eliminates the possibility of transmitting inadvertently modulated CW. The mode switch (S_1) performs these functions.

POWER SUPPLY — Power requirements of the complete 144-megacycle SSB exciter are:

6.3 volts at 5 amperes for heaters;
plus 150 volts DC at 35 to 115 ma.;
plus 200 volts DC at 25 ma.;
plus 300 volts DC at 70 ma.;
minus 22 volts for grid bias.

To assure optimum and stable performance of the exciter, the plus 150, 200 and 300-volt DC supplies should be regulated. A suitable power supply constructed by the author for his exciter will be described in the following issue, September-October, 1962 (Vol. 17, No. 5).

CONSTRUCTION DETAILS — Most of the construction of the exciter is self-explanatory through the pictures and mechanical layouts. However, some details may not be obvious and are explained in detail.

The upper chassis was fabricated with open sides from 18-gauge (0.040-inch thick) sheet aluminum 11½x6½ inches. It is trimmed and folded as shown in the upper chassis layout drawing, Fig. 2. Drill holes for the tube sockets and other parts at the locations marked. Make two end plates 3x6½ inches from the same sheet stock and fasten them to the flanges on the ends with No. 8 sheet metal screws. Also make a shield partition and fasten it in place as shown in Fig. 2.

The main chassis is a standard 7x9x 2-inch type (*Bud* AC-406, or equivalent). Drill and punch holes as shown in the layout diagram for it, Fig. 3. Make shield partitions from 18-gauge aluminum at the locations shown by the dashed lines in Fig. 3, and the bottom view photo. Fit the shields in place and fasten them with No. 8 sheet metal screws.

Fasten the upper chassis down with No. 8 sheet metal screws driven up from the bottom side into the flanges on the bottom of the upper chassis. Also, punch the holes for the power sockets at the left rear corner.

The panel comes with the 8x12½x 8-inch deep cabinet (*Bud* C-1746, or equivalent) and is 8x10 inches in size. Drill and punch the panel as shown in the layout diagram of Fig. 4. The upper and lower chassis, the National MCN dial, and shields should all be assembled temporarily to check on proper alignment before beginning the mounting of parts and wiring.

UPPER CHASSIS — The upper chassis is divided into two sections. On the right hand side facing the front panel is the audio section separated by a shield from the variable crystal oscillator section. The audio section is constructed on Vector socket assemblies, with the exception of the phase shift networks. In the right side detail view on page 7, note that these networks were constructed on a Vector circuit board and suspended under the tube socket for V_{10}. This was convenient, since this tube feeds the audio transformers and the phase shift network. Behind the audio transformers is the plate relay (K_2) for the VOX. The entire VOX was built on a Vector socket assembly with a small terminal board attached to the base of the post on the socket for V_{11} to hold those components which would not fit on the post.

The sideband selector switch (S_2) is mounted through the front of the audio section chassis and passes through the front panel. The mode selector switch (S_2) is mounted directly on the front panel just above the top chassis. In the variable crystal oscillator section of the top chassis, the tuning capacitor (C_1) is mounted directly on the underside as seen in the left side detail view.

The National MCN dial is mounted inside the upper chassis with only the shaft going through the front panel. A small bracket to the left of the top chassis holds three potentiometers for adjustment of receiver gain for the anti-trip circuit (R_5), the CW amplitude (R_9), and the AM amplitude (R_{10}).

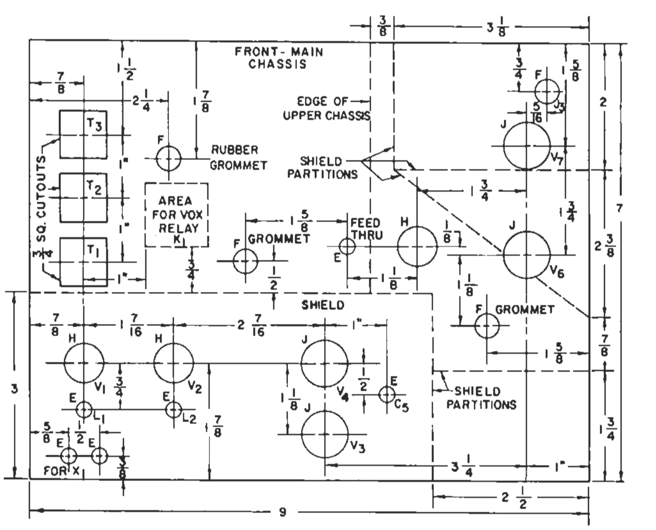


FIG. 3. MAIN CHASSIS layout drawing. Locations for shield partitions under chassis are shown by dashed lines. Upper chassis is fastened over the area indicated. Hole sizes are given in TABLE III — HOLE SIZE CHART.

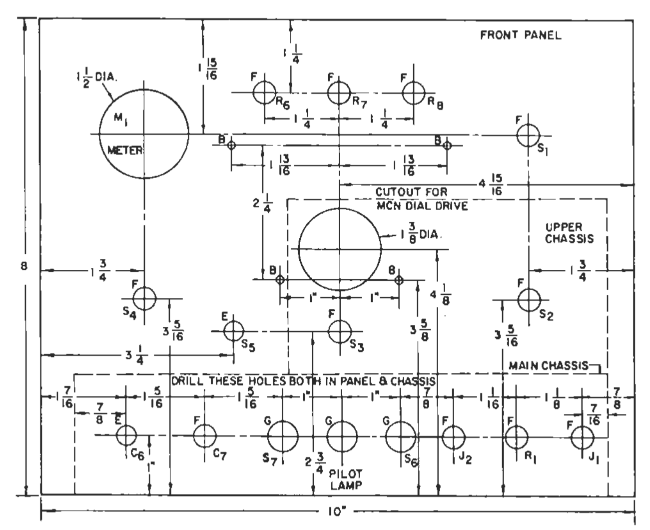
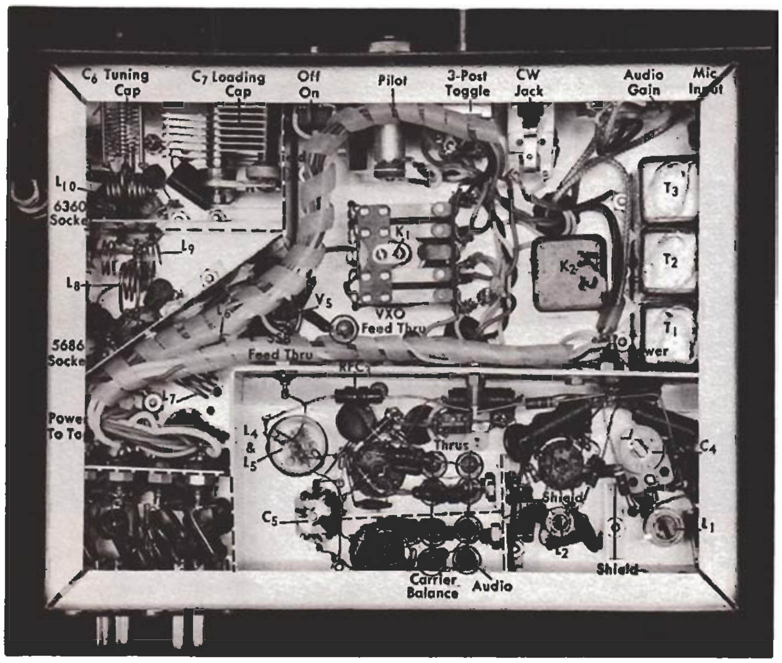


FIG. 4. FRONT PANEL layout diagram. Location of the main and upper sub-chassis are shown by dashed lines. Hole for the meter should be bored to fit the case of the particular meter used in construction.



BOTTOM VIEW of the exciter showing the locations of small parts and wiring. Sheet aluminum shields are fitted around the sideband generator and VHF RF sections of the exciter. Note the group of feedthrough capacitors and small RF chokes in the power lead filter compartment at the lower left.

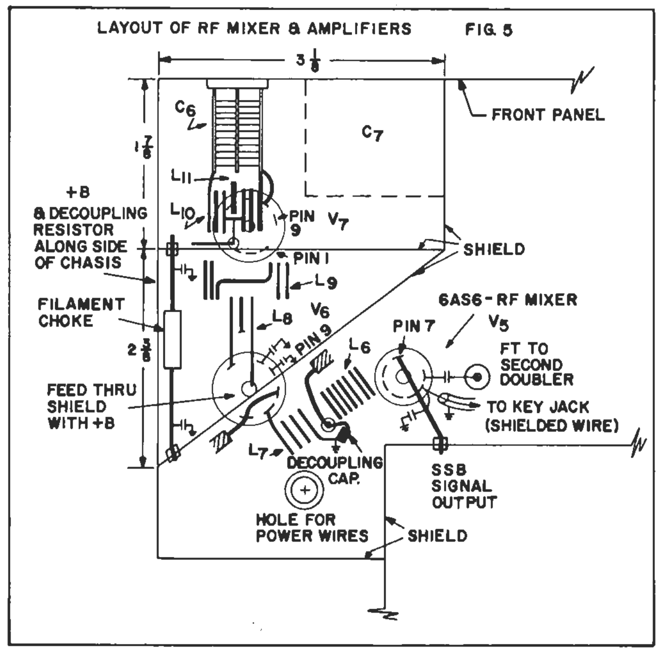


FIG. 5. VHF SECTION parts location diagram, for the mixer and amplifiers. This drawing is printed half actual size so that dimensions can be determined by measuring the diagram and multiplying by 2. All capacitors should have shortest possible leads. Connect 1500-pf. disc capacitors between all cathode and screen grid pins and chassis.

MAIN CHASSIS — The main chassis has four shielded areas. These consist of the single sideband generator, the RF assembly, the control section and the power plug section. Construction of the single sideband generator is seen in the bottom view. The output from the single sideband double balanced modulators (V_3 and V_4) passes through a feedthrough terminal in the shield directly to the suppressor grid pin of the RF mixer tube (V_5). The assembly of the 144-megacycle amplifier stages (V_6 and V_7) is detailed in the sketch of Fig. 5, in addition to the bottom view.

The control section in the middle of the main chassis contains the two relays, K_1 and K_2, plus the pilot light, control switches, key jack, and audio transformers. The power plug section compartment is filled with small RF chokes (RFC_3) and 1500-pf. ceramic feedthrough bypass capacitors mounted in the partition. These filters keep RF energy from leaking out of the exciter through the power leads.

The variable crystal oscillator will only be as stable as the frequency of the crystals. Because the crystal is operated in a parallel mode in which it is pulled from its normal operating frequency, it is more temperature sensitive than a normal crystal. Therefore, in order to insure good frequency stability as the exciter warms up two things must be done. The crystals must be mounted in an assembly as shown in the top view and preferably connected to the front panel by a metal strap in contact with the crystals to keep them at the temperature of the front panel.

This assembly is a simple aluminum frame which mounts on top of the crystal holders thereby providing thermal insulation from the upper chassis, and the aluminum frame reflects the radiant heat from the nearby tubes. Insulation around the crystal prevents additional heating. A metal strap which touches the metal portion of the crystal holder also helps keep the crystal at nearly constant temperature.

An alternate solution is to purchase a crystal oven and operate the crystal in this oven in place of the crystal sockets shown. Two crystal sockets are shown, but only one of the sockets, the one to the right facing the front panel, is connected. The other socket is a dummy in which to store the space crystal at the same temperature. To change to the second crystal, simply reverse them in their sockets.

OPERATION AND ADJUSTMENT — Before applying power to the exciter, all tubes should be pulled out of their sockets. Since some stages are only biased by grid current, if the oscillator or amplifiers are not operating properly some of the stages could be drawing excess current. Place the tubes in their sockets one at a time as the adjustment proceeds.

First adjust the transitron oscillator by removing the 3,900-ohm resistor across the inductor (L_1), removing the crystal and shorting out the socket. Set the variable capacitor (C_4) to approximately one-half of maximum capacity; and, with a grid dip meter tune the inductance to the 25-megacycle crystal frequency. Reconnect the 3,900-ohm resistor and place the crystal in its socket. Connect a vacuum tube volt meter (VTVM) on the control grid of the 6CB6 buffer and tune the variable capacitor (C_4) for maximum output voltage.

The next step is to adjust the plate coil (L_2) of the 6CB6 buffer by setting it to 25 megacycles with the grid-dip meter; it can then be repeaked later. The double balance modulator tank circuit (L_4-C_5), also should be tuned to 25 megacycles. The final SSB generator peaking can then be finished after the variable crystal oscillator and other RF stages have been adjusted. The final single sideband adjustments are made after 144-megacycle output is obtained by listening to the signal on a receiver covering the 144-megacycle band.

RF ADJUSTMENTS — Adjustment starts with the variable crystal oscillator (V_{12}). Insert the oscillator tube and the first doubler (V_{13}), then connect a high impedance volt meter — preferably a vacuum tube volt meter — on the grid of the first doubler. Switch the oscillator to *crystal* position, turn the tuning capacitor (C_1) to minimum capacitance and adjust the feedback capacitor (C_2) for maximum negative voltage on the first doubler grid. Then switch the VXO into the *variable* position. Tune the inductance (L_{16}) to minimum value and the negative temperature coefficient capacitor (C_3) to approximately one-half its maximum value. With the VTVM on the grid of the first doubler, tune C_1 across the band and determine if the oscillator is operating over its whole range. If not, adjust either L_{16} or C_3 or both, until the oscillator delivers equal voltage at the grid of V_{13} nearly to that in the crystal position across the band. Adjustment of the oscillator's tuning range is made by listening on the 144 megacycle receiver after the remainder of the rf section is operating.

Next, switch the VXO to *crystal* position, turn C_1 to minimum capacitance, and place the second doubler tube (V_{14}) in its socket. Connect the VTVM to the grid of the mixer stage (V_5) and adjust L_{13} for maximum negative voltage. If no signal voltage is read, adjust L_{14} and L_{15} until a signal is obtained on the mixer grid, then peak L_{13}, L_{14} and L_{15}. The VTVM on the grid of the mixer stage will probably affect the settings of L_{14} and L_{15}, but this will be peaked again later.

Next, remove the grid bias, screen and plate voltages to the 6360 (V_7) output tube. Connect the VTVM to the grid bias supply of the 6360. Then insert carrier by turning the carrier balance controls off center (they probably will be off balance anyway) and with an insulated tool, adjust L_6 by spreading or compressing the coil for maximum negative voltage on the grid of the 6360. Since the other inductors must also be adjusted the signal at L_9 may be low. If so, tentative adjustments of L_7, L_8 and L_9 can be made. After the inductors have been peaked try adjusting the coupling between L_6 and L_7, and L_8 and then L_9, for a maximum DC voltage of 18 to 25 volts at the grid of the 6360.

Then apply the screen, plate and bias voltages to the 6360 and connect a 50 ohm dummy load to the output connector, J_2. Then dip the plate current of the 6360 with C_6 and develop maximum RF signal out by adjusting the series loading capacitor (C_7). This is best accomplished by alternately switching the meter from plate current to RF voltage. The bias adjustment of the 6360 should be set to a no signal plate current of 20 Ma. (CW Key Open), and with a maximum unbalance of the signal sideband generator a plate current of 50 to 60 ma. will be drawn by the 6360.

VXO FREQUENCY ADJUSTMENT — Most 5955-kilocycle crystals will have a pulling range of 200 to 300 kilocycles at 144 megacycles. However, if L_{16} is set for maximum pulling, the frequency will not be very stable. Therefore, it is recommended that a pulling range of about 100 kilocycles be used. To make this adjustment, set the VXO to crystal position and (C_2) to minimum capacitance. This will result in the highest frequency that can be obtained. Next switch the oscillator to VXO position and usually the frequency will shift slightly lower. Now tune C_1 toward its maximum value and check the amount of frequency change. If it is too great, reduce the value of L_{16}, or if it is too small increase the value of L_{16}.

Upon setting the frequency range to the desired value a check of the output voltage of the oscillator should then be made by placing a VTVM on the grid of the 6AS6 mixer stage and tuning across the band. If the variation is greater than 2 to 1 it will be necessary to adjust the feedback capacitor, C_2. This adjustment will also change the tuning range, so it will be necessary to make several checks to set both the tuning range and keep the mixer grid voltage variation to a minimum.

SIDEBAND GENERATOR ADJUSTMENTS — To insure that all of the circuits are peaked correctly, the entire RF adjustment procedure should be repeated with the tuning capacitor (C_1) set to the center of the tuning band. The drive at the grid of the 6360 is best checked with the screen, plate and bias voltages removed.

Tune the exciter to a convenient frequency on the receiver (set for CW reception) and adjust the carrier balance potentiometers (R_5 and R_6) for minimum output after placing the mode switch in the suppressed carrier position. After adjusting the carrier balance and noting the frequency, set the sideband selector (S_2) to either upper or lower sideband, depending on which may be used the most. Assuming S_2 on upper sideband, insert a 1000-cycle audio tone into the audio input (J_1) from an audio signal generator. With the receiver still set for CW and maximum selectivity, carefully tune to both sides of the carrier. Both sidebands will appear as a tone 1,000 cycles on either side of the carrier frequency before it was suppressed.

Then adjusting for upper sideband, tune the receiver to the lowest frequency sideband, being careful to choose the first signal encountered on the low side of the carrier frequency. Other signals will appear which are second, third and fourth order harmonics of the injected 1,000-cycle signal. These will be suppressed by adjusting potentiometers R_7 and R_8 until the signal on the lower sideband is at minimum. Potentiometer R_2, the phasing adjustment, will not be centered, but will be near one end of the adjustment range.

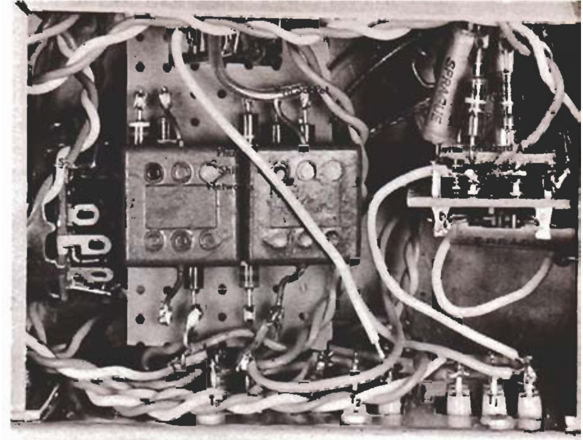
Now switch the receiver to AM, leaving the selectivity in its sharpest position and note the S meter reading. Carefully tune past the carrier toward the upper sideband and note its value on the S meter. If the receiver S meter is correctly calibrated the amount of suppression can be noted by comparing the relative readings of the upper and lower sidebands. Further adjustments are then made until the difference between upper and lower sideband is approximately 30 db, or 5 S units.

Now switch the sideband mode to lower sideband and tune the receiver — still in the AM position — from the lower to the upper sidebands. The lower sideband is now maximum and the upper sideband is suppressed. However, sideband suppression may not be as great in this position. This is not a fault of construction or design — it is simply characteristic of a phasing type sideband rig. Next, switch the sideband selector to double sideband and both sidebands should be approximately equal.

VOICE OPERATED CONTROL ADJUSTMENTS — By talking into the microphone at a normal level after making the previous adjustments on the sideband generator, increase potentiometer R_4 until the voice control relay picks up at a suitable level. Then with the microphone placed in the normal operating position, and receiver gain adjusted for normal speaker volume, adjust the anti-trip potentiometer (R_5), so that the receiver output does not operate the voice controlled relay. The hold-in time constant of the relay can then be adjusted as desired from the front panel adjustment marked VOX HOLD (R_6).

AM AND CW MODE ADJUSTMENT — Adjustment of the exciter in the CW and AM modes is best accomplished by determining the maximum CW input power of the linear amplifier if one is to be used. Simply place the mode selector switch on CW, close the key and increase the CW set potentiometer (R_9) until the linear amplifier is drawing full rated power input. This completes adjustment of the CW mode.

The amplitude modulated mode may then be adjusted by first switching to suppressed carrier and adjusting the audio gain control so that the linear amplifier is being driven to its normal output. Then switch to amplitude modulated mode and, without speaking, adjust the AM SET potentiometer (R_{10}) until the plate current drawn by the amplifier is approximately one-half of its rated value. The carrier is then set at one-fourth the maximum CW power output.



CLOSEUP VIEW of the audio phase-shift networks on terminal board inside right end of upper chassis unit. Terminals on T_1, T_2 and T_3 extend up from beneath the main chassis. When wiring sub-chassis, leave leads for making these connections after mounting upper unit.

Upon speaking into the microphone the input amplitude will then go up to its normal value or in other words ¾ of the power will then be transmitted bearing the speech. This adjustment is approximately 400 percent over modulation but as previously mentioned is very readable by almost any receiver. If normal AM is desired then the carrier should be increased by adjustment of potentiometer R_{10} until the final amplifier is drawing a plate current of two-thirds its maximum value. This provides 100 percent modulation.

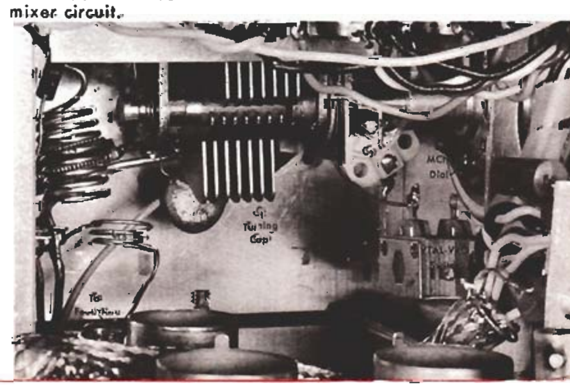
OPERATION — After completing the previous adjustments the power output is controlled by the audio gain control.

It may be found that for some crystals that the VXO will not oscillate if power is applied when the VXO is on variable tuning and the tuning capacitor (C_1) is near the low end of the range. Therefore, if this occurs it is recommended that the VXO be switched to crystal position and then returned to variable. This will start the oscillator.

The spotting switch (S_5) on the front panel applies power to exciter, with the exception of the RF amplifiers, therefore allowing the station receiver to hear the transmitter for zero-beat purposes.

Part II of this special report on VHF SSB will be published in the September-October 1962 issue of *G-E HAM NEWS*. It will contain circuit and construction details on a phasing type SSB generator which operates directly on 144 megacycles; circuit ideas for heterodyning SSB signals to 144 megacycles; a detailed discussion of the function of the transitron oscillator; and the circuit and construction data for the voltage-regulated power supply for the exciter in this issue.

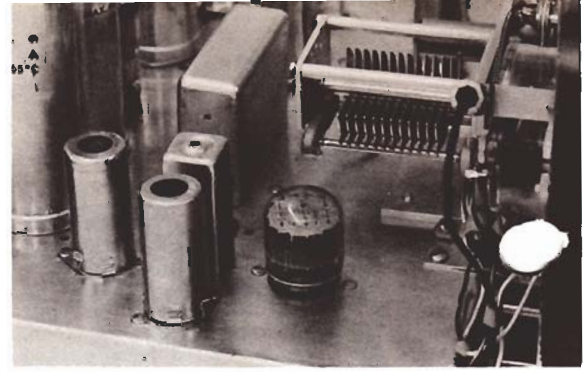
DETAIL VIEW of the VXO compartment in the upper chassis. The VXO-CRYSTAL switch (S_3) is below the coupling on the rear of the MCN tuning dial. Note the loose coupling between coils L_{14} and L_{15} in the second doubler-VHF mixer circuit.



G-E COMPACTRONS IN HAM GEAR

General Electric's new compactron multi-function receiving tubes are appearing in the latest amateur radio equipment now coming on the market. One of the first such equipments is the new *Hammarlund* HX-50 sideband transmitter. In it, a 6C10 triple-triode compactron (each section is similar to those in a 12AX7-A miniature twin triode) is used as the input audio amplifier, audio modulator for the balanced modulator, and the carrier oscillator. One triode section performs each of these three functions.

This is a good example of how G-E's new compactrons can simplify electronic equipment through combining functions usually performed by two or three conventional tubes into one compact envelope. A list of compactron types was published on page 8 of the January-February, 1962 issue (Vol. 17 No. 1) of *G-E HAM NEWS*. A supplement to this list containing a number of new types will be published in the September-October, 1962 issue.



6C10 TRIPLE TRIODE compactron in the new *Hammarlund* HX-50 Sideband transmitter.

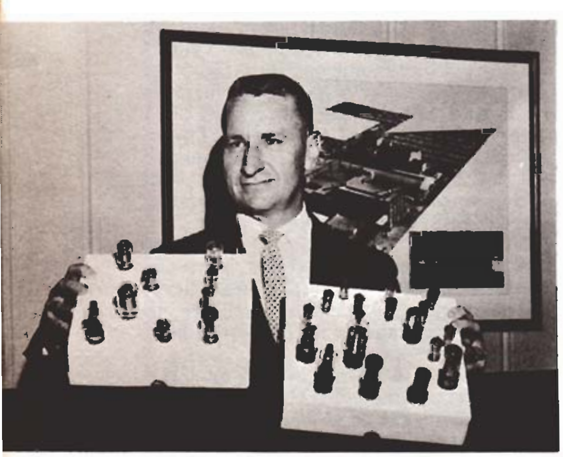
The HX-50 transmitter, incidentally, covers several 1-megacycle segments which include the 3.5, 7, 14, 21 and 28-megacycle amateur bands. It will run up to 130 watts P.E.P. input, and has all of the latest features.

NEW G-E COMPACTRONS SIMPLIFY TV

Radio amateurs have a dramatic demonstration of how General Electric's new line of compactron receiving tubes can simplify electronic equipment in the industry trend toward "compactronized" television receivers.

Tube complements in these new TV sets is reduced about one third through substituting multifunction compactrons for conventional receiving tubes in most circuits. Amateurs can expect the same degree of simplification in amateur radio equipment using compactrons.

In the latest line of General Electric television receivers, an average of 7 or 8 compactrons per chassis replaces 11 to 13 conventional tubes used in preceding models. A total of 19 compactrons replaces 30 tubes in the three basic chassis which go into all 23-inch table and console TV's: in the 19-inch "Designer" series, the 19-inch portable "Century" and "Celebrity" models; and the new lightweight, 22-pound 16-inch "Escort" model.



The photo below shows 8 compactrons and 1 standard tube (left) taking over the complement of the basic chassis of the 16-inch "Escort" portable TV. At the right are the 18 conventional tubes which comprised the tube complement in a typical TV basic chassis of several years ago.

Making the comparison is Christopher D. McCool, Home Convenience Products Design Engineering Manager of G-E's Receiving Tube Department, who spearheaded the compactron development program. Neither the power rectifier or tuner tubes are included in the examples.

The multi-function compactron types have many applications in equipment having a number of circuit functions — like the TV receivers described above. Amateur receivers sideband exciters and transceivers can be simplified with multi-function compactrons in the small signal circuits. And, horizontal sweep type power compactrons are available to perform the tasks to which conventional sweep tubes are usually assigned in amateur radio gear.

G-E HAM NEWS plans to publish articles on "compactronized" equipment for the home constructor in coming issues. Watch for them!

G-E VHF FM GEAR AT K7USA

The VHF FM stations on the 50 and 144-megacycle bands at K7USA the amateur radio station at the Century 21 exhibition in Seattle have been furnished by General Electric's Communication Products Department located in Lynchburg Va.

The 80-watt deck-type base stations, the same as supplied to hundreds of commercial VHF communications users, operate on the national amateur FM calling frequencies of 52.525 and 146-146.940 megacycles. In addition, frequencies of 146.580, 146.760 and 147.330 megacycles are available for casual operating to keep the calling frequencies clear.

If you are planning to attend the Century 21 exhibition in Seattle this summer, and have VHF FM mobile equipment in your car, be sure to take along crystals which cover the above channels so that you can contact K7USA.

G-E TUBES HAM NEWS

Available FREE from your G-E Tube Distributor

JULY-AUGUST, 1962
Vol. 17, No. 4