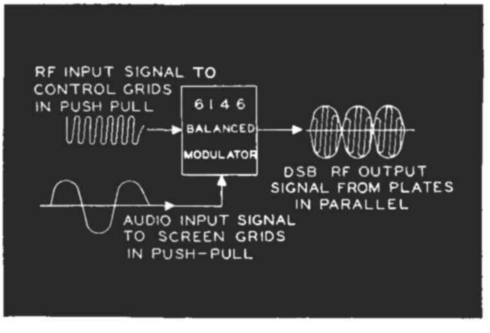
HAM NEWS

MAY–JUNE, 1959



In This Issue . . .

200-watt

DOUBLE SIDEBANDER

Our DOUBLE SIDEBAND JUNIOR article a year ago sparked much interest in a more powerful double sideband transmitter with bandswitching. Now several radio amateurs at General Electric have combined their ideas in this transmitter with 200-watt peak power input capability from a pair of 6146 beam pentodes in the output stage. The complete circuit, and constructional details on the plug-in r.f. unit, is in this issue. Part II, in the July–August, 1959 issue, describes the main chassis containing audio system, power supplies and control circuits.

—Lighthouse Larry

SCANNING the SPECTRUM

TALK ABOUT DX RECORDS—our tiny 7077 microminiature ceramic receiving tube has established a "universe record" for long-distance communications—407,000 miles!

And this was accomplished with milliwatts—not kilowatts—of r.f. power at 960.05 megacycles. A 7077 delivered 180 to 250 milliwatts as a class B final amplifier in the transmitter of the Pioneer IV satellite now hurtling in orbit about the sun. Strong signals from the transmitter were recorded for more than three days.

The 10- to 15-milliwatt transistorized exciter was thus amplified nearly 20-fold by the 7077, producing sufficient power to permit use of 960 megacycles for tracking and telemetering. This frequency is much less subject to bending and reflection by the Earth's ionized layers than 108 megacycles.

An exact duplicate of the record-breaking transmitter was displayed in General Electric's receiving tube exhibit at the 1959 IRE convention and show in New York City.

The 7077, first in a family of G-E ceramic receiving tubes, also is an excellent r.f. amplifier tube for the VHF and UHF amateur bands. See the January-February, 1959 issue of *G-E HAM NEWS* for details on r.f. amplifiers for 144 and 432 megacycles.

From one of our GADGET RACK[1] series authors comes the hint that a two- or three-foot extension cord is very handy for testing accessory units before installing them in the rack. Simply cut 11 lengths of the same types of wire shown for the bus-bar interconnecting system in the schematic diagram, solder them into an 11-pin male octal plug (Amphenol 86-PM11), and add an 11-pin female socket (Amphenol 78-PF11) on the other end. In fact, it's almost a necessity for aligning our CONEL MONITOR receiver[2]. If you're building a GADGET RACK, be sure and make the extension cord too.

[1]See G-E HAM NEWS, September-October, 1958 (Vol. 13 No. 5) and November-December, 1958 (Vol. 13, No. 6), for details.

[2]A 5-tube broadcast band receiver designed specifically for Conelrad monitoring service in the amateur station.

FOR YOUR ELECTRONICS' BOOKSHELF . . .

Here's the latest in reference and instructional publications—packed with useful information for radio amateurs—which should be in your bookcase and the reference library at your local radio club.

THE RADIO AMATEUR'S HANDBOOK—The 36th edition of this volume—now well on its way toward a total of four million copies in thirty years—carries on the tradition of being the "amateur's Bible." All chapters in the book have been updated to include the latest in design and contructional techniques. Published by the American Radio Relay League, its reputation speaks for itself.

ALSO FROM A.R.R.L.—A second printing of the 8th edition of their ***Antenna Book*** includes the latest in mobile and beam antenna systems, in addition to comprehensive background information on antennas and transmission lines.

RADIO HANDBOOK—A completely new 15th edition of this renown handbook by William I. Orr, W6SAI, contains, in 800 pages, undoubtedly the most complete collection of constructional projects ever offered the radio amateur. This, of course, is in addition to chapters of technical background, excellent circuit design information on both basic and the latest techniques. And if you don't see exactly the gear you wish to build in the 15th edition, try looking in Bill's 14th edition. It's still available and has enough build-it-yourself data to last a lifetime.

FOR SIDEBANDERS—The ***New Sideband Handbook***, by Don Stoner, W6TNS, contains a wealth of information on both home constructed and commercial sideband equipment for radio amateurs. Much of the special circuitry from the commercial rigs is explained in detail, making it easy to incorporate these ideas into your own sideband rig. In short, it covers sideband from double down to single and back again!

A PAIR OF HANDBOOKS—Especially written for the newcomer to amateur radio, ***Building the Amateur Radio Station*** and ***Getting Started in Amateur Radio***, these books are all-inclusive guides to their titular subjects. The author, Julius Benens, W2PIK, has described home-built receivers and transmitters, and some popular commercial amateur gear in the first book. The second volume contains complete instructions for learning the code and studying for Novice and General class amateur licenses. Twenty-seven pages of excerpts from the U.S. Communications Act of 1934 will answer virtually every question likely to arise concerning FCC regulations. Both books are published by the John F. Rider Publishers, Inc.

THE PUBLICATIONS described above should be available through book stores and many distributors of electronic components, including our G-E Tube distributors.

—*Lighthouse Larry*

200-watt

DOUBLE SIDEBANDER

Part I

THIS DOUBLE SIDEBAND transmitter is packed with ingenious circuits and construction features. Try them!

THE DOUBLE SIDEBANDER was designed specifically for this mode of transmission; and, in fact, was a prototype for military double sideband and synchronous communications equipment. The frequency coverage is continuous from 2 to 30 megacycles in four bands. It has a peak power output, with sine-wave modulation, of 150 and 120 watts at 2 and 30 megacycles, respectively.

THE R.F. SECTION of the transmitter—a separately shielded and filtered unit—employs an oscillator-driver-final circuit arrangement as shown in the schematic diagram, FIG. 1. All transmitter stages are provided with protective bias to prevent damage to the tubes in the absence of excitation. In the oscillator and driver stages cathode self-bias give the necessary protection. The final stage protective circuit removes its high voltage if the r.f. drive fails.

Switch $S1_A$ in the grid circuit of the 6AH6 oscillator stage provides selection of one of the four crystals or the V.F.O. input as the frequency source. With $S1_A$ in the V.F.O. position the 6AH6 is employed as a Class A amplifier. An input from a V.F.O. of 0.5 to 1 volt r.m.s. will excite the driver stage.

All frequency multiplying is accomplished in the oscillator and the 6CL6 driver always operates as a straight amplifier. Since the pi network in the 6146 balanced modulator plate acts as a low-pass filter, sub-harmonics of the carrier frequency may appear in the transmitter output if the driver stage is operated as a frequency multiplier.

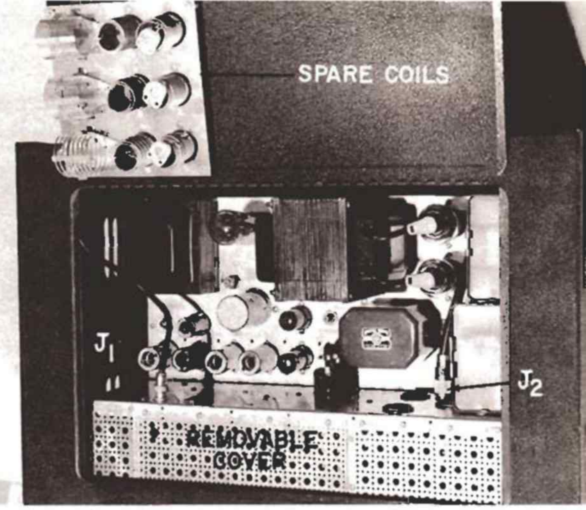
Careful circuit layout and complete r.f. bypassing stabilize the driver stage. The 15,000-ohm, 4-watt potentiometer ("PA GRID DRIVE") adjusts the 6CL6 screen voltage and, in turn, its r.f. power output.

The 6146 balanced modulator stage has the usual push-pull control grids, push-pull screen grids and paralleled plates described in several previous double sideband transmitter articles.[1] The pi-network plate circuit is designed for a 50-ohm output, but will load into impedances up to 300 ohms.

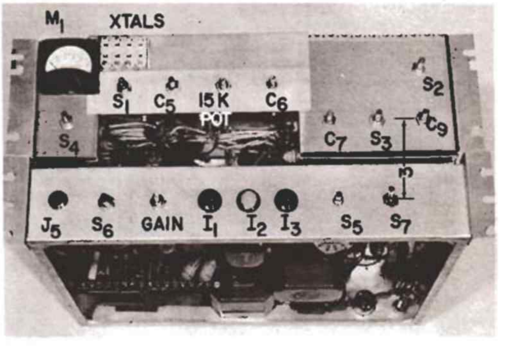
THE MODULATOR SECTION is designed for use with a low-level, high-impedance microphone (crystal, ceramic or dynamic). Low impedance microphones will require a matching transformer. The preamplifier stage (V_7) has a push-to-talk feature that cuts off the second section until closing the microphone switch greatly reduces the cathode bias. A twin diode tube (V_9) serves as an audio peak clipper. The next tube (V_8) is a matching device for the maxially-flat (Butterworth) L/C 3,000-cycle low-pass filter.

A 400-cycle phase-shift R/C sine wave oscillator (V_{10B}) and a split-load phase audio phase inverter (V_{10A}) precede the push-pull driver (V_{11}). The modulator tube (V_{12}) provides about 300 volts peak on each screen grid of the 6146 balanced modulator stage. About 8 decibels of inverse feedback in the driver and modulator stages improves balance and linearity in the 6146 stage.

(continued on page 6)

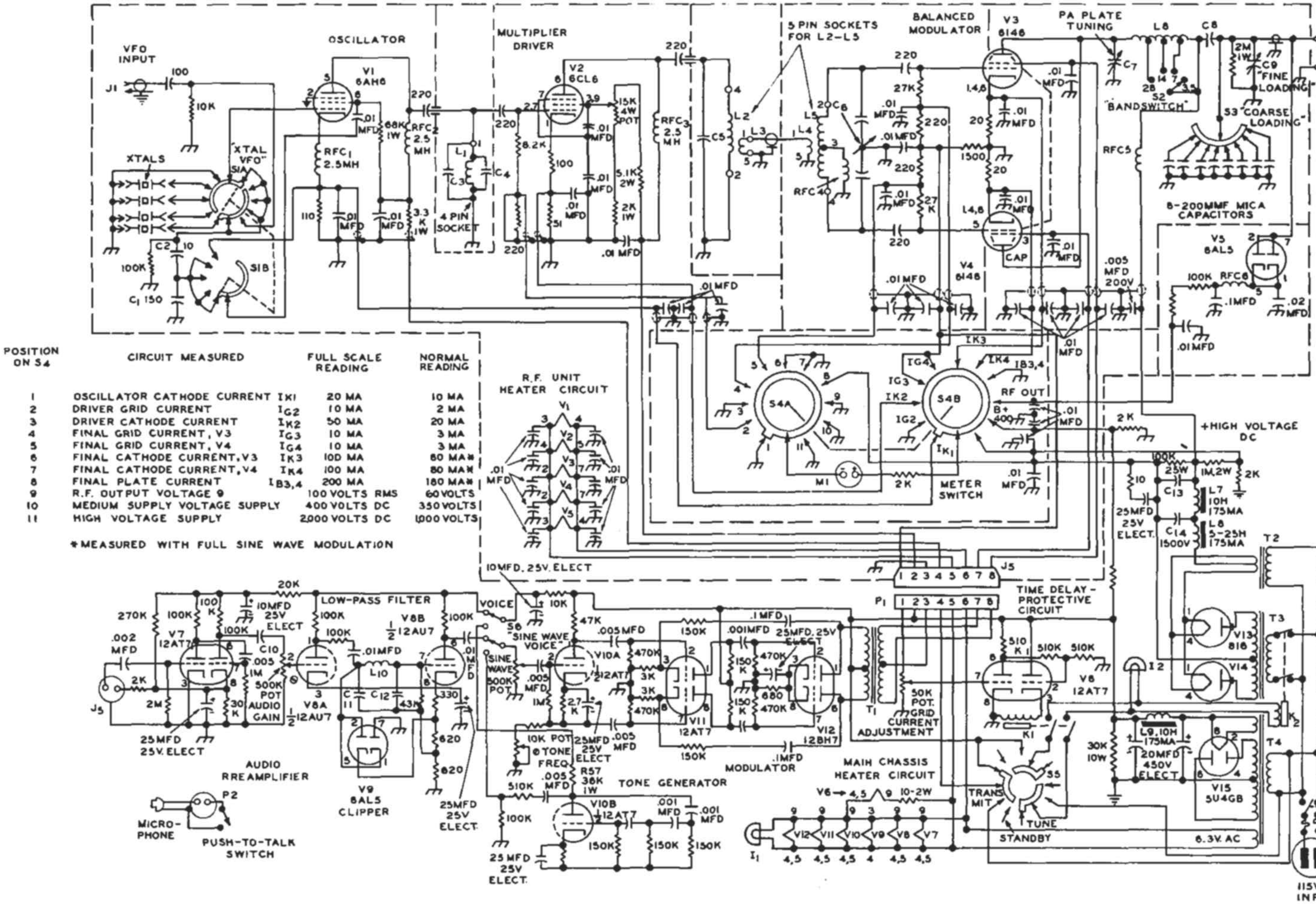


THE TRANSMITTER CABINET with the top lid open, showing the shielded r.f. compartment in the front, audio section in the middle and power supplied at the rear. Note the method of storing spare plug-in coils on an aluminum plate, on which 4 and 5-pin sockets have been mounted. Coils are changed in the exciter simply by removing four self-tapping screws which hold the shield at left-center in place.



FRONT VIEW OF THE TRANSMITTER with cabinet and panel removed. The separate chassis containing the r.f. and metering section plugs into the main chassis, containing the remaining circuits.

[1]See *G-E HAM NEWS*, March - April, 1959, for a bibliography of articles on double sideband techniques.



POSITION ON S4	CIRCUIT MEASURED		FULL SCALE READING	NORMAL READING
1	OSCILLATOR CATHODE CURRENT	I_{K1}	20 MA	10 MA
2	DRIVER GRID CURRENT	I_{G2}	10 MA	2 MA
3	DRIVER CATHODE CURRENT	I_{K2}	50 MA	20 MA
4	FINAL GRID CURRENT, V3	I_{G3}	10 MA	3 MA
5	FINAL GRID CURRENT, V4	I_{G4}	10 MA	3 MA
6	FINAL CATHODE CURRENT, V3	I_{K3}	100 MA	80 MA*
7	FINAL CATHODE CURRENT, V4	I_{K4}	100 MA	80 MA*
8	FINAL PLATE CURRENT	$I_{B3,4}$	200 MA	180 MA*
9	R.F. OUTPUT VOLTAGE 9		100 VOLTS RMS	60 VOLTS
10	MEDIUM SUPPLY VOLTAGE SUPPLY		400 VOLTS DC	350 VOLTS
11	HIGH VOLTAGE SUPPLY		2,000 VOLTS DC	1,000 VOLTS

*MEASURED WITH FULL SINE WAVE MODULATION

PARTS LIST—200 WATT DOUBLE SIDEBANDER

C_1 . . . . 150-mmf mica, 500-volt rating.
C_2 . . . . 10-mmf mica, 500 volt (change value if crystal is erratic).
C_3 . . . . 500-volt, 10 percent mica mounted in L_1; (See coil table for values).
C_4 . . . . 3—30-mmf midget ceramic trimmers mounted on L_1.
C_5 . . . . 6—142-mmf variable, 0.020-inch air gap (Hammarlund HFA-140-A).
C_6 . . . . 6—142-mmf per section, 2-section variable (Hammarlund HFD-140).
C_7 . . . . 10—200-mmf variable, 0.024-inch air gap (Hammarlund MC-200-M).
C_8 . . . . 0.001-mfd, 2500-volt mica (0.001-mfd, 5000-volt ceramic also suitable).
C_9 . . . . 13.5—325-mmf air variable, 0.24-inch air gap (Hammarlund MC-325-M).
C_{10} . . . . 82-mmf, 500-volt mica (Change value to suit audio response).
C_{11} . . . . 0.0018-mfd, 500-volt mica (Value determines cutoff frequency of filter).
C_{12} . . . . 620-mmf, 500-volt mica (Value determines cutoff freqeuncy of filter).
C_{13}, C_{14} . . . . 8-mfd, 1500-volt oil-filled paper capacitors.
F_1, F_2 . . . . 5-ampere type AGC fuses and holders.
I_1 . . . . 6.3-volt pilot lamp and jeweled bracket.
I_2 . . . . 115-volt pilot lamp and jeweled bracket.
J_1, J_2 . . . . chassis type coaxial cable connectors (SO-239).
J_3 . . . . chassis type 2-pin recessed male power connector.
J_4 . . . . chassis type 8-pin male power connector (Jones P-308-AB).
J_5 . . . . chassis type 2-pin female microphone connector (Amphenol 80-PC2F).
K_1 . . . . 2-pole, 2 position sensitive relay, 2-ampere contacts, 10,000-ohm coil with 3- to 5-ma energizing current (Potter & Brumfield LM-11 or KCP-11).
K_2 . . . . 2-pole, 2-position power relay, 5-ampere contacts, 115-volt, 60-cycle coil.
L_7, L_9 . . . . 10 henry, 175-milliampere smoothing filter choke.
L_8 . . . . 5—25 henry, 175-milliampere swinging filter choke.
L_{10} . . . . 3 henry, iron core inductance (toroidal type core preferable).
M_1 . . . . 0—1-milliampere panel meter, 2½ inches square (G.E. DW-71 or DW-91).
P_1 . . . . 8-pin cable type female power connector (Jones S-308-CCT).
RFC_1, RFC_2, RFC_3, RFC_4 . . . . 2.5-mh, 100-ma r.f. choke (National R-100).
RFC_5 . . . . 2.5-mh, 300-ma r.f. choke (National R-300 or equivalent).
S_1 . . . . 3-pole, 5-position, 2-section ceramic rotary tap switch (Centralab 2515).
S_2 . . . . 1-pole, 4-position, 1-section 90-degree ceramic-insulated rotary tap switch, (Centralab No. 2542 or equivalent).
S_3 . . . . 1-pole, 10-position, 1-section, progressive shorting ceramic-insulated rotary tap switch (Centralab P1-S wafer and P-121 index assembly).
S_4 . . . . 2-pole, 11-position, 2-section rotary tap switch (Centralab 1413).
S_5 . . . . 3-pole, 3-position, 1-section rotary tap switch (Centralab 1407).
S_6 . . . . 2-pole, 2-position, 1-section rotary tap switch (Centralab 3122J).
S_7 . . . . 2-pole, 2-position heavy duty toggle switch.
T_1 . . . . audio driver transformer; turns ratio, primary to ½ secondary: 4 to 5. (Use primary of transformer as secondary in this application.)
T_2 . . . . filament transformer: secondary, 2.5 volts at 5 amperes; 115-volt primary.
T_3 . . . . plate transformer: 2400 volts, center tapped at 150 ma; 115-volt primary.
T_4 . . . . power transformer: secondaries, 700 volts center tapped at 150 ma; 5 volts at 3 amperes; 6.3 volts at 6 amperes; 115-volt primary.

FIG. 1. COMPLETE SCHEMATIC DIAGRAM of the 200-watt double sideband transmitter. The r.f. circuit runs across the top of the diagram, with the meter switching circuit below it. The audio system is at the lower left and the power supplies at the lower right. The 12AT7 time delay-protective tube is just to the left of the power supplies.

All capacitances are in mmf, except where otherwise specified. All r.f. coupling capacitors and the 200-mmf mica capacitors on S_3 are micas. All 0.01-mfd bypass capacitors are disc ceramic, 1000 volts working, unless otherwise noted. Resistances are in ohms (K=1000; MEG=1,000,000), ½-watt power rating, unless a higher rating is specified.

Data for winding all the r.f. coils (L_1 to L_6) appears in the COIL TABLE below. The tube types for V_1 to V_{15} appear on the diagram. Shielded wires are indicated by dotted loops encircling the wire. Shielding around r.f. circuitry is shown in dashed lines.

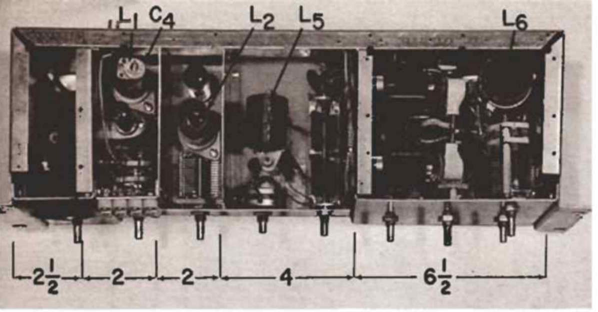
TABLE I—COIL WINDING DATA

NOTE: All coils are wound with tinned copper wire in the sizes specified below.

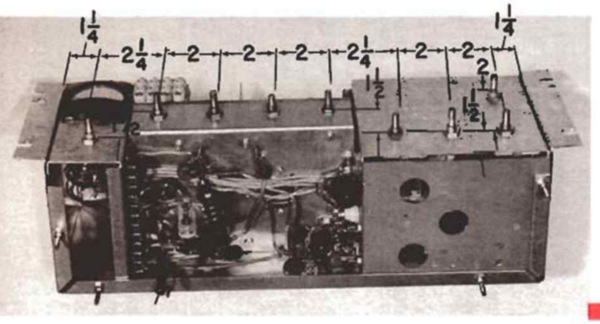
L_1 . . . . wound on 1-inch diameter, 4-pin plug-in forms. Winding length is 1 inch. Capacitors C_3 and C_4 are mounted inside each coil form.
L_2 . . . . wound on 1-inch diameter, 5-pin plug-in forms. Winding length is 1 inch. Link coil L_3 wound at grounded end of L_2 on each form.
L_4, L_5 . . . . B & W "Baby" inductors, center tapped with center link coils, and 5-pin bose.
L_6 . . . . 10.5 uh total, 28 turns 1½ inches in diameter, 4 inches long. Wound with 22 turns of No. 12 (7 turns per inch) and 6 turns of No. 10 (5 turns per inch) tinned copper wire, tapped at 6, 9 and 15 turns from the end with No. 10 wire.

	L_1 and L_2			L_2 Only		L_1	L_4 & L_5	L_6 Output Coil	
Band, MC	Ind., uh.	Turns	Wire Size	Turns, L_3	Wire Size	C_3 mmf.	B & W Number	Turns in Use	Ind., uh.
3.5	17.4	31	24	3	16	82	80MCL-2925	28	10.5
7	4.6	16	18	3	16	68	40MCL-2924	15	5
14	1.4	8	16	2	14	56	20MCL-2923	9	2.4
21[1]	0.75	6	16	—	—	39	——	—	—
28	0.45	4	14	2	14	27	10MCL-2921	6	1.3

[1]28-megacycle coils tune to the 21-megacycle band. A separate 21-megacycle oscillator coil (L_1) is required only when crystals oscillating at this frequency, or a VFO having output at 21 megacycles, are used with transmitter.



TOP VIEW of the r.f. unit with shield covers removed. Note shielding partitions between stages and horizontal mounting of 6146 tubes on shield to isolate grid and plate circuits in the balanced modulator output stage. Main chassis is a 5¼-inch high panel chassis designed for relay rack mounting (Bud CB-1372, or equivalent.



BOTTOM VIEW *of the r.f. unit. The four banana plugs* on the lower rim of the chassis plug into matching jacks on the main chassis. High voltage for the 6146's enters the r.f. unit via a Millen 37001 high voltage connector and the white feed-through insulator on the 6146 compartment shield. The phone-tip jack at the lower left is for plate voltage to the oscillator. Two phono plugs, connected to the row of feedthrough terminals on the meter compartment, are for the 400 and 2000-volt metering circuits. Note the liberal use of 0.01-mfd disc ceramics bypass capacitors and shielded wire for the power and metering circuits.

DOUBLE SIDEBANDER

(continued from page 3)

Both power supplies are of conventional design. The high voltage supply is rated at 1000 volts DC at 145 milliamperes; and the low voltage supply delivers 360 volts DC at 110 milliamperes, both continuous duty.

ADDITIONAL CIRCUITRY on the schematic diagram includes the power supply time delay and 6146 protective circuit. A 10-ohm resistor in series with the heater to this tube (V_6) increases its heating time. This prevents application of high voltage to the 816 mercury vapor rectifiers (V_{13} and V_{14}) for 30 seconds and allows their filaments to reach operating temperature.

When no r.f. drive is applied to the 6146's the left-hand triode of V_6 has no negative bias and draws sufficient plate current through its 500,000-ohm plate resistor to nearly cut off plate current in the right-hand triode. Application of sufficient r.f. drive to the 6146's reduces plate current flow in the left-hand section of V_6. This swings the grid of the right-hand section more positive, resulting in increased plate current flow which energizes relay K_1. This in turn energizes K_2, if S_5 is in the "TRANSMIT" position, and applies primary voltage to T_3.

METERING OF ELEVEN CIRCUITS in the transmitter is accomplished with a single 0–1-milliampere meter (M_1) and the meter switch (S_4). Switch positions—and the full-scale current or voltage reading in each position—are listed on the schematic diagram. The meter measures current by reading the voltage drop (2 volts for full-scale reading) across resistances in series with the various grid and cathode circuits.

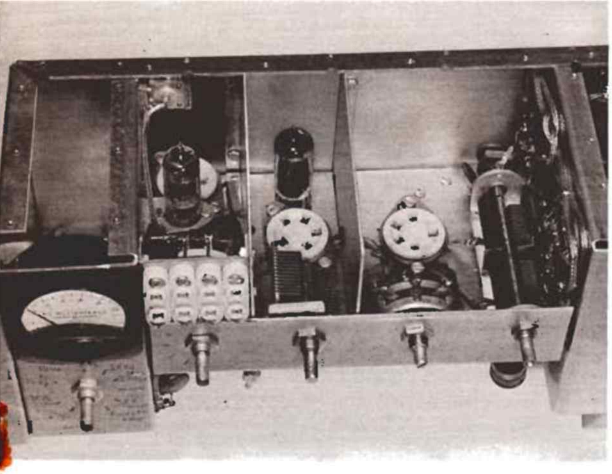
Tube V_5 and its circuitry form a peak detector for measuring the r.f. output voltage of the transmitter. Since the meter reads 0.707 of the peak voltage, the average r.f. power output with sine-wave modulation can be calculated, if the transmitter is operated into a non-reactive load of known impedance.

MECHANICAL LAYOUT of the r.f. unit can be determined from the pictures and explanations accompanying them. Locations of the major components and approximate dimensions have been marked on each view. The usual modern r.f. construction practices have been followed: shielding, both over-all and between stages; shielded wire for all power and metering circuit connections; liberal use of bypass capacitors, etc.

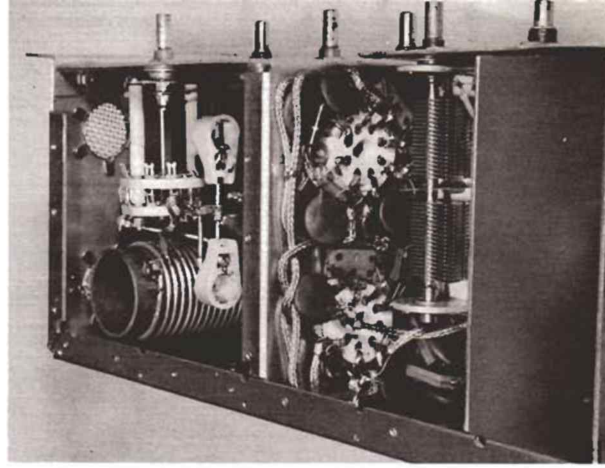
Locations of the holes for the four banana plugs, shown in the bottom view, should be marked on the main chassis to insure proper alignment. Partitions and subchassis can be fastened in place with self-tapping screws; this is much easier than attempting assembly of nuts on machine screws in tight corners! The oscillator tube sits on a small angle bracket fastened to the partition between that stage and the metering compartment.

The oscillator plug-in coils (L_1) are assembled by first soldering two lengths of No. 14 tinned wire into pins 1 and 4 before winding the coil. Next the coil leads and C_3 are soldered to the wires. Finally, C_4 is soldered to the wires at the open end of the form.

TUNE-UP AND OPERATION will be described in this issue—since frequent reference is made to the schematic diagram—even though constructional details for the main chassis will be covered in the next issue. (In other words, we're tuning up the rig before you've finished building it—Ed.) The procedure is similar to any transmitter having class C amplifiers, with one exception: It is necessary to modulate the 6146 stage to obtain r.f. output.



DETAIL VIEW of the wiring around the 6146 balanced modulator tube sockets. The standard technique of bypassing the ends of shielded wire hos been used. The 6146 plate caps were joined with No. 12 tinned wire, then connected with thin copper strips to the circuit components shown in the schematic diagram, FIG. 1.



EXCITER COMPARTMENTS in the r.f. unit. Plug-in coils have been removed to show the coil sockets mounted on metal pillars ¾ of an inch high. All partitions and shelves were fabricated from 1/16-inch thick soft sheet aluminum. The crystal sockets were mounted on a bracket drilled to match the socket holes.

After the usual check to see that all circuits have been wired correctly, plug in the power cord, the set of coils for the desired amateur band and turn the pi-network bandswitch (S_2) to the same position. Insert a crystal of proper frequency, or connect a stable VFO to J_1 and turn S_1 to the proper position. Connect a microphone to J_5 and a 50-ohm dummy antenna load to J_2.

Turn S_7 to the "ON" position and S_5 to the "TUNE" position. With S_4 in position 2, tune C_4 (on the oscillator coil form) with a screwdriver until about 2 to 3 milliamperes of grid current is indicated in the driver stage. Detune this capacitor slightly if the grid current exceeds 4 milliamperes.

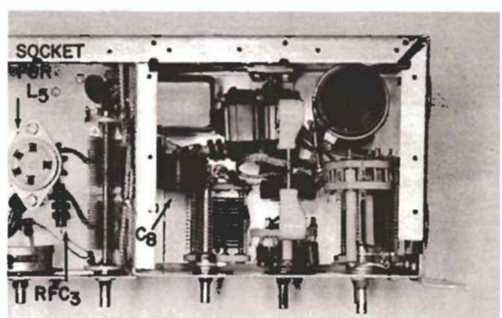
Next, turn S_4 to position 3 and tune C_5 for a dip in driver cathode current. Turn S_4 to positions 4 and 5, and adjust C_6 for maximum grid current in the 6146 balanced modulator. Adjust the "PA GRID DRIVE" control for a reading of 3 milliamperes in each 6146. Now, turn the "GRID CURRENT ADJUSTMENT" potentiometer until relays K_1 and K_2 energize, as indicated by I_2 lighting. Turn the "PA GRID DRIVE" control until the 6146 grid current decreases to 2 milliamperes and again adjust the "GRID CURRENT ADJUSTMENT" until K_1 and K_2 open. The 6146 protective circuit is now adjusted.

To tune up the 6146 balanced modulator, set S_4 on position 6, S_5 on "TRANSMIT" and S_6 on "SINE WAVE." Advance the "MOD. LEVEL" potentiometer (on main chassis) until the 6146 cathode current meter reading increases to 30 milliamperes. Tune C_7 for a dip in plate current. Turn S_4 to position 9 and adjust the "COARSE LOADING" (S_8) and "FINE LOADING" (C_9) controls for maximum output voltage on the meter. Readjust C_7 as necessary for maximum output.

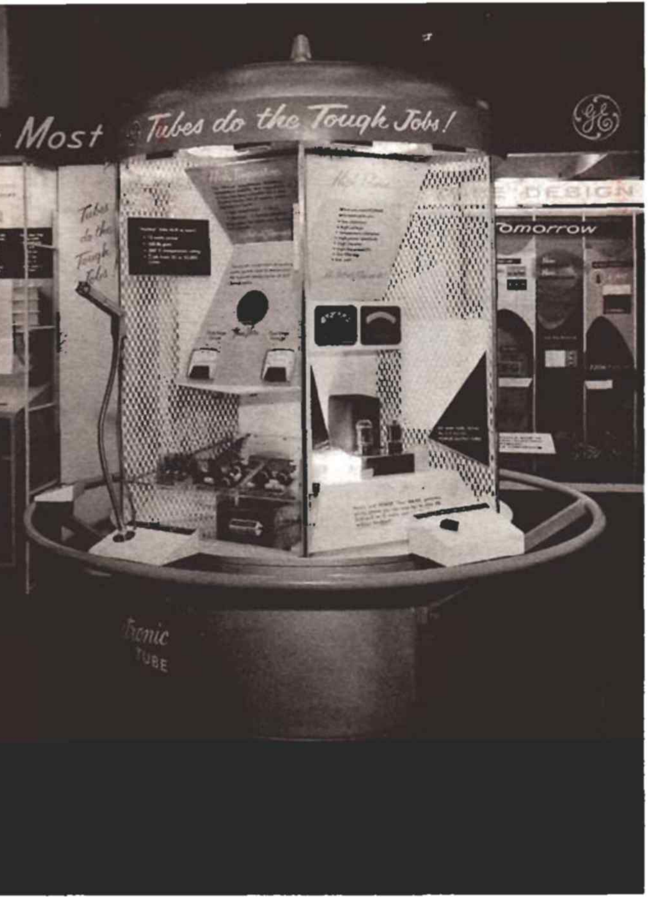
Further advance the "MOD. LEVEL" control slowly to the setting at which little further increase in power output is indicated on the meter. Note this meter reading at which the balanced modulator begins to "flatten out." Next, turn S_6 to the "VOICE" position and adjust the "MOD. LEVEL" control, while talking or whistling into the microphone, until the *peak* output voltage reading on the meter reaches the maximum level noted with sine wave modulation.

Adjustment of the "AUDIO GAIN" and "CLIPPING LEVEL" controls is best made while listening to the transmitter signal, in addition to checking it for flattening of peaks on an oscilloscope. Too much clipping will introduce serious distortion. The "AUDIO GAIN" control setting will depend upon the sensitivity of the microphone and amount of room background noise in the shack.

(Part II will appear in the July-August, 1959 issue.)



TOP VIEW of the 6146 compartment showing the positions of smaller components near the switches, capacitors and coils. The bandswitch, S_2, was modified by adding longer side rods and spacers to shorten the connections to L_6. This compartment was assembled before being fastened to the main r.f. chassis.



7-FOOT G-E TUBE

At 1959 IRE Show

Many radio amateurs were intrigued by this *king-size* "miniature" tube—7 feet tall and 4 feet in diameter—at the 1959 IRE convention and electronics show last March at the New York Coliseum. The tube—actually a display of six basic demonstrations of the outstanding characteristics of receiving tubes—was part of General Electric's receiving tube exhibit at the show.

Based on the theme, "Tubes Do the Tough Jobs," the demonstrations included: ***High temperature tubes***—An all-ceramic tube 15-watt audio amplifier featuring types being developed to withstand temperatures of 300 degrees centigrade, and termed "the hottest little Hi-Fi in town" (left); ***High power tubes***—A pair of latest type power output tubes—6L6-GC's—delivering 55 watts output in class AB_1 audio amplifier service, with less than 2 percent total harmonic distortion (right).

The other four demonstrations were based on receiving tube reliability, high frequency performance, high voltage capability and uniformity. Viewers could actuate each display with handy controls.

HAM NEWS

Available FREE from your G-E Tube Distributor

MAY–JUNE, 1959

VOL. 14—NO. 3

E. A. Neal, W2JZK—Editor

BUILD-IT-YOURSELF IDEAS

from the 999 radio amateurs at

GENERAL ELECTRIC

published bi-monthly by

RECEIVING TUBE DEPARTMENT

Owensboro, Ky.