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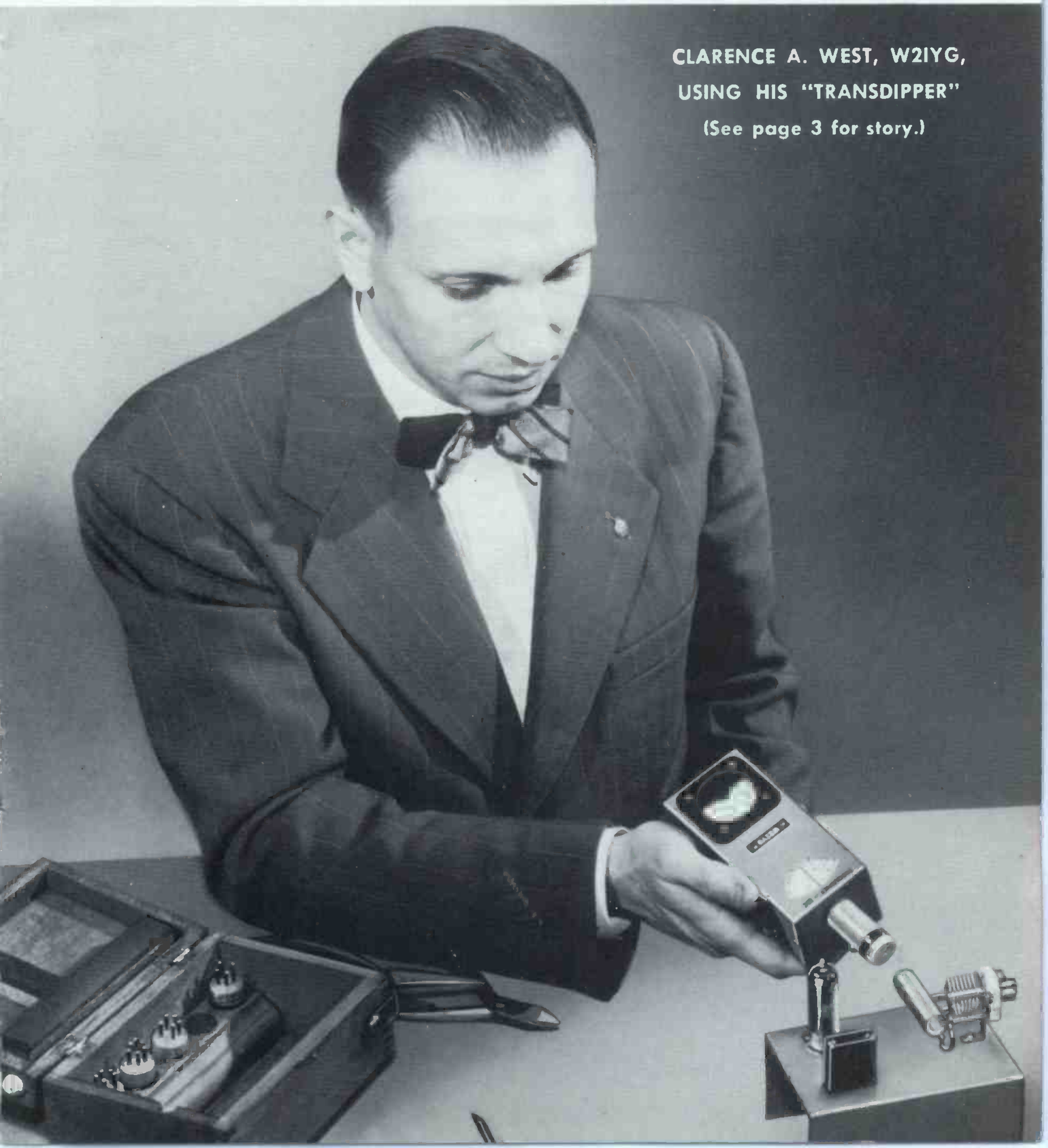


CLARENCE A. WEST, W2IYG, USING HIS "TRANSDIPPER"

(See page 3 for story.)

A Bandpass Transmitter-Exciter Using an RCA 6146

Part II

By Richard G. Talpey, W2PUD*

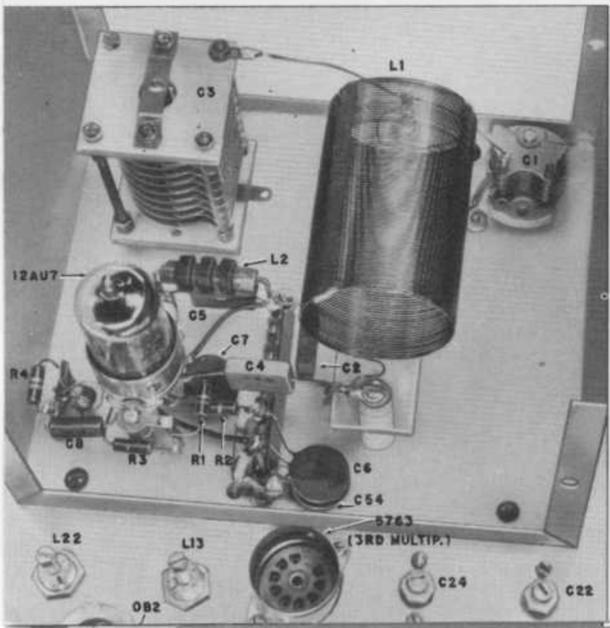
THE TRANSMITTER is built on an 8 by 17 by 3-inch aluminum chassis. The construction is somewhat unconventional inasmuch as the controls project out of the bottom of the chassis through a standard 8 3/4-inch relay-rack panel which forms the front of the shield enclosure.

The VFO is completely housed in the smaller aluminum box shown in *Fig. 1*. The larger box shields the 6146 final amplifier. The layout of the components of the VFO and the final-amplifier plate circuit are shown in *Figures 2* and *4*, respectively. Most of the other components are shown in *Fig. 3* which is a close-up view of *Fig. 2* (Part I). This method of construction permits the bandswitches to be coupled with a single right-angle drive. This arangement provides single-knob control of all bandswitches, thereby facilitating the layout.

The shield for the final-amplifier plate circuit was made from two aluminum cases (See Parts List, Part I). The unflanged portions were discarded, and the flanged sections were overlapped in the center. A sheet of aluminum was cut to fit the top.

The bandswitch is mounted in the center of the chassis so that the switch sections are located near the multiplier tubes. The bandswitch is made from a standard index assem-

Fig. 1. Inside view of the VFO (with cover removed). Note that coupling capacitor C_8 and R_4, the grid resistor for the 6AU6 keyed amplifier, are located in the VFO compartment (See text).



This second and concluding part of W2PUD's article contains the constructional details and adjustment procedures. A complete description of the circuit together with a schematic diagram and parts list appeared in Part I in the June-July issue of HAM TIPS. (If you missed Part I, ask your RCA Distributor for a copy; if his supply has run out, write to RCA, Commercial Engineering, Harrison, N. J.)

bly and separate switch sections selected according to function. A standard two-section switch for the final tank is mounted above the chassis in line with the bandswitch knob; the switches for the multipliers are coupled to the right-angle drive located inside the chassis. The other controls are placed to provide a neat panel arrangement.

VFO

The VFO coil, L_1, was wound by hand on a piece of mailing tube covered with a layer of wax paper. The wire was wound over the wax paper and spaced to occupy the required length. A few extra turns were included to allow for final trimming. A coat of household cement was applied in three longitudinal stripes 120° apart to secure the winding. A second coat was applied after the first coat hardened. The mailing tube was then collapsed and withdrawn along with the wax paper. Finally, each cement stripe was given one more coat of cement (inside and out) to make the coil rigid. After trimming, the whole coil was cemented to a 1/2 by 1/16-in. poly strip which was mounted on ceramic standoff insulators. This type of coil is very rugged and has the high Q required for the Clapp oscillator. The coil must be mounted as far from the sides of the shield as possible, because the shield acts like a shorted turn coupled to the coil and will reduce its Q materially if the spacing is made too small. Care should also be taken to see that the tuning capacitors and other parts cannot move with respect to the 'hot' end of the coil, which is the end connected to the capacitors.

The socket for the 12AU7 is mounted on metal spacers to permit the connectors to be made easily. All of the VFO components (as well as connections) should be made as rigid as possible because the stability of a Clapp oscillator depends to a great extent on its

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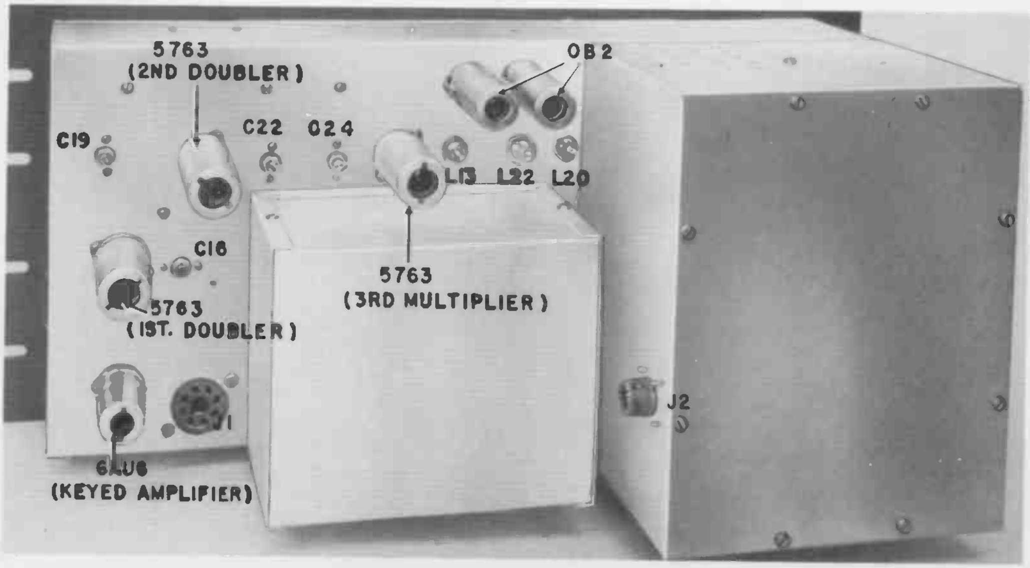


Fig. 2. Rear view of the transmitter. Complete shielding plus the pi-L tank circuit for the 6146 make this unit a "TVI-free" transmitter. The small shield box contains the VFO; the final amplifier is housed in the larger box.

mechanical construction. The grounds to the shield braids for the power leads should be made near the hole where they enter the compartment, and the by-pass capacitors should be grounded to this same point.

General Layout

As many of the holes as possible should be drilled beforehand to eliminate difficulty later on. The paint should be scraped off the back of the panel where it butts against the flange of the chassis to insure a good rf connection and to prevent rf leakage. Careful layout of the panel is required to insure that the shafts for all controls line up properly. Be sure to use panel bearings where the shafts protrude through the panel to prevent the shafts from becoming antennas for TVI. It is helpful to drill the holes for the shield cans and make a trial assembly of the shields before mounting any of the major components. Trial fits for shaft line-up for the bandswitch and tuning capacitors are also recommended.

"First-Layer" Wiring

After making certain that everything will fit where intended, the tube sockets may be mounted and the heater and power wiring started. *All grounds for each stage* are made to lugs bolted under the tube-socket lugs. Components which are not mounted directly on the tube sockets are mounted on tie lugs bolted to the sides of the chassis. All of this "first-layer" wiring is best done before assembly of the bandswitch and coils.

Power is brought into the transmitter by means of an octal socket, and all leads are by-passed at the socket to a common ground point (to which are also tied the shield braids of the power wiring). Pins 5 and 6 on power plug P_1 are connected by a jumper on socket J_1 This arrangement serves as an interlock for the external power supply by preventing application of power to the primary winding of the plate-voltage transformer when plug P_1 is removed from J_1. By-pass capacitors for the 600-volt leads are made from two 0.01-μf, ceramic-disc capacitors connected in series to provide adequate voltage rating. The by-pass capacitor for the high-voltage lead to the final-amplifier plate is a Hypass unit, mounted through a hole in the chassis and supported

COVER PHOTO

Clarence A. West, W2IYG, of the RCA Tube Department's Commercial Engineering section is shown checking the resonant frequency of a tuned circuit with the aid of his "Transdipper" — a grid-dip oscillator employing an RCA 2N33 point-contact transistor in place of the usual vacuum-tube oscillator.

Developed in W2IYG's shack, this experimental unit is believed to be the first grid-dip oscillator using a transistor and covering five amateur bands (1.7 to 33 Mc). Probably the smallest grid-dip oscillator in existence, this complete unit is housed in a metal case measuring only 5 by 2¼ by 2¼ inches. The Transdipper is powered by a self-contained 22½-volt, hearing-aid battery (an RCA VSO84).

Clarence will be remembered by many of the readers of HAM TIPS for his unusual article, "The Big Hunt (or) De-TVIing a 600-Watt, 14-Mc Transmitter," (Summer, 1951 issue) which outlines a straightforward method for eliminating TVI.

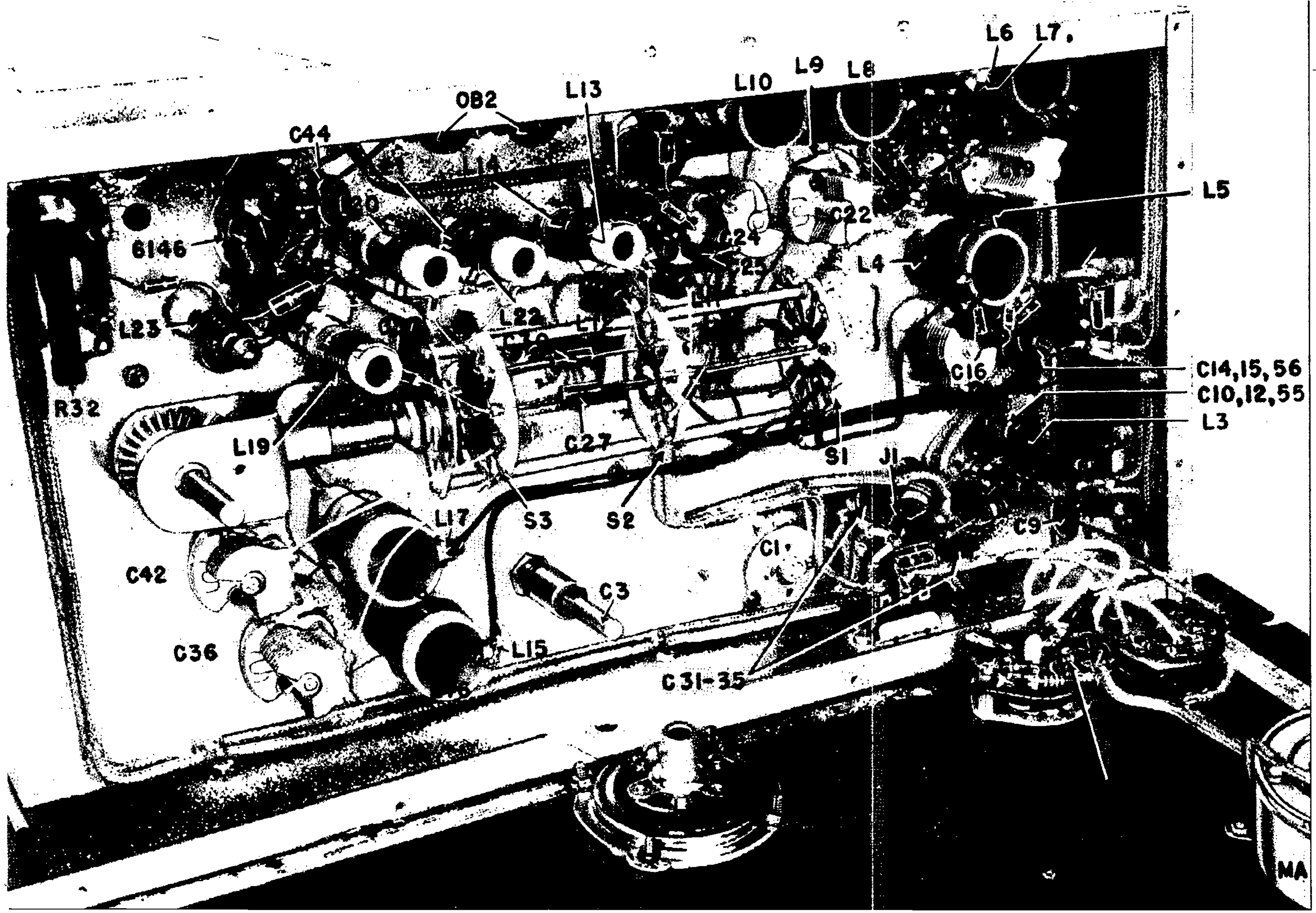


Fig. 3. Inside view of the chassis. This is a close-up of the same view shown in Fig. 2 in Part I of this article. Note that all power and heater leads are wired with shielded wire which is clamped to the chassis at convenient points.

by a small bracket as shown in *Fig. 4*.

Coils

After the preliminary wiring is completed, the bandswitch and the coils may be mounted. The coils should be wound according to the coil specifications given in the Parts List (Part I). Before they are mounted, the coils (with the exception of the link windings which will have to be adjusted later) should be given a coat of polystyrene coil dope. To obtain a high coefficient of coupling, the links are wound over a layer of cellophane tape on top of the main windings of the 3.5-Mc coils (L_4, L_5, L_{15}, and L_{16}).

All other links are wound at the "cold" end of the coils with provisions to move them slightly during line-up. Links L_{14} and L_{21} are made from a single length of No. 18 stiff, insulated wire and supported by cement on L_{13} and L_{22}, respectively, after final adjustment. Link connections to the bandswitch and between various coils are made with 75-ohm Twinlead.

Adding the VFO

After the VFO section has been constructed, it may be placed onto the main chassis at any convenient time. The output lead connects directly to the grid of the 6AU6; make certain that the portion projecting from the braid is as short as possible. Because this lead is in the low-impedance output circuit of the cathode follower, its length is not critical. Grid capacitor C_8 and resistor R_4 are placed inside the VFO shield to preclude any possibility of radiation from exposed parts.

Connections to Panel

Initially, the leads to the switches on the panel should be longer than needed so that it will be convenient to allow the panel to rest on the bench while initial adjustments are made. After the adjustments are completed and the unit is ready for "buttoning up," these leads may be shortened and connected to the switches; they should be just long enough to allow the panel to be swung out.

TVI Precautions

The rear of the meter case is covered with a shield cut from an evaporated-milk can. Fortunately, these cans are just the right size and can be easily cut with a pair of tin snips. The particular make of meter chosen (See Parts List in Part I) is slightly shorter (behind the panel) than some others and does not interfere with the coils which are mounted inside the chassis. The meter shunts, R_{29} and R_{33}, were wound with resistance wire to provide full-scale readings of 200 ma for the final plate current and 10 ma for the final grid current, respectively.

Final Amplifier

The coils for the pi network were cut from coil stock as noted in the Parts List (Part I), and no difficulty should be encountered if the taps are located as shown in the coil specifications. Coil L_{27} is mounted to the chassis by means of a small bracket which is attached to one of the plastic strips which was left a bit longer for this purpose. Coil L_{28} is supported by means of its leads, all of which are short. The output lead from L_{28} to the coax connector is shielded to reduce its inductance and to reduce stray pickup. Padding capacitors C_{50} and C_{53} are mounted between the bandswitch and ground lugs located directly underneath.

All under-the-chassis ground connections for the final amplifier are made to a lug which is mounted *on top* of the chassis and bent down through a clearance hole to receive the under-chassis leads. This arrangement *keeps all rf paths on one side of the chassis* and as short as possible. Copper strap is used for rf connections in the final amplifier to reduce inductance and keep spurious resonances at the highest frequency.

Adjustments

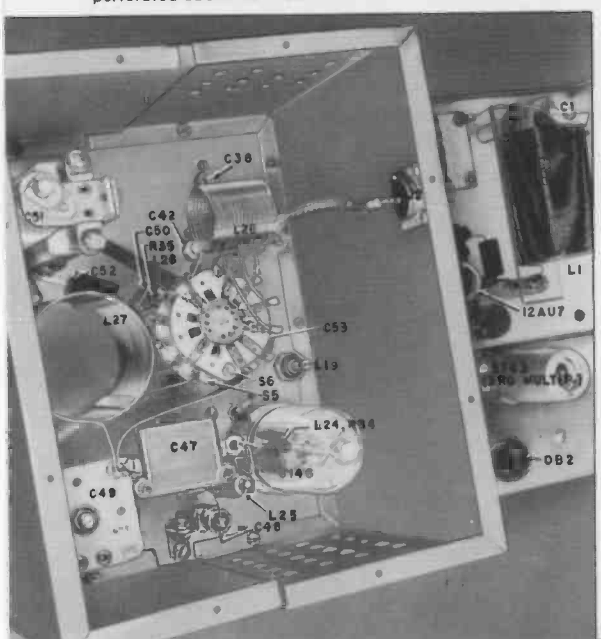
After the wiring has been completed, the rig is ready for lining up; the lineup may be done once and then forgotten. Remove all tubes except the 12AU7 from their sockets and test the VFO with the shield off. Adjust C_1 to set the band edge, and set C_2 for minimum capacitance to make certain that the band is covered. Some cutting of L_1 may be necessary to make the band fit the dial fully. Put the shield on the VFO, and check to determine whether the VFO can be heard in the receiver. If the shield is tight and the decoupling is done properly, the VFO will not be audible.

A milliammeter should be inserted in the 250-volt lead during the lineup procedure to check plate currents. A high-resistance, dc meter such as an RCA VoltOhmyst® will be found useful for reading the rectified grid voltage, although a milliammeter wired temporarily in series with the ground end of the grid resistor will also serve the purpose. The connection between the meter and resistor should be by-passed if this latter method is used. With the 6AU6 and the first 5763 in their sockets, about 2 ma of grid current will flow in R_9 when the key is down. (Link L_5 should have its coupling reduced, and the first doubler tank should be tuned to resonance.)

Insert the 6146; with the plate voltage off and the bandswitch in the 3.5-Mc position, grid current should flow in the 6146 when the grid tank is tuned to resonance. Connect a 1,000-ohm carbon resistor temporarily across L_{16} and set the VFO to about 3.7 Mc. Slide links L_5 and L_{15} down over the coils slightly and resonate both circuits. The 1,000-ohm resistor reduces the Q of the coupled circuits to a low value, and in so doing, reduces the coefficient of coupling (dependent upon the Q). The undercoupled circuits can be peaked easily without interaction.

The grid current under this condition will be fairly small, but enough to indicate resonance. After the circuits have been tuned to resonance, remove the temporary resistor and check the grid drive over the band. It should have two peaks near the ends of the band and a valley in the center. If necessary, readjust C_{16} and C_{36} slightly so that the drive is fairly uniform over the band. A couple of tries may be necessary to obtain the right coupling between the link and the tuned circuits for the best uniformity of drive. The above procedure should be repeated each time in tuning up.

Fig. 4. Beam-power final — 1953 design! Copper strap is used to reduce lead inductance between the bandswitch and the tuning and loading capacitors. The shield box is perforated above and below the 6146 for adequate ventilation.



Next, insert the second doubler tube and turn the bandswitch to 7 Mc and set the VFO to 7.2 Mc. Connect the grid-current meter to R_{13}, and connect the 1,000-ohm resistor across L_7. Couple L_6 to L_7 and resonate the circuit with C_{19} without touching the adjustment of C_{16}. Removal of the 1,000-ohm resistor should now provide nearly uniform drive to the second doubler over the range of the VFO from 3.5 to 3.72 Mc. Again, the spacing of the links may have to be changed a couple of times to obtain the best results. The grid drive to the final amplifier through L_9 may now be adjusted by the same technique, although it will usually be unnecessary to use the 1,000-ohm resistor for the bandwidth required to cover the 7-Mc band. (The bandwidth of the circuit containing L_4 and L_7 must be broad enough to cover the 28-Mc band, whereas the plate circuit of the second doubler when coupled to the final grid need only cover 7 to 7.3 Mc.) Adjust C_{22} and C_{42} to provide uniform drive over the 7-Mc band.

Now, connect the 1,000-ohm resistor across L_{10} and resonate this circuit with C_{24} (at 7.2 Mc) with the aid of the grid meter in series with R_{17}. Do not readjust C_{22} unless it is necessary in order to make the drive to the third multiplier uniform over the range of the VFO from 3.5 to 3.7 Mc. If C_{22} has to be readjusted, go back and check the final grid drive on 3.5 Mc to be sure it has not been altered. Remove the resistor again and check the drive to the third multiplier. The location of L_{10} with respect to L_8, as given in the Parts List (Part I), should be about correct; however, this spacing may have to be changed slightly if the coils have not been wound exactly as described. L_{10} should not be closer to L_8 than is necessary for the required bandwidth for 28-Mc operation.

The difficult part of the lineup is now over and you may relax. The slugs in L_{19} and L_{20} may be adjusted to peak the final grid drive in the center of the 14- and 21-Mc bands, respectively. The 1,000-ohm resistor loading should be repeated on L_{22} and L_{13} to provide uniform drive across the 28-Mc band.

Go back and check the drive on each band and readjust wherever necessary. Then lock all capacitors and slugs. Apply a dab of cement to secure the links to the coils – you will not have to adjust these circuits until you rebuild!

Power may now be applied to the final amplifier. It is best to start at reduced plate voltage with a series resistor in the high-voltage lead. Connect a 50-ohm dummy load to the output jack with a pilot lamp across it. On any band, with C_{51} at maximum, C_{49} should be rotated to obtain a dip in plate current. The dip will be more pronounced on the higher frequency bands because the required capacitance for light loading will be less. Decreasing C_{51} will raise the plate current and the power output. Capacitor C_{49} should always be tuned for minimum plate current after C_{51} has been changed or the pi network will not behave correctly for best harmonic reduction. The presence of parasitics can be determined by reducing the fixed bias until the amplifier draws about 100 ma with the key up. Rotate C_{49} and note whether there are any changes in plate current. If there are, the amplifier is oscillating and the frequency of the parasitic oscillation should be determined with a grid-dip meter or wavemeter. During the design, the addition of L_{24} and L_{26} removed the last traces of parasitics and no tendency to oscillate was ever noted at the operating frequency.

TVI Check

With the panel and shields bolted securely, and a shielded dummy load connected to the output, no TVI was encountered with the transmitter on the bench beside a TV receiver protected with a high-pass filter. This test was made 30 miles from the TV transmitter. An inefficient TV antenna was used on the receiver which caused considerable snow on most channels. Removal of the shield from the dummy load produced crosshatching on some channels when the transmitter was operating on 14, 21, or 28 Mc. (The if amplifier in this receiver was not in the 21-Mc band!) When the 6146 plate circuit was tuned off resonance, the weak channels were obliterated – dramatic proof that the final tank must always be tuned to resonance. In regions where TV signal strength is low, a low-pass filter may be required to reduce TVI to a minimum.

Antenna Matching

The pi-L network will accommodate slight variations from the 50-ohm antenna impedance it is designed for; if the coax is not reasonably well matched, some trouble may be experienced in loading the final. A standing-wave bridge is invaluable for checking line match, either with direct feed or a line feeding an antenna tuner.

Keying

Very satisfactory keying was obtained without the use of a key-click filter. Because the multiplier stages and the final are not overbiased, no appreciable squaring of the wave shape results and the keying is clean, but not hard. If a softer note is desired, some filtering may be used provided that the cathode resistor of the 6AU6 is altered to take into account any resistance in the filter. The bias on the 6AU6 should be kept between 1 and 1.5 volts.

Modulation

The usual precautions in modulating any tetrode amplifier apply to this transmitter. The screen and plate are modulated together – about 40 watts of audio should be available. The use of a fixed screen supply for the 6146 is not recommended for phone operation.

A Few Afterthoughts

After the conclusion of such a project it is natural to wonder what possible improve-

Table of Voltages & Currents *(Typical at 7 Mc)

Tube	E_p (volts) Key Down	E_p (volts) Key Up	I_p (ma) Key Down	I_p (ma) Key Up	E_{g2} (volts) Key Down	E_{g2} (volts) Key Up	I_{g2} (ma) Key Down	I_{g2} (ma) Key Up	E_{g1} (volts) Key Down	E_{g1} (volts) Key Up	I_{g1} (ma) Key Down	I_{g1} (ma) Key Up
12AU7	45	45	6**	6**	—	—	—	—	—	—	—	—
6AU6	240	240	7	0	150	265	2.2	0	—	0	—	—
5763	240	240	20	17	145	180	1	1	—	–7	—	—
5763	240	240	18	19	130	170	1.5	1.5	—	–7	—	—
5763	240	220	14	19	160	180	1.0	1.2	—	–7	—	—
6146	600	650	150	10	200	210	15	—	–85	–45	3	0

* Heater voltage: 6.3 v. Supply voltages: 260 v and 600 v. ** Both sections.

ments could have been made, given the benefit of hindsight. Among these afterthoughts might be included the following:

(1) Bandspreading of the VFO to make the narrow bands easier to tune.

(2) Substitution of slug-tuned coils and fixed capacitors for the tuning capacitors in the low-frequency stages.

(3) Several changes in mechanical layout to facilitate wiring and improve the appearance. But as one who enjoys rebuilding occasionally, these changes were left for another session.

Acknowledgment

The author wishes to thank Mr. George Grammer, W1DF, for his helpful correspondence on the matter of harmonic response and Q of the pi network, and Mr. George D. Hanchett, Jr., W2YM, for his encouragement and many helpful suggestions.

Errata

There are four errors in the parts list on page 5 of the June-July, 1953 issue of HAM TIPS. L_1 should have 80 turns instead of 40; L_{28} is made from B & W 3015 Miniductor instead of 3105, and C_{48} should have a rating of 1,000 wv instead of 500 v. C_{25} should be listed with C_4, etc.

RCA TRANSISTORS NOW COMMERCIALLY AVAILABLE

The commercial availability of four RCA transistors was recently announced in an RCA Tube Department ad appearing in several trade publications.

The four types of RCA transistors announced are:

2N32—Point-contact type designed for large-signal applications such as switching circuits.

2N33—Point-contact type designed for oscillator applications up to 50 Mc.

2N34—Junction p-n-p type designed for low-frequency, low-power amplifier applications.

2N35—Junction n-p-n type designed for low-frequency, low-power amplifier applications.

Bulletins containing characteristics and technical information on these RCA transistors may be obtained by writing to RCA, Commercial Engineering, Harrison, N. J.

Because of the heavy demand for these transistors, please bear with us if your RCA distributor is out of stock.

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Joseph Pastor, Jr., W2KCN
Editor

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