GE TUBES HAM NEWS

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KCS COMPACTRON AMATEUR BAND RECEIVER

Part I—Design and Electrical Circuitry

By Norman L. Morgan, W7KCS/9

W7KCS/9 TRIES OUT his new receiver in actual operation on the 14-megacycle band after completing adjustments. Norm devoted a year to the design, construction and optimizing of circuits in this receiver to assure top-notch performance. Transmitter beneath receiver is also home-constructed, and runs 250 watts input on CW and AM phone. Norm is an experienced author; his previous article in G-E HAM NEWS, "Transmitter Protective Circuitry," was published in the September-October, 1961 issue. He also has written several articles on electronic control circuitry for electrical industry magazines. W7KCS/9 is an application engineer with General Electric's Specialty Motor Department, in Fort Wayne, Indiana. His department, as the name indicates, produces large quantities of special electric motors for appliances, portable power tools, and innumerable types of electrical industrial equipment.

Part II — Construction, alignment and operation, will appear in the Spring, 1963 Issue. Complete fabrication details for all home-made special parts will be included.

FEATURES —

- **4 Compactrons perform 10 functions**
- **Double-conversion superhetrodyne**
- **Crystal-controlled HF oscillator**
- **Accurate tuning dial calibration**
- **2-Kilocycle selectivity for SSB**
- **High-stability tunable oscillator**
- **Tunes 8-500-kilocycle segments**
- **10 megacycle coverage of WWV**
- **Low-noise, high-gain first mixer**
- **Compact, modern styling**

THE KCS COMPACTRON amateur band receiver was developed to fill the need for a high-quality, high-performance receiver for the popular amateur bands that the experienced constructor could build using the usual home workshop hand tools. Only eight tubes are employed to perform a total of seventeen functions, including four of General Electric's new compactron tubes which perform ten circuit functions. Four modern types of conventional tubes perform the other seven functions.

The KCS covers the principal amateur bands from 3.5 to 29.5 megacycles, in seven 500-kilocycle tuning ranges, plus the range from 9.75 to 10.25 megacycles for reception of WWV on 10 megacycles. Design objectives of the receiver included: minimum cross modulation from strong signals on adjacent channels; high stability and low frequency drift; excellent usable sensitivity; sharp selectivity; low noise generated within the receiver; top-notch single sideband reception; a compact mechanical package; and, simplicity of adjustment and operation.

As can be seen from the panel views of the receiver, it is not a "knob-twister's delight." All the essential controls are on the panel; this simplifies operation. Only a signal generator, and a vacuum-tube voltmeter with an RF probe is needed for complete alignment. The critical circuits are aligned with adjustable capacitors and coils; however, an effort was made to eliminate all such adjustments where sufficiently precise fixed components could be used.

A readily-available war-surplus worm and worm-gear drive mechanism was incorporated into a home-made slide rule type dial giving a professional appearance and "feel" to the receiver. The tuning rate is 25 kilocycles per revolution of the tuning knob, slow enough for easy tuning of single sideband signals. The tunable oscillator was designed to give a nearly linear tuning rate, so that frequency can be read directly from the vernier scale on the tuning knob to within a kilocycle or two. A modern-appearing standard cabinet, plus standard chassis and sub-chassis type construction, simplifies mechanical fabrication and assembly.

THE COMPACTRONS in the receiver — as shown in the block diagram, Fig. 1—are: a 6D10 triple triode (V_2) as cathode-follower and mixer, and crystal oscillator; a 6J11 twin pentode (V_4) as a two stage IF amplifier; a 6AG11 twin-triode, twin diode (V_6) as first audio amplifier, AGC gating stage, and AGC rectifier; and, a 6AL11 double pentode (V_7) as audio power amplifier, and 100-kilocycle crystal calibration oscillator. The multi-function capability of compactrons thus contributes greatly to the simplicity of design and compact size of the receiver.

The four conventional tubes, and their functions are: a 6BZ6 RF pentode (V_1) as a tuned RF amplifier, a 6U8-A triode-pentode (V_3) as second mixer and tunable oscillator; a 6AL5 twin diode (V_5) as the detector for amplitude-modulated (AM) signals; and, a 6JH8 double-plate sheet beam tube (V_8) as a product detector and IF carrier oscillator. The circuit was designed around those compactrons available at the time construction was started, but later additions to G-E's compactron line will make possible the further combining of functions.

High-efficiency silicon rectifiers in a full-wave bridge type circuit are used in the high voltage power supply. All

IN THIS ISSUE

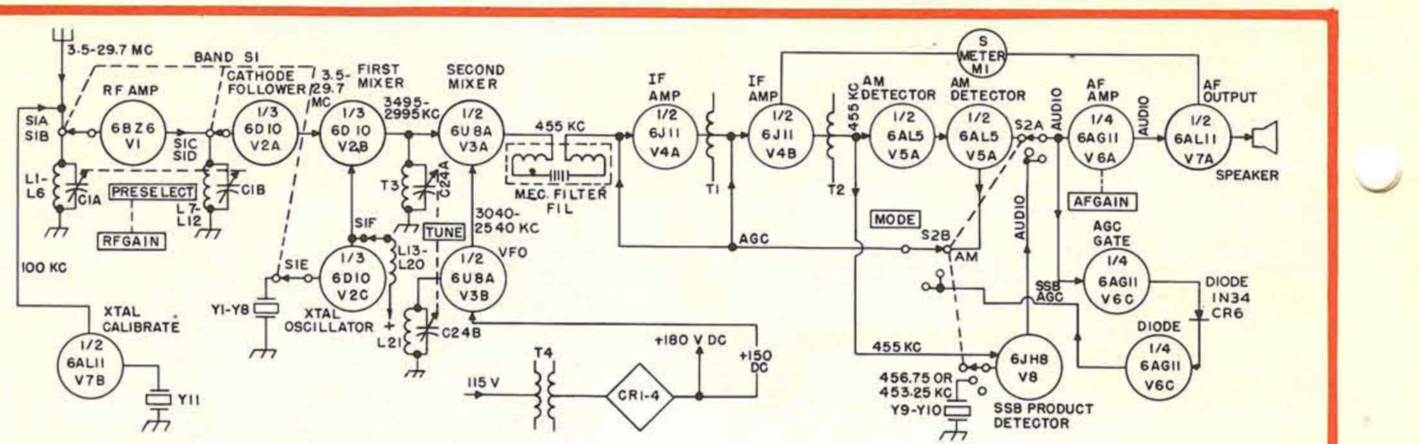

FIG. 1. BLOCK DIAGRAM showing the seventeen major circuit functions performed by the four compactrons and four miniature tubes in the KCS receiver. Front-panel controls are identified with boxes around their function. The band and mode switches have sections ganged, and the preselector and tuning dial controls also drive ganged variable capacitors.

tubes operate with a maximum of 180 plate supply volts, resulting in low power dissipation, while still providing high gain and good stability. Even in the compact cabinet the receiver runs quite cool during extended periods of operation.

DESIGN CONSIDERATIONS AND CIRCUIT — Starting at the antenna input, the sensitivity, or signal-to-noise ratio, in a receiver can be made as high as practical by choosing low-noise RF amplifier and mixer circuits. Referring to the schematic diagram, Fig. 2, the 6BZ6 semi-remote cut-off RF pentode (V_1) was chosen for the RF amplifier stage because of its low noise resistance, high gain-bandwidth product, and high input and output resistances. The tube operates with a fixed gain of approximately 5. Additional voltage gain in this stage is provided by the step-up ratio of the RF input coils.

Cross modulation from strong local signals on adjacent frequencies is minimized by using high-Q RF coils, and operating the 6BZ6 within the linear portion of its curve. The constant amplification eliminates the need for automatic gain control (AGC) of the control-grid circuit. Usually, AGC resistance in the grid acts as a shunting impedance, reducing the Q of the RF tuned circuit.

All RF coils (L_1 to L_6, and L_7 to L_{12}) were purchased with the secondaries prewound as standard items. The primaries were then wound on the coils by the author. With the possible exception of the universal-wound coils (L_5, L_{11}, L_{20}, L_{21} and L_{22}), the coils can be wound by the constructor on J. W. Miller type 42A000CB1 coil forms (⅜-inch diameter, 1 inch long) for L_1 to L_{12}, and type 4500 (¼-inch x ⅞-inch long) for L_{13} to L_{19}.

The antenna input is a fixed impedance for 72-ohm transmission lines; however, it can be adjusted between small limits by adjusting the slug tuning in the antenna coils. Although a lower capacitance could have been used for the tuned circuit, thus achieving higher L/C ratios and Q, the 7 to 100-picofarad capacitor (C_1) provides easy coverage of all bands on the PRESELECT knob.

Both the input and output of the RF amplifier stage are tuned to the same frequency and use identical inductors so that tracking between the input and output is easily accomplished. Small errors in coils, and between sections of C_{1A} and C_{1B}, are compensated for by C_2 and C_6. RF gain can be reduced by the RF gain control (R_5) which increases the negative grid-cathode voltage by making the cathode voltage more positive. In order to limit the cathode-to-heater voltage gradient, R_4 and R_3 form a bridge which holds the cathode-to-heater voltage to below 100 volts when the function switch (S_3), or an external mute switch is opened.

The type 6BZ6 pentode is a relatively quiet tube and probably represents the highest noise level in the receiver. This is in contrast to most receivers in that the maximum amount of noise is generally generated by the mixer stage. A lower noise RF amplifier tube such as a General Electric 6FG5 shadow grid beam pentode could have been used, but this did not seem worthwhile at the frequencies at which this receiver operates. The 6FG5 produces less noise than the 6BZ6 tube and would be an excellent choice for a receiver operating on the 50- or 144-megacycle amateur bands. Even with the 6BZ6 tube the KCS receiver has such low noise that it is difficult to realize that it is operating until a signal is tuned in.

THE FIRST MIXER — The first mixer stage uses a rather unusual cathode-coupled circuit. The first section of the 6D10 triple triode (V_{2A}) acts as a cathode follower, isolating the signal input from the crystal oscillator injection signal. Signal voltage is coupled into the cathode of V_{2B} via a common cathode resistor (R_8). The second section, V_{2B}, acts as a mixing triode with the local oscillator signal being injected into its grid. The remaining triode section of the 6D10 tube (V_{2C}) is the crystal controlled first conversion oscillator.

Very low mixing noise is achieved with a triode mixer, and the circuit allows a triode to be used without neutralization. Because of the mutual cathode resistor there is a certain amount of self-limiting when strong signals are received, making unnecessary AGC control of the RF amplifier stage to prevent overloading. In order to produce linear mixing in this circuit the value of the transconductance (Gm) of V_{2A} should be large compared to the transconductance of V_{2B}. Consequently, the supply voltage for V_{2A} is approximately 140 volts while the supply voltage for V_{2B} is reduced to approximately 40 volts[1]. The advantages of the cathode-coupled mixer circuit can be utilized in this receiver with a single 6D10 triple triode compactron. If conventional tubes — say a twin triode, plus a single triode — were used in this circuit, two tubes are necessary and a large chassis area for the mixer circuit is required.

Since the crystal controlled first oscillator operates higher in frequency than

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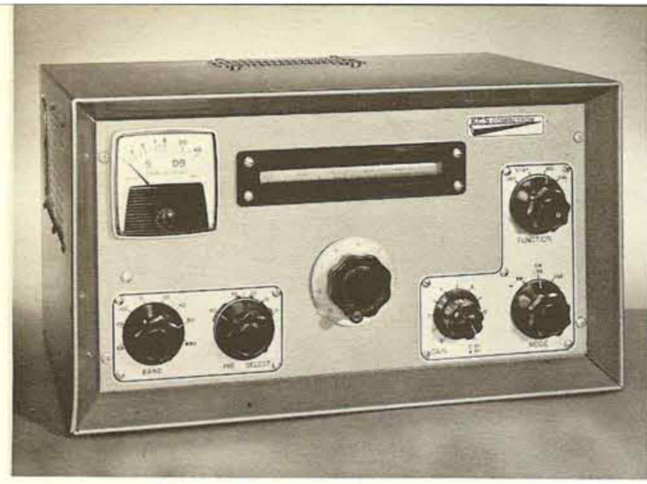
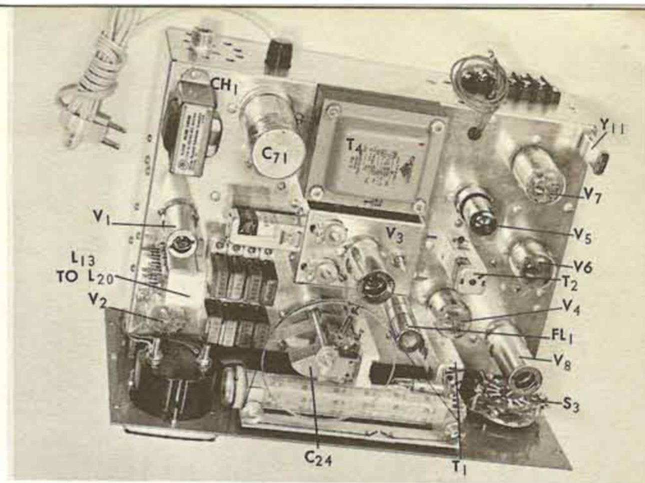


NEATNESS AND SIMPLICITY of front panel of the receiver is apparent in this view. Vernier scale on tuning knob has 100 divisions, but scale showing 25-kilocycle-per-knob-turn tuning rate can be applied over it. Concentric type potentiometers are used on RF and AF gain controls. "S" meter is standard General Electric DW-91 "Big Look" meter with hand-calibrated scale added by W7KCS/9.



TOP VIEW of the receiver chassis. Home-made slide-rule type dial scale is driven from large plastic pulley mounted on upper end of shaft of C_{24}. Tunable oscillator (V_3) is in box between capacitor and power transformer (T_{24}). First oscillator coils (L_{13} to L_{20}) are all housed in the small box behind the meter. Chassis layout diagram will appear in Part II of this article in the next issue.

the incoming signal on all tuning ranges, the resultant subtraction in the mixer produces a first IF signal in the 3-megacycle region. The crystals for the 3.5- and 7-megacycle bands operate in the fundamental mode, while the six crystals for the higher-frequency ranges operate in the third-overtone mode. If a matched set of crystals[2] is obtained for Y_1 to Y_8, tuning dial calibration will remain virtually the same for all bands. The crystal-controlled first oscillator provides the advantage of high stability over a tunable first oscillator on the bands above 14 megacycles where it is needed.

SECOND MIXER — The output of the first mixer is fed into T_3. The tracking circuit, composed of C_{23}, C_{24A}, C_{25}, C_{21} and C_{22}, together with the secondary of T_3, tune the variable IF frequency range of 3495 to 2995 kilocycles. The tunable oscillator (V_{3B}) output voltage is applied to the cathode of the 6U8-A pentode section (V_{3A}) second mixer. The 6U8-A tube is a good choice for this combination mixer-oscillator because of its low partition noise, good conversion gain characteristics, and low grid-plate interelectrode capacitance. By using cathode injection, interaction between the signal and oscillator is minimized. The fixed cathode resistor (R_{16}) presents essentially a constant load on the VFO.

A constant k filter with low pass characteristics is composed of L_{22}, L_{23} and C_{76}. This filter effectively attenuates harmonics of the VFO. The tracking of the mixer and VFO is accomplished by means of C_{24A}, C_{24B} and the associated capacitors, and is designed to track within several kilocycles throughout the band. By proper choice of these components the tuning is nearly linear throughout the useful range. By using a combination of grid leak bias (R_{15} and C_{26}), together with cathode bias (R_{16}) on the mixer, a reasonable flat conversion gain can be achieved with moderate changes in the oscillator injection voltage.

TUNABLE OSCILLATOR — The triode section of a 6U8-A (V_{3B}) in a tuned-grid circuit is used for the tunable oscillator. It delivers good stability and an easy method of obtaining oscillation without putting plate voltage across C_{24B}. Additionally, all power consuming components (R_{18}, R_{20} and R_{19}) are mounted below the chassis so that the heat does not dissipate into the VFO-mixer compartment.

Provision was originally made for a voltage regulator tube for the oscillator plate voltage but it was not necessary for moderate changes in line voltage. A check showed a frequency change of approximately 250 cycles for a voltage change between 105 to 125 volts. In locations where this voltage range might be greater, or where very low line voltage is encountered, it might be wise to add an 0A2 150-volt regulator tube.

The second oscillator tunes backwards. For example, on the 3.5- to 4.0-megacycle range the oscillator tunes from 3.04- to 2.54-megacycles respectively. The combination of the crystal first oscillator and tunable second oscillator frequencies were chosen to minimize spurious beat frequencies. By use of the frequency combinations the lowest spurious frequency occurs on 7 megacycles with the fourth harmonic of the tunable oscillator and the first harmonic of the crystal oscillator. Since the attenuating filter network affectively minimizes the fourth harmonic of the local oscillator this signal is extremely weak.

Ceramic tube sockets and low drift capacitors are used in the tunable oscillator which is built into a rigid compartment of its own. Heat dissipating components of this stage are mounted below the chassis and out of the compartment, thus minimizing heat transfer to critical parts.

IF AMPLIFIERS — The output of the second mixer is fed directly into a Collins mechanical Filter (FL_1) which is tuned to resonance on the input side by C_{27} and C_{28}, and on the output side by C_{31}, plus the input capacitance of V_{4A}. If the receiver is to be used principally for SSB reception, a 2.1-kilocycle bandwidth filter (Collins F455J-21) is recommended. However, if good AM reception is important, then the 3.1-kilocycle bandwidth filter (Collins F455J-31) is recommended so that the AM carrier and one sideband will pass through the filter. Other types of mechanical filters — the Collins "Y," or new low-cost "FA" series filters — also are suitable, but will require different mounting than the 9-pin socket used on the "J" type filter.

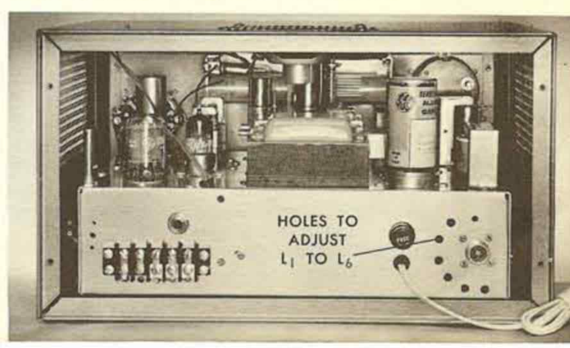
A 6J11 twin pentode compactron (V_4) — each section is similar to a 6EW6 miniature pentode — operates as a two-stage IF amplifier. The 6J11 is ideal for this application, since it has high gain, and saves considerable space over two separate tubes. It is the only tube controlled by the negative AGC bias voltage in the receiver, since all previous stages have constant gain.

Resistors R_{22} and R_{21} together with capacitor C_{35} provide effective decoupling in the AGC circuit between the controls grids of the first and second IF amplifier stages. Because of the extremely high gain of these tubes ($GM=14{,}000$) a neutralizing circuit was included. It consists of C_{46}, C_{47} and decoupling circuit R_{28}, C_{48} and R_{27}.

The S meter circuit monitors the cathode voltage of V_{4B} and compares it against a constant voltage across R_{48}. By using the S meter in the cathode circuit of the second IF stage, low voltage operation results which cuts down on the wattage rating of R_{30} and the zero set potentiometer (R_{49}). The S meter therefore reads the complete tube current of the second IF amplifier as AGC is applied to its control grid in a value which changes in proportion to the signal strength. On single side band and CW operation the AGC circuit is taken from the first audio amplifier so that the S meter follows the audio strength rather than the RF strength, as is the case with AM reception.

AM DETECTOR — The output of the IF transformer (T_2) is fed into an integrating diode AM detector and also into the single side band product detector. The integrating diode detector, consisting of both sections of a 6AL5 twin diode tube (V_5) reduces distortion by presenting a capacitance load to the output transformer windings on both the positive and negative IF signal peaks. With positive peaks the output

REAR VIEW of receiver in cabinet, showing positions of antenna jack, headphone jack, terminal board, fuse holder and AC power cord on rear of chassis. Receiver is housed in a Bud SB-2140 "Shadow Cabinet," 14¼ inches wide, 8 inches high, and 10 inches deep.



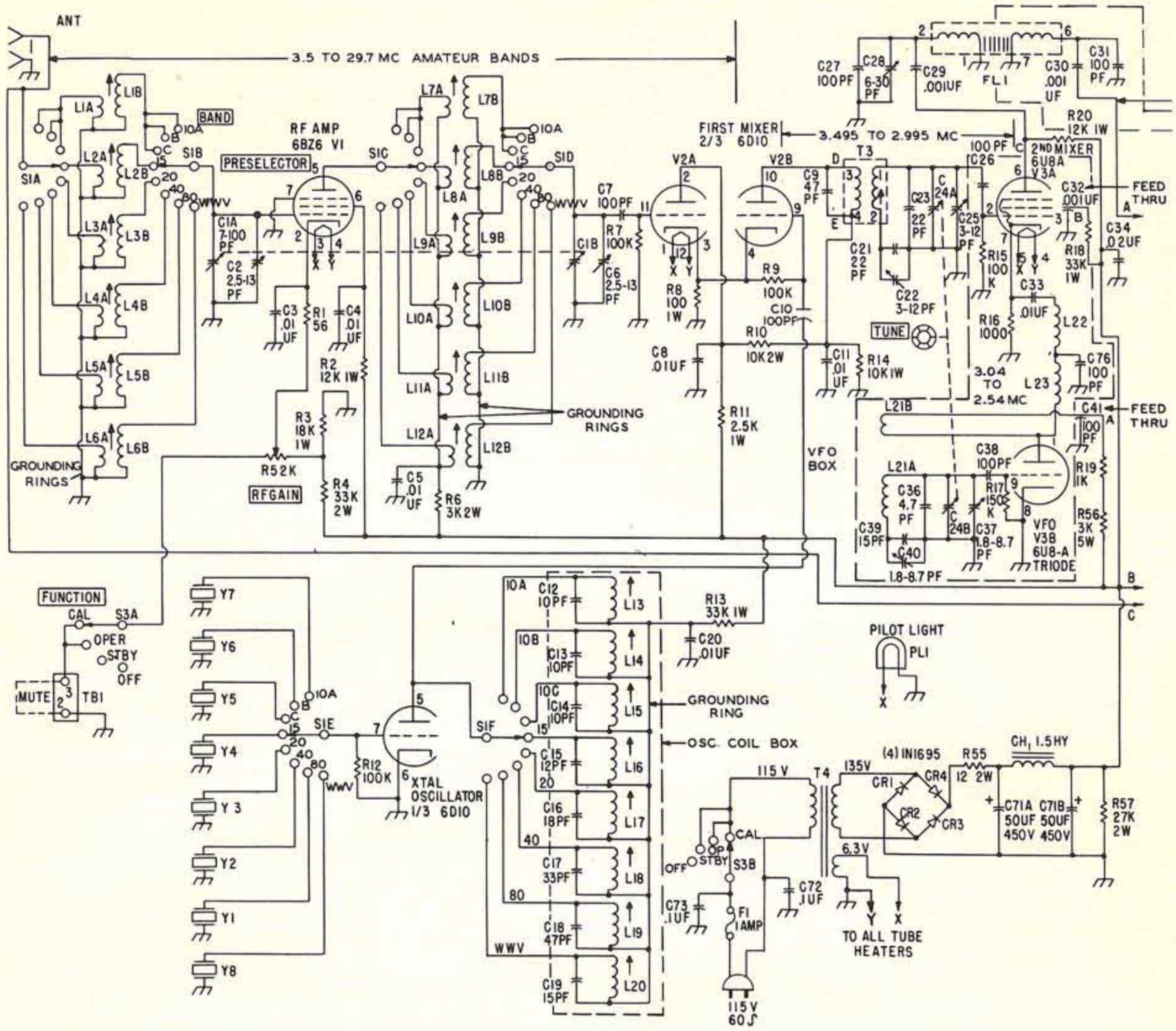


TABLE I—PARTS LIST

C_1......10—100-pf. per section, two-section straight-line variable (Hammarlund MCD-100-S).

C_2, C_6....2.5—13-pf. midget ceramic trimmer, zero-temperature coefficient (Centralab 822-BZ).

C_9, C_{12}, C_{13}, C_{14}, C_{15}, C_{16}, C_{17}, C_{18}, C_{19}, C_{21}, C_{23}, C_{39}, C_{59} and C_{69}......all zero-temperature coefficient ceramic in values marked on Fig. 2 (Centralab TCZ).

C_{22}, C_{25}....3—12-pf. ceramic trimmer, zero-temperature coefficient

C_{24}....10—100-pf. per section, two-section midline type variable (Hammarlund MCD-100-M).

C_{27}, C_{31}, C_{76}....100-pf. tubular ceramic, zero-temperature coefficient

C_{28}....6—30-pf. ceramic trimmer (Centralab 827-C).

C_{36}....12-pf. ceramic tubular, zero temperature coefficient

C_{37}, C_{40}....1.8—8.7-pf. ceramic air trimmer (E. F. Johnson type M-160-104, 9M11).

C_{47}....7—35-pf. ceramic trimmer (Centralab 827-D).

C_{60}....820-pf. $\pm$1 percent 500-volt silvered mica (Elmenco type CM-20).

C_{68}....10—50-pf. air trimmer, zero-temperature coefficient

CH_1....1.5-henry, 200-milliampere filter choke (Stancor C-2327).

FL_1....Mechanical bandpass filter, 455-kilocycle center frequency, 2.1-kilocycle bandwidth for SSB reception (Collins type F-455J-21 filter used in this receiver[2]).

F_1......1-ampere midget cartridge fuse, type 3AG, and holder.

CR_1 to CR_4....400-volt peak inverse, 750-milliampere silicon rectifiers (G-E 1N1695).

J_1......chassis type coaxial cable connector (SO-239).

J_2......closed circuit type phone jack.

L_{21}....135-UH universal wound coil; primary, J. W. Miller No. 42A154-CB1; secondary, 15 turns, No. 28 SE wire, random-wound ⅛-inch long and ⅛-inch spacing from primary.

L_{22}, L_{23}....47-UH RF Choke, pi-wound coil (National B-15980).

L_{24}....455-Kc. tapped oscillator coil, midget type (Miller 5481-C).

M_1......0—1-milliampere, 2½-inch square panel meter (General Electric DW-91, Cat. No. 513X22).

PL_1....6.3-volt pilot lamp and socket.

R_5......2,000-ohm control potentiometer for concentric shaft mounting on rear of R_{40} (*IRC Snaptrol* rear section, right hand semi-log. taper, No. CR25 with SR16 shaft and DC1 dust cover).

R_{30}....500-ohm ½-watt control potentiometer, screw-driver slot

R_{40}....1-megohm control potentiometer, left-hand audio taper (*IRC Snaptrol* front section No. CF26 with SF12 shaft and BU5 bushing).

R_{49}....2,000-ohm, ½-watt potentiometer, screw-driver slot

S_1......6-pole, 6-section, 2-12 position steatite miniature, non-shorting rotary tap switch, stop set for 8 positions (Centralab PA-2025).

S_2......3-pole, 1-section, 3-position, 2-5-position steatite miniature, shorting rotary tap switch, stop set for 3 positions (Centralab PA-2006).

S_3......3-pole, 1-section, 4-position shorting rotary tap switch

T_1......455-kilocycle IF input transformer (J. W. Miller 12-C1).

T_2......455-kilocycle IF output transformer (J. W. Miller 12-C2).

T_3......1500-kilocycle IF input transformer, modified (Miller 13-W1).

T_4......Power transformer, 115/135-volt secondary, 200 milliamperes; 6.3 volts at 5.5 amperes, 115-volt primary (Triad R-73B).

T_5......Audio output transformer, 4,000-ohm primary, 3.2-ohm secondary, 3 watts (Stancor A-3328).

V_1 to V_8....General Electric receiving tubes, types as indicated in Fig. 2.

Y_1 to Y_8....Quartz crystals, ET-243 type holders; see TABLE II—COIL DATA, for frequencies.[3]

R_9......quartz crystal, FT-243 holder, 456.2 kilocycles, for lower side-band reception.

Y_{10}....quartz crystal, FT-243 holder, 453.9 kilocycles, for upper side-band reception.

Y_{11}....100-kilocycle standard frequency quartz crystal, HC-6/U holder (C-W Mfg. Co. type HX-100).

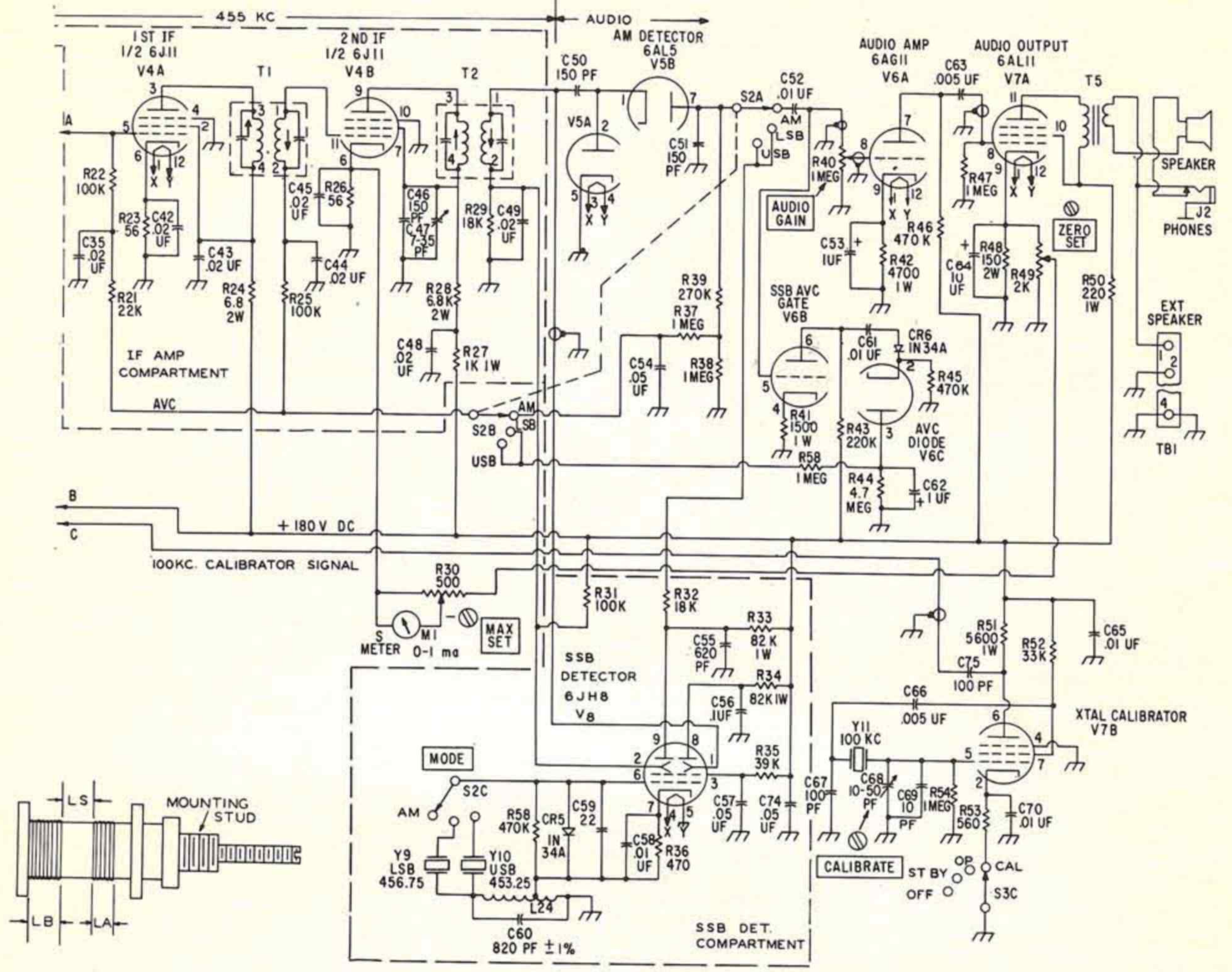


FIG. 2. MAIN SCHEMATIC DIAGRAM of the KCS receiver. Parts requiring additional explanation are described in TABLE I—PARTS LIST, or TABLE II—COIL DATA. Resistances are given in ohms, ½-watt rating, unless marked for higher wattage. Capacitances are in picofarads (PF), or in microfarads (UF), as marked. Capacitors with polarity signs are electrolytic types of the capacitance and voltage rating specified.

TABLE II—COIL DATA

Band & Freq. in MC.	Ant. & RF Coils	PRIMARY L Pri UH	PRIMARY Turns	PRIMARY Wire Size	PRIMARY Length L_A	PRIMARY Space L_S	SECONDARY L Sec UH	SECONDARY Turns	SECONDARY Wire Size	SECONDARY Length L_B	Miller No.	OSCILLATOR Coil	OSCILLATOR L UH	OSCILLATOR Turns	OSCILLATOR Wire Size	OSCILLATOR Length	OSCILLATOR Miller No.	CRYSTAL No.	CRYSTAL Freq. KC.
10A—29.2 = 29.7	L_1 & L_7	0.35	4	22	⅛	⅛	0.76	8	20 DCC	⅜	42A106CB1	L_{13}	2.3	17	28 SE	¼	4503	Y_7	32,695
10B—28.7— 29.2	L_1 & L_7	0.35	4	22	⅛	⅛	0.76	8	20 DCC	⅜	42A106CB1	L_{14}	2.4	17	28 SE	¼	4503	Y_6	32,195
10C—28.2 = 28.7	L_1 & L_7	0.35	4	22	⅛	⅛	0.76	8	20 DCC	⅜	42A106CB1	L_{15}	2.5	17	28 SE	¼	4503	Y_5	31,695
15—21.0— 21.5	L_2 & L_8	0.44	5	22	⅛	⅛	1.1	8	20 DCC	⅜	42A106CB1	L_{16}	3.5	23	30 SE	¼	4504	Y_4	24,495
20—14.0— 14.5	L_3 & L_9	0.60	5	24	⅛	⅛	2.0	12	22 DCC	⅜	42A226CB1	L_{17}	4.3	23	30 SE	¼	4505	Y_3	17,495
40—7.0— 7.5	L_4 & L_{10}	1.2	7	28	⅛	5/32	6.5	21	28 LITZ	5/16	42A686CB1	L_{18}	7.0	33	32 SE	9/32	4505	Y_2	10,495
80—3.5— 4.0	L_5 & L_{11}	2.5	10	30	⅛	3/16	18.6	UNIVERSAL WOUND			42A225CB1	L_{19}	11.0	40	36 SE	¼	4506	Y_1	6,995
WWV—9.75— 10.25	L_6 & L_{12}	1.0	6	28	3/32	3/32	3.6	16	24 DCC	⅜	42A336CB1	L_{20}	9.4	UNIVERSAL WOUND			4309	Y_8	13,245

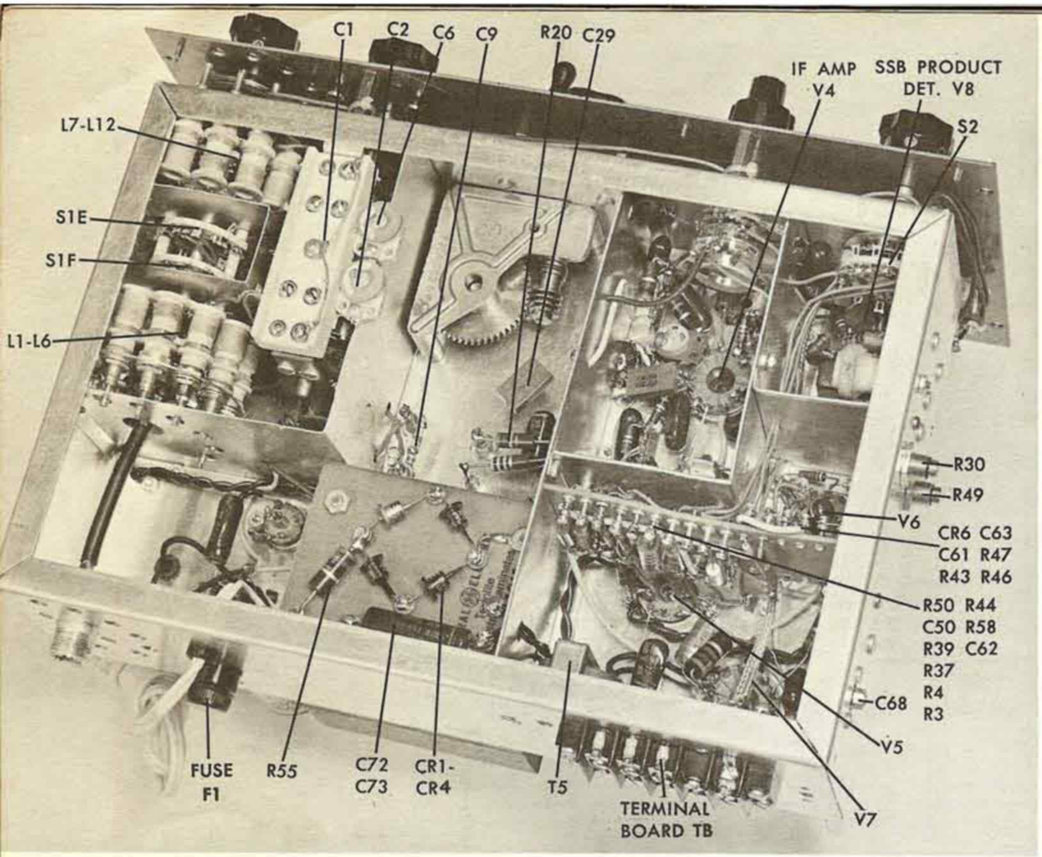
NOTES

All coils wound on J. W. Miller ceramic slug-tuned coil forms, Part No. 42A000CB1, ⅜-inch diameter, 1 inch long.

Inductance values given are those actually in circuit.

All coils closewound unless specified.

Enameled wire used on all coils unless otherwise specified.
DCC = Double Cotton-covered wire.
SE = Silk-enameled covered wire.



BOTTOM VIEW of the chassis, showing the antenna input (L_1 to L_6) and RF (L_7 to L_{12}) coils in a shielded compartment at the upper left, worm and worm-gear drive from the tuning knob in the center, and IF, detector and audio sections in compartments at the right. Locations of major components are identified. Note how parts are not crowded around the socket for the 6J11 IF amplifier compactron (V_4).

transformer load is essentially C_{50}, while on negative peaks, the output load sees the capacitive reactance of C_{51} in parallel with the AGC resistors. Audio filtering is provided by R_{39} and R_{38}, while R_{37} and C_{54} form the charge time constant network. During discharge of the AGC circuit, C_{54}, R_{37} and R_{38} provide a charge time constant of 0.12 seconds and a discharge time constant of 0.18 seconds. A slight delay voltage is applied to the AGC line due to contact potential in the 6AL5 tube. This delays application of AGC voltage until a signal of approximately 20 microvolts is received.

The 6AL5 tube could be replaced by two 1N34 diodes directly with no changes in the circuit. This would reduce the receiver complement to seven tubes; however, the diodes would provide no delay and result in slightly more distortion and less gain than the tube equivalent.

SINGLE SIDE BAND PRODUCT DETECTOR — The unique characteristics of the General Electric 6JH8 double-plate sheet beam tube (V_8) are utilized in an excellent performing product detector circuit. The good separation possible with this tube makes it ideally suited for single side band product detector applications. It requires low oscillator injection voltage, and has freedom from spacecharge coupling effects which are present in dual-control pentodes and heptodes. It delivers relatively linear output voltages, and is relatively insensitive to a wide range of variation in oscillator amplitude.

The circuit makes use of a single ended balanced design, with the balancing voltage on the deflectors provided by the resistance bridge R_{31} and R_{29}. The audio output signal emerges from one plate through the filtering resistor R_{32}. The oscillator which is crystal controlled by Y_9 or Y_{10} for lower side band or upper side band, respectively, injects its voltage between the control grid and cathode of the tube. In order to eliminate a trimmer capacitor, C_{60} is specified as a plus or minus 1 percent value. A 1N34 diode (CR_5) protects the sheet beam tube from positive grid bias by shunting positive voltages to ground.

AUDIO AMPLIFIERS — Audio output from the AM or single sideband detector is first amplified in a conventional triode audio amplifier (V_{6}A). The ½ 6AL11 audio output tube (V_{7}A) provides about 2½ watts of useful output power. The coupling networks between the two audio stages tend to produce slightly higher cutoff frequencies than might normally be expected when using a mechanical filter. Resistor R_{50} provides some additional attenuation of the low frequencies so that the audio output has a crisp, sharp, rather pleasant quality without ringing or excessive bass boominess.

The use of the 6AL11 compactron (V_7), which is essentially a 6DT6 combined with a 6AQ5, allows the 100-kilocycle crystal calibration oscillator to be put into the same envelope. The crystal calibrator is on only when the function switch (S_3) is turned to calibrate. The output of the crystal oscillator is fed directly into the antenna to give a signal every 100 kilocycles across the tuning range.

Audio voltage from both AM and SSB detectors is also applied to the single side band automatic gain control gate triode tube (V6B). This is the second section of the audio amplifier tube — a 6AG11 four-section compactron — essentially a 12AT7 twin triode, plus 6BW8 diodes with separate cathodes. AGC voltage then runs through the AGC diode (CR_6) and one diode section of V_6C. The resulting DC voltage is applied across the charging time constant composed of the forward resistance of V_6C and C_{62}. This provides a very fast attack voltage for the AGC. The release voltage time constant is provided by R_{44}, C_{62} and the back resistance of V_6C and R_{45}.

This network provides a release time of approximately 5 seconds. The single side band AGC voltage follows audio signal strength; however, because of the time constant involved, it does not rapidly fluctuate with instantaneous changes of audio level. Since only one of the 6AG11 compactron diodes is used in this receiver, it would be possible to use the unused diode section as a noise limiter if the constructor felt it desirable.

POWER SUPPLY — The power supply consists of a full wave bridge rectifier system using General Electric type 1N1695 750-milliampere silicon rectifiers. The semiconductor rectifiers minimize space requirements in the power supply compartment. The pi-section filtering components (C_{71}A, C_{71}B and CH_1) were chosen to result in a very low ripple voltage of 0.01 percent, which is barely discernible with the audio volume control wide open. Because of the high capacitance of the input capacitor a current surge limiting resistor (R_{55}) was provided to limit current through the diodes during the first charging cycle.

Note that all tube heaters are connected together by means of twisted wire and are grounded at only two points. There is a ground at the power transformer (T_4), and also on pin 5 of the 6JH8 tube (V_8). In order to reduce hum in the single side band product detector it was necessary to ground pin 5 directly to the chassis. This pin is also connected to the internal shield and focusing electrodes of this tube. Rather than a single heater-wire and a direct chassis ground for the other side of the heater circuit, the twisted pair of wires reduces any tendency of hum pickup in the audio output. This extreme may not be necessary; however, other methods were not tried to determine its superiority.

Note that switch S_3 is a shorting switch or make-before-break type rotary switch which allows the next circuit to be energized before the previous circuit is disconnected. This prevents transient voltages from being

FOOTNOTES

[1]Those persons who are interested in the details of the cathode-coupled mixer circuit can refer to *Conductance Design of Active Circuits*, by Keats A. Pullen, Pages 259-263.

[2]*Collins Radio Company*, Components Division, 19700 San Joaquin Road, Newport Beach, Calif., has recently announced the availability of a new low-cost mechanical filter for amateur radio service, with a 2.1-kilocycle bandwidth, Model No. F455 FB-21. It is housed in a "bath-tub" type case, 2½ inches long, with connections on the bottom side. It can be mounted on the chassis of the KCS receiver in place of the 9-pin filter socket shown in this model, with connections brought down under the chassis on either side of the shield partition shown in the bottom view. Postpaid price is $26.50.

[3]A matched set of crystals for the KCS receiver, which includes all crystals for Y_1 to Y_{10}, is available as set MRG-3H from the C-W Manufacturing Co., P.O. Box 2065, El Monte, Calif., for approximately $29.00.

THE LOADBOX — A POWER-INDICATING DUMMY ANTENNA

By Philip E. Hatfield, W9GFS*

HIGH-QUALITY SIGNALS from amateur transmitters are more important today than ever before, but with today's crowded amateur band conditions, on-the-air testing is frowned upon. Thus, a dummy-antenna load is a necessity in the amateur station.

The LOADBOX is a modernized version of one of the dummy loads described in an earlier issue of *G-E HAM NEWS*[1]. It features complete shielding to reduce radiation and an internally mounted RF ammeter to allow comparative power readings.

It is built in a 4x5x6-inch aluminum utility box. An unpainted box was used, since good contact between the body of the box and the covers will decrease unwanted radiation. The covers furnished with the box were replaced by covers cut from perforated aluminum sheet (Reynolds Home Aluminum) to assist in cooling the resistor assembly. Additional sheet-metal screws were used to assure good contact between the covers and the body of the box.

The resistor assembly consists of ten, non-inductive, wirewound, 500-ohm, 10-watt resistors connected in parallel to give a nominal resistance of 50 ohms. Two copper disks (see photos) were used to parallel the resistors. Copper connection straps were fastened to the center of the disks with machine screws and solder before the resistor assembly was made. The resistor leads were slipped through the holes around the edge of the disks, soldered, and clipped. One strap was used to connect the resistor assembly to the bottom of the aluminum box and the other to connect to the RF ammeter, as shown in the schematic diagram.

The RF ammeter is mounted on supports inside the box with the face visible through the screened hole on the front of the box. The meter used in this model has a 0—1.5-ampere range, which allows power inputs up to approximately 110 watts.

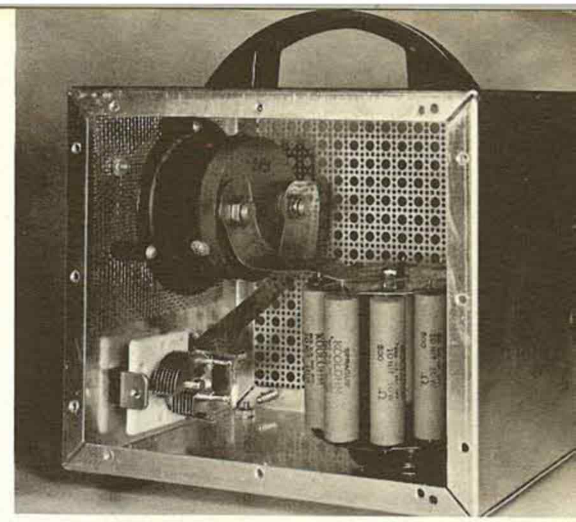
The front of the box also carries the input coaxial connector and the variable capacitor used to compensate for the reactance of the resistor assembly. The resistor assembly may be compensated by connecting the Loadbox, through an SWR bridge, to a source of RF and adjusting the variable capacitor on the front of the box for a null indication on the SWR bridge at the center of each band on which the Loadbox is to be used. Marks may be made on the front of the box to allow resetting of the capacitor.

In operation, approximate power being dissipated in the load may be calculated by squaring the reading of the RF ammeter and multiplying by 50. However, the Loadbox is most useful for determining whether changes in a piece of equipment increase or decrease the power output. This is difficult to do with a lightbulb load as most of us are unable to "remember" the intensity of a lightbulb between tests.

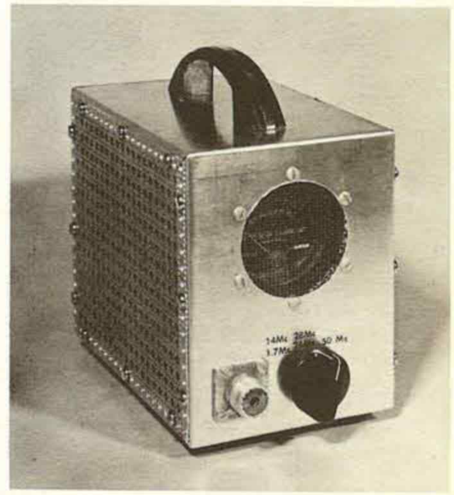
The resistance of the model illustrated was measured from 1.7 to 50 Mc. The results are shown on the curve. From this it can be seen that some error in calculated power output will prevail at all frequencies if a resistance of 50 ohms is assumed, but that the error will increase sharply above 30 megacycles. However, this does not affect the usefulness of the Loadbox as an indicator of *relative* power at a given frequency.

Although the nominal rating of the resistor assembly is 100 watts, powers as high as 300 watts may be dissipated for short intervals. However, if this is done the RF ammeter must have the proper range and the overload should not be applied for more than one minute, followed by a fifteen minute cooling-off period. Cooling may be assisted by using a fan or blower to move air through the perforated covers of the box.

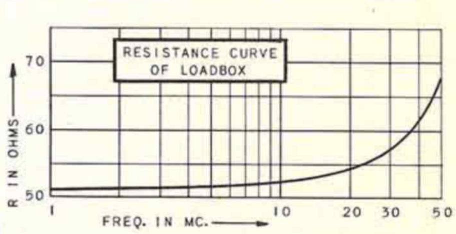
For maximum convenience, the Loadbox may be connected to the transmitter through one position of a coaxial cable selector switch (B&W Model 550A, or Waters Mfg. Co. Model 335) which also selects the "live" antennas. So, whenever you test out your transmitter — even for only a minute or two — connect it to the Loadbox and prevent needless interference to other stations.

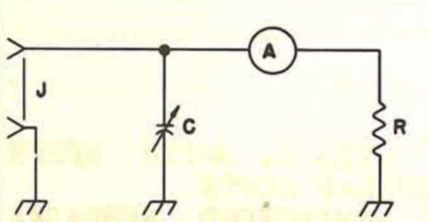


SIDE VIEW of the Loadbox, showing how the bank of resistors is connected in parallel, and the copper strip leads between components.



PANEL VIEW OF THE LOADBOX, showing the calibrated settings for the reactance-cancelling capacitor for different bands. Note wire screening over RF ammeter openings.





PARTS LIST—LOADBOX

- A......0—1.5-ampere RF ammeter, internal thermocouple type.
- C......5—50-pf. miniature variable (*Hammarlund* HF-50, or equivalent).
- J......Chassis-type coaxial cable jack (SO-239).
- R......Ten 500-ohm, 50-watt non-inductive resistors (*Sprague* 10-NIT).
- Box....Aluminum utility box, 4x5x6 inches, covers on 4x6-inch sides (*Bud* AU-1029).

FOOTNOTES

[1]See "Technical Tidbits — Using Resistors as RF Loads," *G-E HAM NEWS*, January-February, 1951 (Vol. 6, No. 1), for details.

*W9GFS is a technical data engineer with General Electric's Receiving Tube Department, Owensboro, Kentucky. He is author of a number of articles in *QST*, *Popular Electronics*, *Electronics World*, and *G-E HAM NEWS*.

applied onto the primary of T_4 and thus producing excessive transient voltages on the 1N1695 diodes in the bridge rectifier.

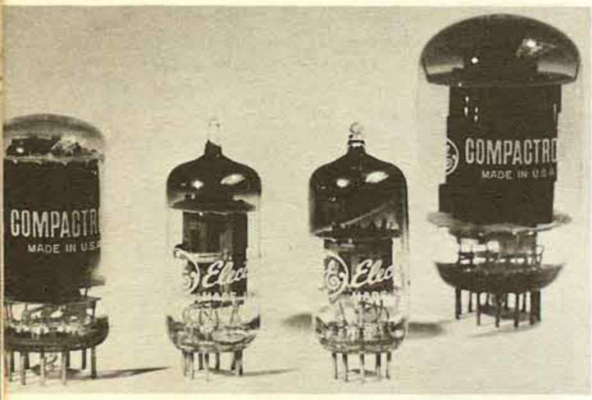
The headphone jack (J_2) cuts off the internal speaker — mounted inside the top of the cabinet — when headphones are plugged in. Provision is made for an external speaker to be connected to terminals 1 and 2 on the terminal board (TB_1). It remains in operation even when the headphones are plugged in. These connections also can be run to the speaker muting circuit in a single sideband transmitter with which the receiver is used.

Muting of the receiver while a companion transmitter is operating is accomplished by opening the circuit between connections 2 and 3 on the terminal board, and thus biasing the 6BZ6 RF amplifier tube to cutoff by applying high positive voltage on the cathode.

MECHANICAL DETAILS — The construction, alignment and operation of the KCS COMPACTRON amateur band receiver will be covered in detail in the following issue of *G-E HAM NEWS*, Spring, 1963 (Vol. 18 No. 1).

SCANNING THE SPECTRUM

FOUR NEW SMALL G-E TRANSMITTING TUBES ANNOUNCED



NEW MOBILE transmitting tubes by General Electric are: (left to right) 8156 21-watt beam pentode compactron; 8106 beam pentode multiplier-driver; 8102 triode-pentode for tripling and modulating; and the type 7984 compactron 46-watt beam power amplifier. Designed specifically for reliable and economical equipment in the 175 Mc. range of commercial communications, the 7984 and 8156 feature high power output at moderate plate voltage, compact size, short internal leads, multiple base-pin connections for positive RF grounding of cathode and screen-grid elements, and 13.5-volt heaters which operate directly from 12-volt auto electrical systems.

RADIO AMATEURS who are planning to build new mobile equipment will find two new compactrons, and two 9-pin miniature tubes ideal for transmitter circuits. All four new tubes — pictured at the left — have been designed specifically for reliable and economical mobile communications at frequencies up to 175 megacycles.

The popular 6146 transmitting tube has been compactronized in such fashion that it delivers more power output in the VHF range (at 175 megacycles) but at the same time requires less driving power. It bears the EIA designation of type 7984, and is rated for 46 watts output, as compared with the rated 35 watts of the 6146 under similar conditions.

Seated height is only 2.5 inches, as compared with the 3.25-inch seated height of the 6146. The saving is gain because the 7984 has neither a composition base, nor a top cap. Eliminating the top cap for the plate connection in mobile equipment is advantageous because it eliminates a long loose wire lead which is difficult to keep from vibrating or otherwise moving about.

Maximum ratings of the 7984 in intermittent mobile RF service, class C telegraphy and FM telephony, are: DC plate voltage, 750 v.; DC screen-grid voltage, 250 v.; DC grid No. 1 current, 4.0 ma.; and plate dissipation, 35 watts. Typical operation as amplifier at 175-megacycles: plate voltage, 450 v.; screen-grid, 125 v.; grid No. 1, —60 v.; plate current, 180 ma.; screen-grid current, 12 ma.; grid No. 1 current, 2.5 ma.; driving power, 2 watts; and power output, 46 watts.

Another new compactron, type 8156, is a medium power tube with 15 watts plate dissipation. A new multiplier-driver tube, the 8106, is rated at 6 watts plate dissipation. The 8106 can double and drive the 7984, can drive two 7984's in push-pull, or can double and drive a pair of 8156's. For frequency tripling and FM modulator, the triode-pentode 8102 miniature tube is available.

Other significant characteristics are:

8156 — This beam pentode compactron has four pins for connecting to the cathode and beam plates, three plate pins, and two screen-grid pins. Ratings are: 600 volts maximum DC plate, 250 volts screen grid, 100 ma. plate current, 5 ma. control-grid current, 15 watts plate dissipation, and 2.5 watts screen-grid dissipation. In typical operation at 175 megacycles with 400 plate volts, 170 screen-grid volts, and minus 60 control-grid volts, the tube draws 90 ma. plate current, 10 ma. screen-grid current, and 3 ma. grid current. With 1.0 watt of driving power, the useful output is 21 watts.

8106 — A 9-pin miniature beam pentode, the tube features three cathode-beam plate pins, and two screen-grid pins. Maximum ratings are: 330 plate volts, 300 screen-grid volts, 6.0 watts plate dissipation, and 40 ma. DC cathode current.

8102 — A 9-pin miniature triode-pentode, the tube has a large cathode cross section, and the pentode section is rated to carry 20 ma. cathode current. Both plates are rated at 330 volts maximum, and 2.5 watts dissipation. In typical operation at 125 volts, the plates draw 12 and 13.5 ma., respectively.

These new tubes will bring higher efficiencies to amateur radio mobile equipment, as they are doing for commercial VHF two-way radio.

Complex or Simple? . . .

We feel that with articles like the KCS receiver and LWM-3 transceiver,[1] we are helping to advance the "state of the art" in home-constructed amateur radio equipment. We have shown that the equivalent of fine commercial equipment can be constructed at home. And, we estimate from mail received that at least 400 to 600 SSB transceivers similar to the LWM-3 are being constructed, and many more SSB exciters are being converted to include transceive operation. However, for those who like simple projects, we publish shorter articles too, like the LOADBOX in this issue, and thus provide a balanced "diet" of articles. [1]See November-December, 1961, and January-February, 1962 issues.

While the KCS Compactron receiver is admittedly an ambitious project, the construction and alignment are well within the capabilities of the experienced radio amateur. It enables amateurs with a good supply of parts on hand to "step-up" to a higher performance receiver at low cost. The KCS receiver also is a "goldmine" of circuit and constructional ideas for thousands of other amateurs who may not construct a complete receiver, but who can use these ideas in equipment they now have, or are constructing.

—Lighthouse Larry

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