The Deluxe HBR Receiver

Extracted from 'The Radio Handbook, 17th Edition' Edited by William Orr

One of the most popular receiver designs in recent years has been the HBR circuit, the creation of Ted Crosby, W6TC, and others. Described in this section is a modernized version of this popular receiver incorporating many improvements over the earlier HBR models. The Deluxe HBR amateur-band receiver is expressly designed for high-quality performance on SSB and CW and has a high order of selectivity and stability. It has good dynamic signal range to help protect it from excessive cross modulation caused by strong signals and features high-Q RF circuits for "up front" selectivity. Best of all, the receiver may be built for a modest price and without the use of special metal-handling tools.

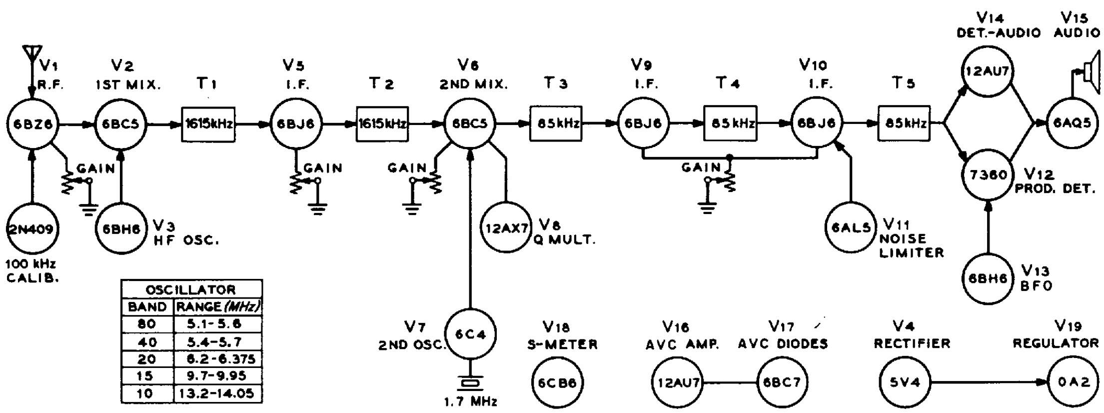
The Deluxe HBR receiver (photo at end of article) is a double conversion superheterodyne employing nineteen tubes.

A high-C electron-coupled oscillator is used in the first conversion stage to combine a good order of stability with circuit simplicity. Receiver coverage is restricted to the high-frequency amateur bands only (80 through 10 meters), and inexpensive plug-in coils are used to simplify receiver construction and to achieve high-Q circuitry. Separate gain controls are provided for the RF stage, the first IF stage, the second mixer, and the low-frequency IF system. These adjustments permit the operator to establish the over-all gain of the receiver in such a way as to accommodate his particular operating conditions, and this flexibility has proven to be one of the outstanding features of this receiver. A delayed AGC system provides ample control for local signals, yet allows full sensitivity for weak signals.

Auxiliary circuitry includes a 100-kHz transistor crystal calibrator, IF noise limiter, S-meter, and Q-multiplier.

Construction of the Deluxe HBR receiver is done on two chassis, with the RF circuitry placed on a separate small chassis that may be assembled and tested as a separate unit, if desired. Receiver RF alignment is easily accomplished by separate bandset and bandspread adjustments using an auxiliary signal source.

A block diagram of the Deluxe HBR receiver is shown in figure *49.*



OSCILLATOR	
BAND	RANGE *(MHz)*
80	5.1-5.6
40	5.4-5.7
20	6.2-6.375
15	9.7-9.95
10	13.2-14.05

Figure 49

BLOCK DIAGRAM OF THE DELUXE HBR RECEIVER

The deluxe HBR receiver employs a tunable first oscillator (V_3) and a crystal-controlled second oscillator (V_7) The second harmonic of the tunable oscillator is used for operation above 40 meters. Separate gain controls are incorporated in the receiver to enable the user to set the stage gains for optimum reception. Use of 1615-kHz first intermediate frequency provides good image rejection while second intermediate frequency of 85 kHz provides excellent adjacent-channel selectivity. Extra operating aids such as Q-multiplier, S-meter, and noise limiter make SSB reception a pleasure.

The RF Section – the receiver covers the amateur bands between 80 and 10 meters with sufficient overlap at the band edges for auxiliary activities such as MARS.

- Plug-in coils are employed in the RF tuned circuits.
- The RF stage employs a 6BZ6 semi-remote-cutoff pentode (V_1) to provide maximum weak-signal performance while still allowing freedom from crosstalk and front-end overload. The RF stage gain control is normally run open and is only backed off in the presence of strong local signals.
- A 6BC5 serves as a high-gain, low-noise mixer (V_2), with conversion oscillator injection on the control grid. The injection level is adjustable to provide optimum signal-to-noise level consistent with good overload capability.
- The first conversion oscillator (V_3) is a 6BH6 in a plate-feedback circuit having good frequency

stability. Fundamental-frequency injection is employed on the 80-and 40-meter bands and second-harmonic injection is used on the 20-, 15-, and 10-meter bands.

Electrical and mechanical bandspread tuning are both employed in this receiver. A high-ratio tuning dial (110:1) is used, permitting easy tuning of SSB signals. In addition, a tapped-coil bandspread technique (see *Radio Receiver Fundamentals* chapter) is employed (figure *51).*

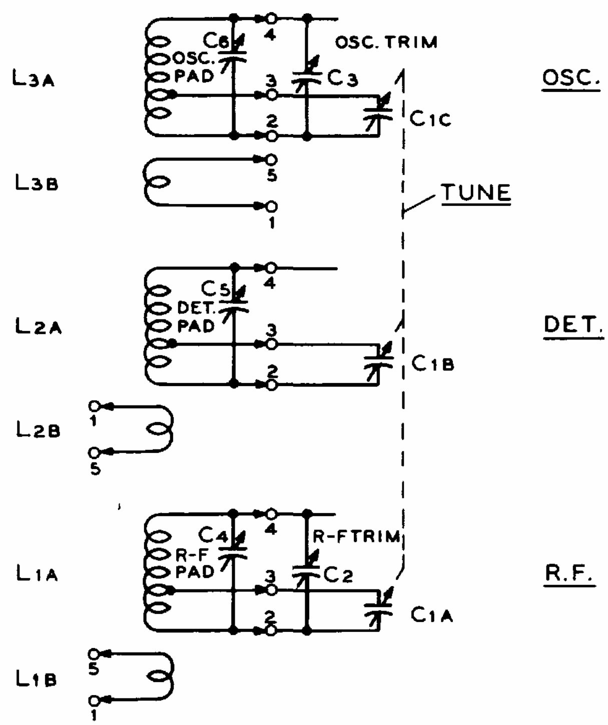


Figure 51

BANDSPREAD SYSTEM FOR RECEIVER

A simple and proven bandspread system is used in the Deluxe HBR receiver. Because the oscillator operates "offset" in frequency from the detector and r-f circuits, a tapped bandspread system is used to allow the oscillator to track when similar tuning capacitors are ganged. The oscillator operates on the high-frequency side of the received signal on 80 and 40 meters, and on the low-frequency side on the higher bands. Adjustment of the coil tap provides the correct tuning rate. This must be smaller than that of the detector and r-f stage, because the oscillator covers a smaller range than the other stages, when both ranges are expressed as a percentage of frequency. Minute frequency corrections are taken care of by the "Osc. Trim" capacitor (C_3), and r-f stage alignment is accomplished by means of the "R-f Trim" capacitor (C_2). Padding capacitors for each band are placed inside the plug-in coil forms.

The tuning rate of the high-frequency oscillator (expressed as a percentage of frequency) may be matched to the rate of the RF and detector stages by proper adjustment of the padding capacitors in the bandspread circuit.

The IF Section – two intermediate frequencies are used in the Deluxe HBR receiver. The first intermediate frequency is 1615 kHz, which provides good image rejection in the high-frequency range. The second intermediate frequency is 85 kHz, which provides excellent adjacent-channel selectivity. Separate gain controls are provided for the two IF sections and also for the second mixer stage. Normally, the IF and mixer gains are retarded as the receiver has more than sufficient gain for all modes of operation. Ample selectivity is available at 1615 kHz to prevent broadcast and 1650-kHz navigational-aid signals from causing interference to desired signals.

- A 6BJ6 (V_5) is used in the high-frequency IF stage, followed by a 6BC5 (V_6) second mixer.

- The second conversion oscillator is a 6C4 (V_7) in a crystal-controlled Pierce circuit. The conversion frequency is 1.7 MHz.

Small, high-Q IF transformers designed for 100-kHz operation are padded down to 85 kHz to provide excellent over-all selectivity. The nose of the selectivity curve is under 2 KHz in width, with the over-all passband measuring about 4 KHz wide at 60 decibels below the reference signal level.

- A 12AX7 Q-multiplier (V_8) provides additional IF selectivity for CW reception or may be used to place a rejection notch at any point in the IF passband to attenuate interference.
- An IF noise limiter employing a 6AL5 diode clipper (V_{11}) is employed in the plate circuit of the last 85-KHz IF amplifier stage. Clipping level is adjustable.

The Detector, AGC and Audio Section – Dual detectors are provided in the Deluxe HBR receiver. A 7360 is used as a product detector for SSB and CW reception (V_{12}) with local-oscillator injection on the control grid. The IF signal is injected at one deflection plate, with the resulting output containing signal components produced by the product of the input signals. The desired audio component is selected and filtered in the plate circuit of the 7360.

- A 6BH6 beat-frequency oscillator (V_{13}) serves for CW and SSB reception.
- A 12AU7 infinite-impedance detector (V_{14}) is used for AM reception.

The AGC system makes use of an audio-controlled *hang circuit* especially designed for SSB and CW modes. It features a very rapid response that prevents receiver overload on a syllabic burst of SSB, instantly reducing the receiver gain. The gain reduction remains in effect as long as the signal is in evidence, then hangs on for about 0.5 second after the removal of the signal. This sequence reduces to a minimum the usual “thump” that occurs at the start of a syllable and removes the “rush” of background noise at the end of a syllable, both of which occur with less sophisticated AGC circuits. A choice of fast or slow release action may be made. A triple diode 6BC7 (V_{17}) and a 12AU7 double triode (V_{16}) comprise the AGC system. The double-diode circuit (V_{17A} and $_{B}$) and the 470K/0.01-mfd RC combination determine the “on” time of the attack network, permitting the 0.1-mfd AGC capacitor to charge up in a relatively quick time. The capacitor remains charged, as the 12AU7 (V_{16A}) triode is cut off by this action, and there remains no discharge path to ground in the AGC circuit, even when the voltage across the RC network is removed. The time constant of the release network is considerably longer, and is adjusted by the “slow-fast-off” AGC switch (S_1). After a predetermined period, the voltage across this network decays sufficiently to permit the triode release gate (V_{16A}) to conduct and discharge the AGC line capacitor. A slight degree of delayed AGC action is provided by applying fixed bias to the attack diode to prevent the circuit from being tripped by background noise or weak signals.

A single 12AU7 triode section followed by a 6AQ5 provides sufficient audio level for earphone reception, or to drive a speaker to good room volume. Feedback is incorporated in the 6AQ5 stage to provide smooth audio response.

The S-Meter and Power Supply – the S-meter consists of a simple VTVM that compares AGC voltage against a fixed voltage reference. The 6CB6 bridge plate circuit (V_{18}) is balanced for a meter null with no signal input to the receiver, and AGC voltage in the presence of a signal unbalances the bridge and causes a reading on the meter proportional to signal strength. The meter may be used for all modes of reception, providing useable readings on CW signals as well as SSB or amplitude modulation.

The power supply utilizes a choke input circuit, with critical voltages regulated by a 0A2.

Standby is accomplished by relay RY that breaks the RF stage cathode and speaker circuits of the receiver when actuated by the VOX circuit of the transmitter.

A separate filament transformer is used for the oscillator tubes, permitting them to run continuously, thus drastically reducing the warm-up drift of the receiver, especially in a humid location.

Receiver Construction

A receiver such as this is a complex device and its construction should only be undertaken by a person familiar with receiving equipment and who has built and aligned equipment approaching this complexity.

- The first step is to layout the chassis, panel, tuning dial, and larger components in a “mockup” assembly to ensure that the receiver will go together without a conflict between the components.

- The receiver is built on an aluminum chassis measuring 10” X 14” X 3”. A chassis having welded seams with triangular braces in each corner is recommended for maximum rigidity.

- The complete receiver fits in a steel cabinet measuring 11” x 15” x 9”.

- A series of 1/8—inch holes are drilled around the upper edges of the sides and back of the chassis for ventilation and another series of 3/8–inch holes is drilled across the rear top and bottom edges of the cabinet.

- The bottom of the cabinet, in addition, is “honeycombed” with 3/8-inch holes.

- Additional holes are also required in the rear of the cabinet for various cables and terminations to plugs and receptacles mounted on the rear apron of the chassis.

The RF circuits of the receiver are built on a steel sub chassis measuring 5″ x 7″ x 2″ mounted above the main chassis as shown in the photographs.
The sub chassis is affixed to the main chassis by means of 6-32 spade bolts mounted in the corners of the smaller unit. Placement of the sub chassis is shown in figure 54.

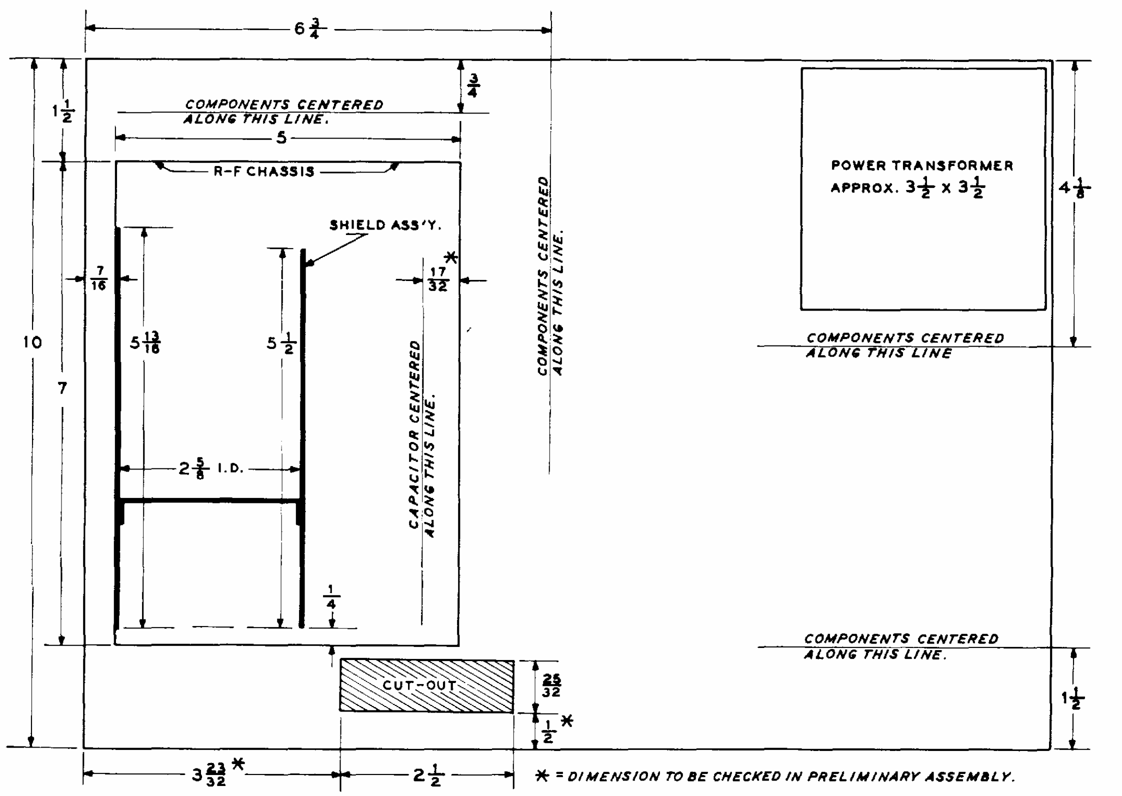


Figure 54

TOP CHASSIS LAYOUT OF MAJOR COMPONENTS

Alignment of the dial on the panel is determined by the positioning of the main tuning capacitor (C_{1A-B-C}). The capacitor used is a high-quality unit having full ball-race bearings front and back and a controlled torque. This unit provides minimum drag on the geared dial. The tuning capacitor is mounted above the chassis on two bolts as shown in the various illustrations. Note that the capacitor is insulated from the top of the chassis and the dial, the rotor frame being grounded by a separate ground strap running from the capacitor frame to the under-chassis area of the RF unit. This grounding technique avoids spurious ground loops in the RF assembly that may give rise to regeneration and instability. The tuning capacitor is driven via a rigid insulated bushing and the supporting bolts are adjusted and locked after alignment of the front panel, thus assuring minimum dial drag.

The receiver chassis rests on the floor of the cabinet and the chassis is mounted nearly flush with the bottom edge of the panel.

The dial assembly is positioned as shown in the layout drawing (figure *55).*

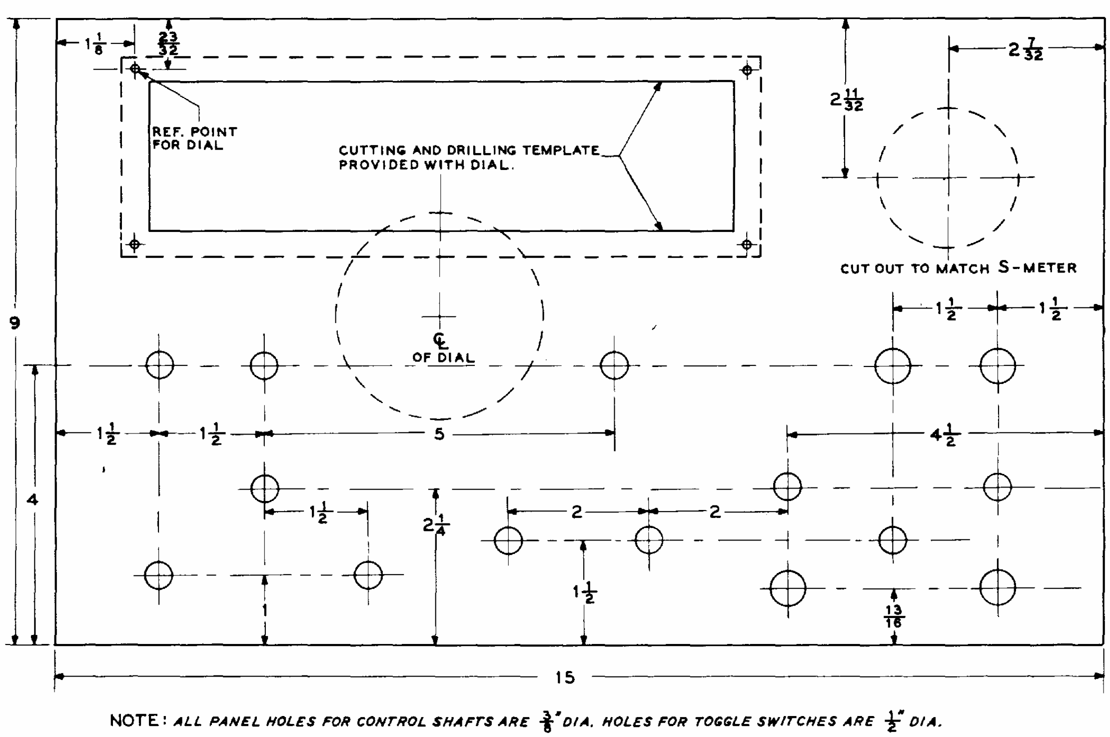


Figure 55

PANEL LAYOUT FOR DELUXE HBR RECEIVER

It is suggested that the RF chassis be temporarily placed on the larger chassis after mounting the tuning capacitor and dial placement can then be checked before any holes are cut in the panel.

The panel is held in position by means of the various hexagonal potentiometer and switch control nuts. Two sets of nuts are used, one to hold the control to the chassis (and to space the panel from the chassis) and the second to fasten the panel firmly to the chassis. The space between panel and chassis accommodates the lower lip of the steel cabinet, which may be cut down in length and width to facilitate placing the receiver in the cabinet.

The chassis, sub chassis, dial, and panel should be assembled and studied before the chassis holes are drilled. Placement of the remaining components may be done from a study of the photographs and layout drawings. Use of a paper layout template for drilling the chassis is recommended.

The RF Assembly

- The three plug-in coils, the tuning capacitor, the RF tubes (6BZ6, 6BC5 and 6BH6), together with the first 1615-kHz IF transformer (T_1) are mounted on the sub chassis.
- An above-chassis shield compartment isolates RF coil L_1 from the tuning capacitor and from the oscillator coil (L_3).
- A second compartment isolates the mixer coil (L_2). The 6BZ6 and 6BC5 tubes are in the same compartment as coil L_2.
- A small shield plate is required across the bottom of the 6BZ6 socket and is notched to fit directly over the socket, isolating the grid wiring from the plate circuit. The various 6BZ6 bypass capacitors are grounded to the shield plate, as is the center stud of the socket.

Ceramic sockets are used for the plug-in coils and for the 6BH6 oscillator tube.

- The socket for coil L_1 is placed so that pin 4 is adjacent to pin 1 of the 6BZ6 socket.
- Coil socket L_2 is oriented in the same manner with respect to the 6BC5 socket.
- If the socket for coil L_3 has a metal mounting plate, an application of “coil dope” or cement should be placed around the ceramic to eliminate movement

between the socket and the plate, providing a solid mounting for the oscillator coil.

Use #18 solid wire for wiring socket connections to avoid instability caused by lead movement in the RF assembly.

The lead from pin 3 of the oscillator coil socket to the stator of capacitor C_{1C} should be #12 wire for best mechanical stability.

All power connections to the RF sub chassis are made to a multi-terminal strip mounted on one wall of the unit.

The connection between IF transformer T_1 on the sub chassis and the 6BJ6 IF amplifier socket (pin 1) is made via a small feed-through insulator mounted on the rear wall of the sub chassis, the lead from the insulator passing through a grommet mounted in the chassis deck of the under-chassis area.

The IF System – The 6BJ6 IF amplifier (1615 KHz), transformer T_2 and the second mixer (6BC5, V_6) are located on the main chassis directly behind the RF sub chassis. The 12AX7 Q-multiplier is placed in the rear left corner of the chassis, with the 6C4 crystal oscillator and 1.7-MHz crystal at the right end of the IF strip, as seen in the photographs.

The 85-kHz IF system is positioned from front to back along the center of the chassis. The transformers are oriented so that plate and grid leads to adjacent sockets are short and do not cross over each other. Sockets, too, are oriented to provide short grid and plate leads.

The AGC, Audio, and Power Systems – The power supply occupies the right rear corner of the chassis, with the ‘S-meter adjustment’ and ‘S-meter zero’ potentiometers placed in front of the power transformer.

The noise limiter and detector tubes are near the front of the chassis, adjacent to IF transformer T_5.

The product detector and audio system are to the right front of the chassis.

Beneath the chassis (figure *56),* the BFO components are housed in an aluminum box measuring 2″ x 2.75″ x 4″, centered under the BFO tube socket.

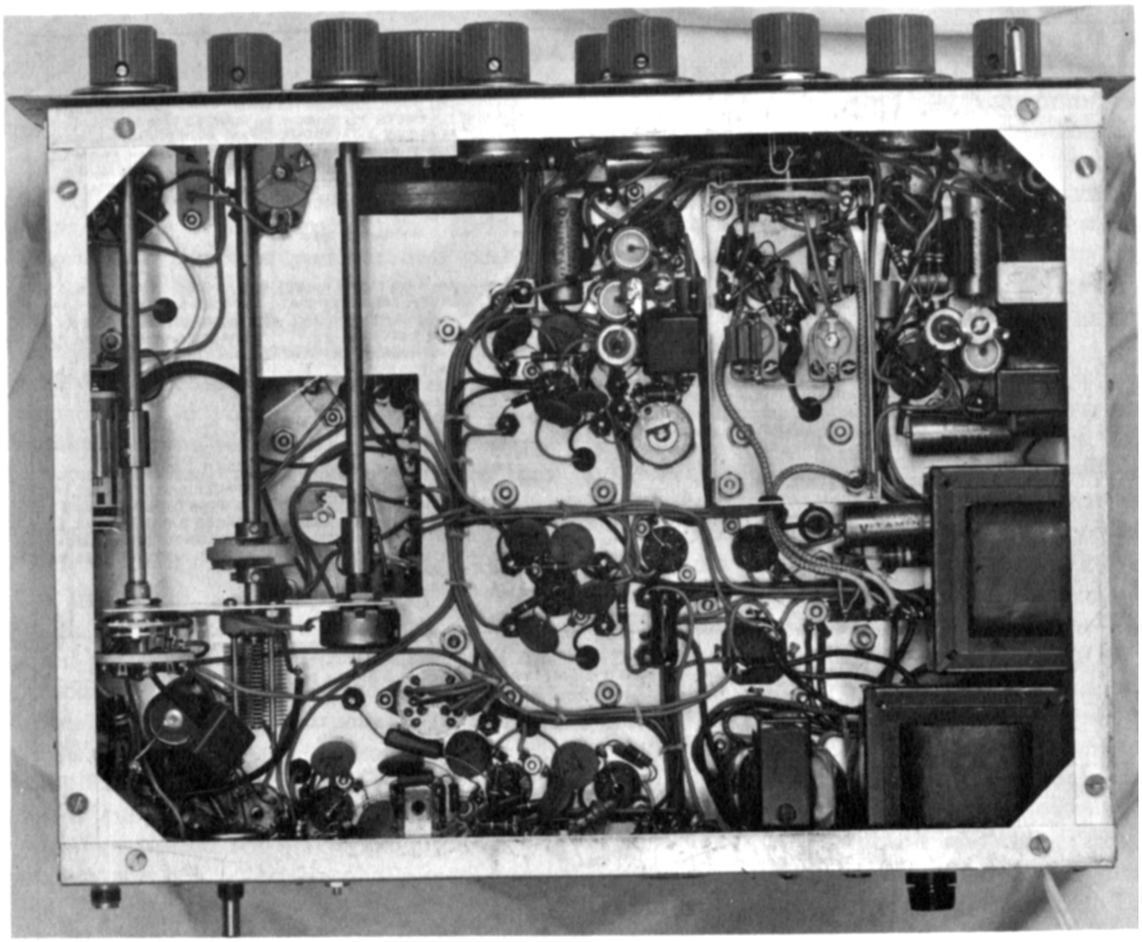


Figure 56

UNDER-CHASSIS VIEW OF RECEIVER

Q-multiplier controls and selector switch are mounted on small aluminum bracket in lower left corner of chassis, with cutout for access to r-f area directly in front. Bfo components are mounted in aluminum box at right, front. Power leads to bfo stage are shielded. The output transformer and agc transformer are mounted to the side wall of the chassis next to the bfo box, with the larger filter chokes to the rear. Oscillator filament transformer is mounted on rear wall of the chassis. Note corner braces bolted to lower lip of chassis for extra rigidity.

Various chokes and transformers are mounted to the sidewall of the chassis, with the Q-multiplier controls mounted on a sub panel placed near the rear of the receiver. Extension shafts couple these controls to the panel dials. Panel bushings are placed on all extension shafts.

Receiver Wiring

The receiver should be wired in an orderly manner, a stage at a time. The power supply and filaments should be wired first. The builder should avoid overloading the filament wiring by wiring the sockets in several branches of four to five tubes, with separate leads running from the filament transformer to each branch.

To reduce RF ground-current intercoupling, all grounds for a single stage should be returned to that stage, preferably to a common ground point near the tube socket. The cathode, AGC-bypass, and screen capacitors, for example, can all return to a ground connection near the cathode pin of the socket in question. Components should be grouped about a socket where possible, and not “stacked” above the socket so the latter can be reached for voltage measurements.

Before BFO transformer T_6 is mounted, the compression-type mica trimmer capacitor is removed from the case and the transformer reassembled. A 25-pf ceramic trimmer (C_{11}) in parallel with a 175-pf silver-mica capacitor is mounted under the chassis in the BFO enclosure. This substitution removes a slight frequency instability noted on SSB signals due to the flexing of the spring on the compression capacitor.

After the power supply has been wired and tested, the audio system may be checked out by applying an audio signal to the top end of the audio gain control (R_7).

The BFO may be checked for proper operation with a VTVM, if handy, by measuring the rectified RF voltage at the plate of the 6BH6 oscillator tube, which should be about 10 volts.

Power leads from the BFO enclosure should run in shielded braid, with the braid grounded at both ends of the leads.

The IF system and crystal conversion oscillator may be checked by injecting a 1615 KHz test signal at the grid of the first IF amplifier tube (V_5).

The complete receiver, less the RF assembly may be completed and checked, stage-by-stage as work progresses.

The RF Circuits

Plug-in coil data is given in the accompanying table.
The coils are easy to wind and the receiver is simple to align. Five-pin, 1.25-inch diameter polystyrene coil forms,

available from *Allied Radio Co.,* Chicago, Ill. (catalog number 46-Z-696) are used.
Figure *57* summarizes the windings and shows them in relation to the coil pins.

COIL TABLE

3.5 MHz	L1A, L2A: 29 TURNS No. 26, CLOSE-WOUND, THEN 3 1/2 TURNS SPACED 1/4 INCH, THEN 4 TURNS CLOSE-W'D. TAPPED AT 31-1/4 TURNS; (TOTAL 36-1/2 TURNS). L3A: 15 TURNS No. 22 CLOSE-WOUND, THEN 3-1/2 TURNS SPACE-WOUND OVER 5/16 IN.; TAPPED AT 18-1/4 TURNS (TOTAL 18 1/2 T'S). C4, C5: 50-PF AIR PADDER. C6: 75-PF AIR PADDER.	L1B: 5-7/8 TURNS No. 26, SPACED 3/8 IN. FROM L1A. L2B: 9-7/8 TURNS No. 26 SPACED 5/16 IN. FROM L2A. L3B: 11-7/8 TURNS No. 26, SPACED 3/16 IN. FROM L3A.
7 MHz	L1A, L2A: 6-1/2 TURNS No. 22, CLOSE-WOUND, THEN 16 TURNS SPACE-W'D TO AN OVER-ALL LENGTH OF 1 IN; TAPPED AT 9-3/8 TURNS, (TOTAL 22-1/2 TURNS) L3A: 6-1/2 TURNS No. 22, CLOSE-W'D THEN 7 T'S SPACE-WOUND TO AN OVER-ALL LENGTH OF 9/16 INCH; TAPPED AT 13-1/4 TURNS, (TOTAL 13-1/2 TURNS) C4, C5: 50-PF AIR PADDER. C6: 50-PF AIR PADDER, + 68-PF SILVER MICA.	L1B: 2-7/8 TURNS No. 26, SPACED 7/16 IN. FROM L1A. L2B: 3-7/8 TURNS No. 26, SPACED 3/8 IN. FROM L2A. L3B: 10-7/8 TURNS No. 26, SPACED 3/32 IN. FROM L3A.
14 MHz	L1A, L2A: 11-1/2 TURNS No. 22. LENGTH 15/16 INCH. TAPPED AT 4-1/4 TURNS. L3A: 8-1/2 TURNS No. 22, LENGTH 1/2 IN. TAP'D AT 8-1/4 TURNS. C4, C5: 25-PF AIR PADDER. C6: 50-PF AIR PADDER, +200-PF SILVER MICA.	L1B: 3-7/8 TURNS No. 26, SPACED 5/16 IN. FROM L1A. L2B: 3-7/8 TURNS No. 26, SPACED 7/16 IN. FROM L2A. L3B: 11-7/8 TURNS No. 26, SPACED 1/8 IN. FROM L3A.
21 MHz	L1A, L2A: 8-1/2 TURNS No. 22 LENGTH 7/8 IN; TAP'D AT 2-1/4 TURNS. L3A: 5-1/2 TURNS No. 22 LENGTH 3/8 IN; TAP'D AT 4-1/4 TURNS. C4, C5: 25-PF AIR PADDER. C6: 50-PF AIR PADDER, + 140-PF SILVER MICA.	L1B: 3-7/8 TURNS No. 26, SPACED 5/16 IN. FROM L1A. L2B: 3-7/8 TURNS No. 26, SPACED 5/16 IN. FROM L2A. L3B: 8-7/8 TURNS No. 26, SPACED 5/32 IN. FROM L3A.
28 MHz	L1A, L2A: 5-1/2 TURNS No. 22, LENGTH 15/16 IN; TAPPED AT 2-3/8 TURNS. L3A: 5-1/2 TURNS No. 22, LENGTH 1/2 IN; TAPPED AT 5-1/4 TURNS. C4, C5: 25-PF AIR PADDER. C6: 50-PF AIR PADDER, + 47-PF SILVER MICA.	L1B: 3-7/8 TURNS No. 26, SPACED 3/16 IN. FROM L1A. L2B: 3-7/8 TURNS No. 26, SPACED 3/8 IN. FROM L2A. L3B: 8-7/8 TURNS No. 26, SPACED 5/32 IN. FROM L3A.

NOTES:
ALL COILS WOUND WITH ENAMELED WIRE ON $1\frac{1}{4}$-INCH DIAMETER POLYSTYRENE 5-PIN PLUG-IN FORMS, (*ALLIED RADIO 46-Z-696*) TAPS ARE COUNTED FROM BOTTOM END OF COIL.
ON "A" COILS, TURNS SHOULD BE EVENLY SPACED TO LENGTH SPECIFIED; "B" COILS ARE CLOSE-WOUND.
"A" AND "B" COILS ARE WOUND IN SAME DIRECTION.

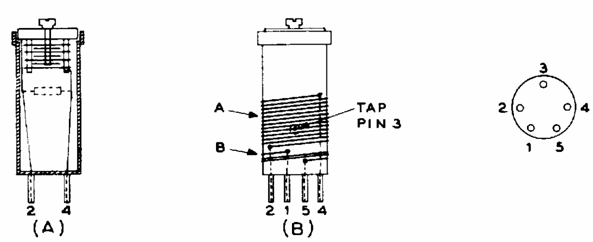


Figure 57

COIL TABLE FOR DELUXE HBR RECEIVER

All coils are tightly wound in the same direction on the form, and an air padding capacitor is mounted within the form. The MAPC-style capacitor used as a trimmer should have brass (not aluminum) plates for best frequency stability. The *Hammarlund* units are recommended. The trimmer capacitor is held in place by *Duco* cement, plus the wire leads running to it from the proper base pins.

A silver-mica padding capacitor is used in the oscillator coil assembly and is mounted in position as shown in the drawing. The rotor terminal of the MAPC padding capacitor is connected to the RF ground end of the coil winding and the *stator* to the topmost turn (grid) of the coil.

The first step is to wind the primary coil (Diagram *B* winding).

- Make two small holes in the sidewall of the form for the connections to pin 1 and pin 5.
- The holes are about 1/2-inch apart with the pin-5 hole close to the point where the bottom turn of the secondary winding will be placed. This allows sufficient space to slide the primary winding up or down the coil form to provide the proper degree of coupling between the windings.

- The amount of wire for the winding is estimated and one end of the length is cleaned, passed through the predrilled hole above pin 1, and into the pin. It is brought out the end of the pin and quickly soldered with a hot iron. Hold the pin with a long-nose pliers acting as a heat sink so that the coil form will not be deformed by excessive heat.

- The free end of the length of wire is now attached to a vise or stationary object. The wire is straightened by a gentle pull, and wound on the coil form under tension, rotating the top of the form towards you, keeping the wire taut at all times.

- When the proper number of turns is on the form, grasp the winding to prevent it from unraveling and cut the wire a few inches longer than the length needed to go through the predrilled hole above pin 5 and to protrude through the pin.

- Clean the end of the wire; thread it through the form and out the pin. Pull it taut, solder the wire to the pin tip and trim off the excess length. Scrape the pin free of rosin and solder.

The same technique is used for the larger secondary winding.

- An extra hole is needed in the coil form for the tap connection to the winding. The tap hole is somewhat larger than the others (make it about 0.25 inch diameter) to permit the joint to be soldered without the iron damaging the low-melting polystyrene form.

- The ends of the secondary winding are not soldered until the additional wires of the MAPC padding capacitor are also inserted in the same pins.
- It is easy to approximate the turn spacing as the coil is wound, and the spacing may be adjusted after the winding is finished, if necessary.
- The winding can be temporarily wound on the form in order to determine the position of the tap hole. Once the winding is positioned, the enamel on the wire is scraped away at the tap point and a small length of wire soldered at this spot, passed through the tap hole and out through pin 3.

The last step is to fix the MAPC padding capacitor in place and to mount the auxiliary silver-mica padding capacitor used in some oscillator coils. Lengths of bare wire are soldered to the rotor and stator terminals of the variable capacitor. The wires pass into pins 2 and 3, with the rotor going to pin 2 (RF ground) and the stator going to pin 3.

Once the wires of the MAPC capacitor are in place, along with the ends of the secondary winding, the pins may be soldered. Before soldering, check that no wires interfere with the rotation of the capacitor and that the capacitor may be turned easily without the rotor binding on the side of the coil form. When soldering is completed, the MAPC capacitor may be wedged in place before cement is applied using a length of toothpick.

The fixed padding capacitor of the oscillator coil is mounted between one stator post of the MAPC capacitor and the wire dropping down from the MAPC rotor to pin 2. The assembly of MAPC capacitor and fixed padding capacitor is soldered together before the unit is slipped into the coil form.
When one set of coils is finished, it may be placed in the receiver and the circuits adjusted to the approximate frequencies by means of a grid-dip oscillator.

Receiver Alignment

The IF system of the Deluxe HBR receiver is aligned first, followed by the RF section. While an experienced builder can align the receiver “by ear”, it is recommended that a

BC-221 (or LM) frequency meter be used for alignment along with a grid-dip oscillator and a general-coverage receiver.

Alignment is done by injecting signals of various frequencies into the receiver and peaking the adjustable capacitors of the tuned circuits for maximum response. If the test signal is modulated with an audio tone, the receiver response may be noted on a high impedance AC voltmeter placed across the speaker output terminals. If the test signal is unmodulated, the receiver S-meter may be employed, or a vacuum-tube voltmeter placed across the AGC line may be used.

IF Alignment – The HBR receiver's BFO is used for alignment of the 85-kHz IF system.

- With the "function switch" in the BFO position, the second harmonic of the BFO is adjusted to 170.0 KHz using the low-frequency range of the BC-221 frequency meter.
- A small amount of signal from the BFO is coupled into the plate circuit of the second mixer tube (V_6) and transformers T_3, T_1, and T_5 are adjusted for maximum response.
- To couple the BFO to the second mixer, run a length of wire from the top of the 7360 socket (remove the tube and probe pin 3) to the mixer.
- Wrap the wire around the bulb of the mixer. Switch S_3 is set in the SSB position for this procedure.
- Once the IF system is aligned to 85 KHz, the BFO may be adjusted for proper CW and sideband selection. This is done with the BC-221 frequency meter, adjusting the second harmonic of the BFO to 168.4 kHz for *SB1* reception and to 171.6 KHz for *SB2* reception.
- The BFO is adjusted to 169.2 KHz for c-w reception.
- Note that SB1 and SB2 alternate between upper and lower sideband. On 80 meters where the high-frequency tuning oscillator is higher than the received signal, upper sideband is reversed from the 20-meter situation, where the tuning oscillator is lower than the received signal.

Once the low frequency IF system is aligned, the 1.7-MHz conversion crystal and 6C4 oscillator tube are plugged in and crystal operation is checked by tuning a general coverage receiver to 1.7 MHz and noting stable oscillator operation.

Next, the BC-221 is tuned to 1615 kHz and the test signal is loosely coupled to the plate of the 6BC5 first mixer (V_2). Transformers T_1 and T_2 are aligned for maximum response at this frequency.
Gain controls are retarded to prevent overload as receiver gain rises.
Instability may be noted when controls are advanced to a position of maximum gain.
The receiver has a large reserve of gain, and with correct alignment, no sign of oscillation will be apparent at normal operational gain levels.

RF Alignment – RF alignment is accomplished by adjustment of the various padding capacitors in the plug-in coils, and by varying the inductance of the coils if need be. Two adjustments are necessary – tracking and bandspread. Both of these adjustments are performed on the high-frequency oscillator circuit and are then repeated for the mixer and RF circuits.
The procedure is best carried out first on a low-frequency band, and the 40-meter adjustments are chosen as an example.
The alignment chart shows that the proper 40-meter alignment is achieved when the high-frequency oscillator stage (OSC) tunes the 5.4 - to 5.7-MHz range while the RF and mixer (DET) stages tune the 7.0 - to 7.3 MHz range.

CHART 2.

TUNING CHART FOR THE RECEIVER			
Band	Stage	C_1 Max.	C_1 Min.
80	R.F. DET. OSC.	3500 3500 5100	4000 4000 5600
40	R.F. DET. OSC.	7000 7000 5400	7300 7300 5700
20	R.F. DET. OSC.	14.0 14.0 6.2	14.35 14.35 6.375
15	R.F DET. OSC.	21.0 21.0 9.7	21.5 21.5 9.95
10	R.F. DET. OSC.	28.0 28.0 13.2	29.7 29.7 14.05

- The first step is to adjust the oscillator range for proper bandspread, which is accomplished with the aid of the BC-221 frequency meter. The BC-221 is set to 5.4 MHz and the main tuning dial of the receiver is adjusted so that the tuning capacitor is about 90 percent meshed.
- Oscillator trimming capacitor C_3 is set at mid-capacitance.
- Oscillator padding capacitor C_6 (in the coil form) is adjusted until the frequency of the oscillator is 5.4 MHz, as measured on the frequency meter.
- The dial reading of the receiver is noted and the BC-221 is then set to 5.7 MHz.
- The main tuning dial of the receiver is adjusted to tune the high-frequency oscillator to the same frequency, which should occur with the tuning capacitor about 10 percent meshed.
- If it does not, the oscillator padding capacitor (C_6) should be readjusted to properly place the 5.7-MHz checkpoint on the receiver dial.
- If the padder must be increased in capacitance to align the circuit to 5.7 MHz, it indicates the tap on the oscillator coil is too high and that the portion of the winding between the tap and ground must be spread slightly apart to decrease the inductance.
- If the padder must be decreased in capacitance, it indicates that the tap on the coil is too low, and therefore the portion of the winding between tap and ground must be bunched together to raise the inductance.
- By slight adjustment of the lower portion of the oscillator coil winding, the 5.4-MHz and 5.7-MHz points may be placed near the ends of the tuning dial, and the proper coverage is positioned on the dial without necessitating readjustment of the padding capacitor in the oscillator coil.
- If more or less bandspread is desired, the tap on the coil may be moved a fraction of a turn, changing the inductance of the winding below the tap.

Once the oscillator circuit tracks across the appropriate range, the mixer tube may be placed in its socket, along with mixer coil, L_2. The BC-221 frequency meter is adjusted to 7.0 MHz and the receiver dial tuned to the 5.4-MHz oscillator point. The test signal should be heard in the

receiver, and the detector padding capacitor adjusted for maximum response.
The signal generator is now set to 7.3 MHz and the receiver dial tuned to the 5.7-MHz Oscillator point. The detector padding capacitor is readjusted for maximum response, noting whether the capacitance is increased or decreased. The winding below the tap of the mixer coil (L_2) and ground is now adjusted in the fashion described for the oscillator coil until the setting of the padding capacitor remains the same at both ends of the tuning range.
This adjustment is repeated with the RF stage, with the RF trimming capacitor (C_2) set at mid-scale. With due care, the whole alignment operation should take less than an hour for the first set of coils, and with experience the adjustments to the remaining coils may be done in less time.

Adjustment of the 20-, 15- and 10-meter coil sets follows the same technique used for the 40- and 80-meter coils, except that the second harmonic of the oscillator frequency is used for signal injection. Even so, the oscillator tuning range should be adjusted at the fundamental frequency with the aid of the frequency meter.

After alignment has been completed, the dial of the receiver may be calibrated. The last step is to cement the coil windings in place. Do not coat the entire winding but use five or six vertical lines of plastic cement to hold the turns in place.

S-meter Adjustment — with the receiver in operation and the 6CB6 (V_{18}) removed from the socket, the sensitivity control is adjusted to permit full-scale S-meter reading. The 6CB6 is inserted in the socket and (after a warm-up period) the AGC switch is set to *off* and the zero-set control adjusted for zero meter reading.

Final Touchup Adjustments — Once the receiver is operating and signals are received, final alignment may be done. Correct adjustment of coils L_1 and L_2 is especially important on the higher-frequency amateur bands. The true indication of proper tracking is the action of the MAPC padding capacitor in the RF and mixer. Some compensation for misalignment in the RF stage may be achieved with antenna trimmer capacitor C_2.

Maladjustment of the mixer-tuned circuit can result in a loss of sensitivity, especially on the 15- and 10-meter bands.
The correct level of first oscillator injection to mixer V_2 determines mixer gain. Coupling capacitor C_2 should be set at the minimum value consistent with maximum strength of a weak signal as read on the S-meter.

Oscillator feedback is determined by the degree of coupling between the primary and secondary windings of coil L_3. Insufficient feedback may be noted by erratic oscillator operation, frequency instability, or low conversion efficiency in the first mixer stage.
Excessive feedback is characterized by a hissing or “squegging” sound on received signals, or perhaps by erratic frequency excursions as the oscillator is tuned.

Feedback adjustment, however, is not critical and the coil data is optimized for the correct degree of feedback consistent with smooth and proper operation.

Gain and RF selectivity of the RF circuits of the receiver may be varied by adjusting the degree of coupling between the primary and secondary windings of mixer coil L_2. The separation between the windings may be increased to 0.625 inch to prevent overloading by strong signals and desensitization. The receiver gain will, of course, be reduced accordingly.
A reduction in the number of turns of the antenna winding of coil L_1 may be helpful in some cases.

Because of the open construction of the Deluxe HBR receiver and the use of plug-in coils, it is the “experimenter’s delight” and many interesting variations and modifications may be done to the basic receiver once it is operating properly. The receiver is a valuable addition to the station of an active amateur.

More Figures and Diagrams Follow…

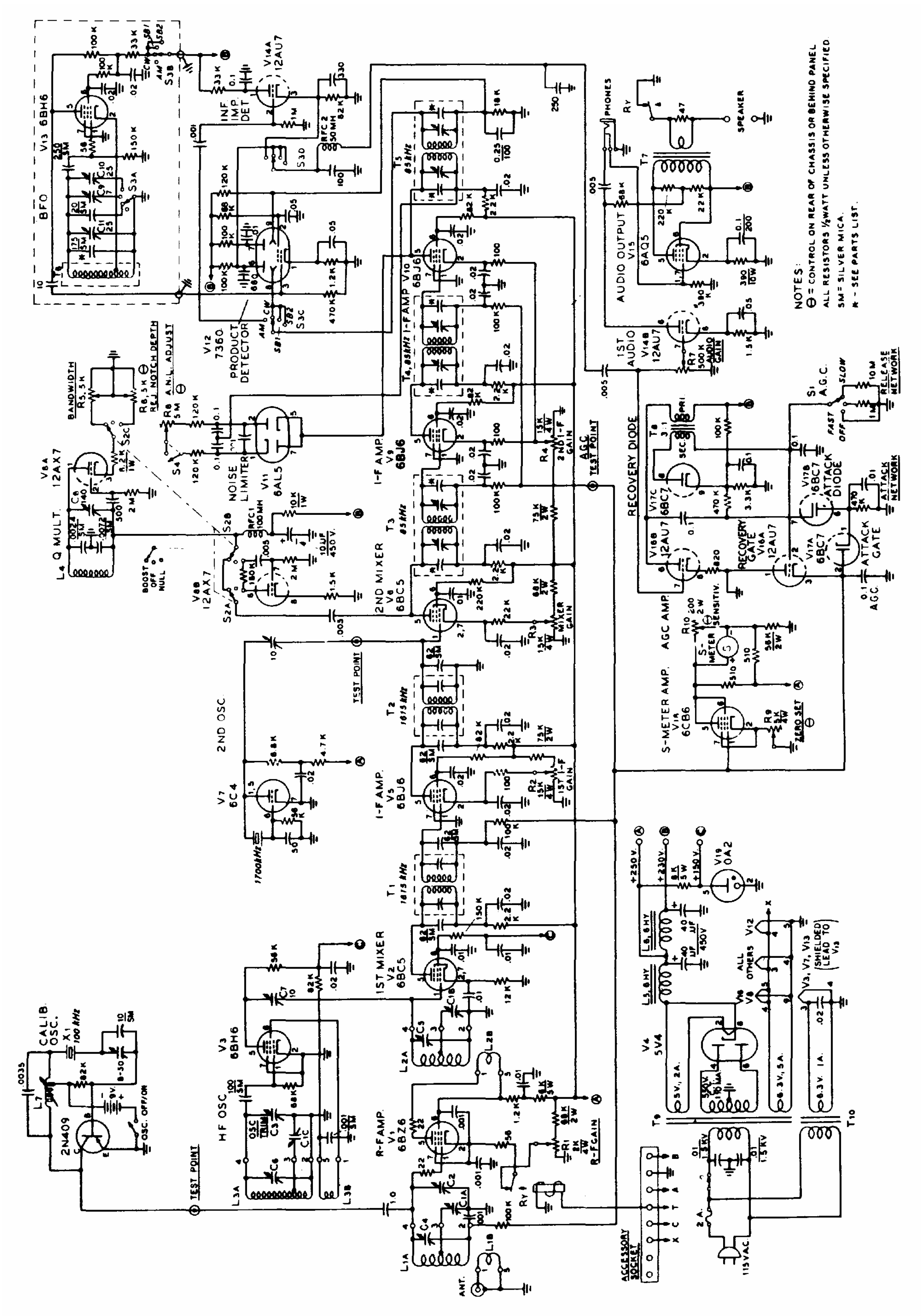


Figure 50

SCHEMATIC OF HBR RECEIVER

Figure 48

THE DELUXE HBR RECEIVER

The 19-tube HBR receiver is a double-conversion superheterodyne covering the amateur bands. Employing plug-in coils, the receiver combines simplicity of design with good r-f selectivity. Delayed automatic gain control and an efficient product detector make the receiver well suited for SSB reception. Layout of the panel controls may be seen in this photograph. To the left of the main tuning control are the antenna trimmer (C_2) and the r-f gain control (R_1), with the Q-multiplier tuning (C_8) centered below. To the right of the main tuning control is the first i-f gain potentiometer (R_2) with the noise limiter switch (S_4) and the 100-kHz calibration oscillator switch to the right. Across the lower edge of the panel are (l. to r.): Q-multiplier control (S_2), bandwidth-adjust potentiometer (R_5), mixer-gain potentiometer (R_3), second i-f gain potentiometer (R_4), mode selector switch (S_3), audio-gain potentiometer (R_7) and agc time-constant switch (S_1). Below, to the right are the phone jack and the main power switch.

PARTS LIST FOR FIGURE 50

C_1A, B, C—5-23-pf, 3-section. Miller 2102, or Polar C28-143-6/015
(Note: one rotor plate must be removed from each section of the Polar capacitor to achieve proper bandspread. The Miller unit needs no modification)
C —15-pf Hammarlund MAPC-15B
C_3—2-pf Hammarlund MAPC-15 with all but one rotor and one stator plate removed.
C_4, C_5, C_6—See coil table, figure 57. (Hammarlund type MAPC)
C_7—10-pf Centralab 822EZ
C_8—140-pf Hammarlund APC-140B
C_9—7-pf Centralab 822EZ
C_{10}, C_{11}—25-pf Centralab 822AZ
L_1, L_2, L_3—See coil table, figure 57
L_4—3.5-mH Miller 9003
L_5, L_6—6-henry, 110-ma, Triad C-11X
L_7—0.7-mH, tapped. Miller 9012
RFC_1—100-mH Miller 960
RFC_2—50-mH Miller 958
RY—dpdt relay with coil to match transmitter control circuit
S_2—Single-section, 3-pole, 3-position. Centralab PA-2006
S_1—Two-section, 2-poles per section, 4-position. Centralab PA-2010
T_1, T_2—1800-kHz transformer. Pad to 1615 kHz with 62-pf silver micas. Miller 1730
T_3, T_4, T_5—100-kHz high-Q transformer, 2.5-kHz bandwidth. Pad with 130-pf silver micas to 85 kHz. Miller 1709. For 3-kHz bandwidth, use Miller 1710 transformers
T_6—132-kHz bfo transformer padded to 85 kHz with 175-pf silver mica. Remove compression trimmer and use threaded bushing of trimmer as mount for lugs to hold wires from bfo coil. Miller 012-M5
T_7—5K to 4 ohms. Stancor A-3877
T_8—3:1 audio interstage. Triad A-31X
T_9—550-volt c.t., 110-ma. 5 volt 2 amp., 6.3 volt 5 amp. Triad R-12A
T_{10}—6.3-volt 1 amp. Stancor P-6134
S-meter—0-1 d-c milliammeter
Chassis—(1) 10" x 14" x 3" (2) 5" x 7" x 2"
BFO box—2¾" x 2" x 4"
Cabinet—15" x 11" x 9". Wyco CR-7725
Dial—Eddystone 898

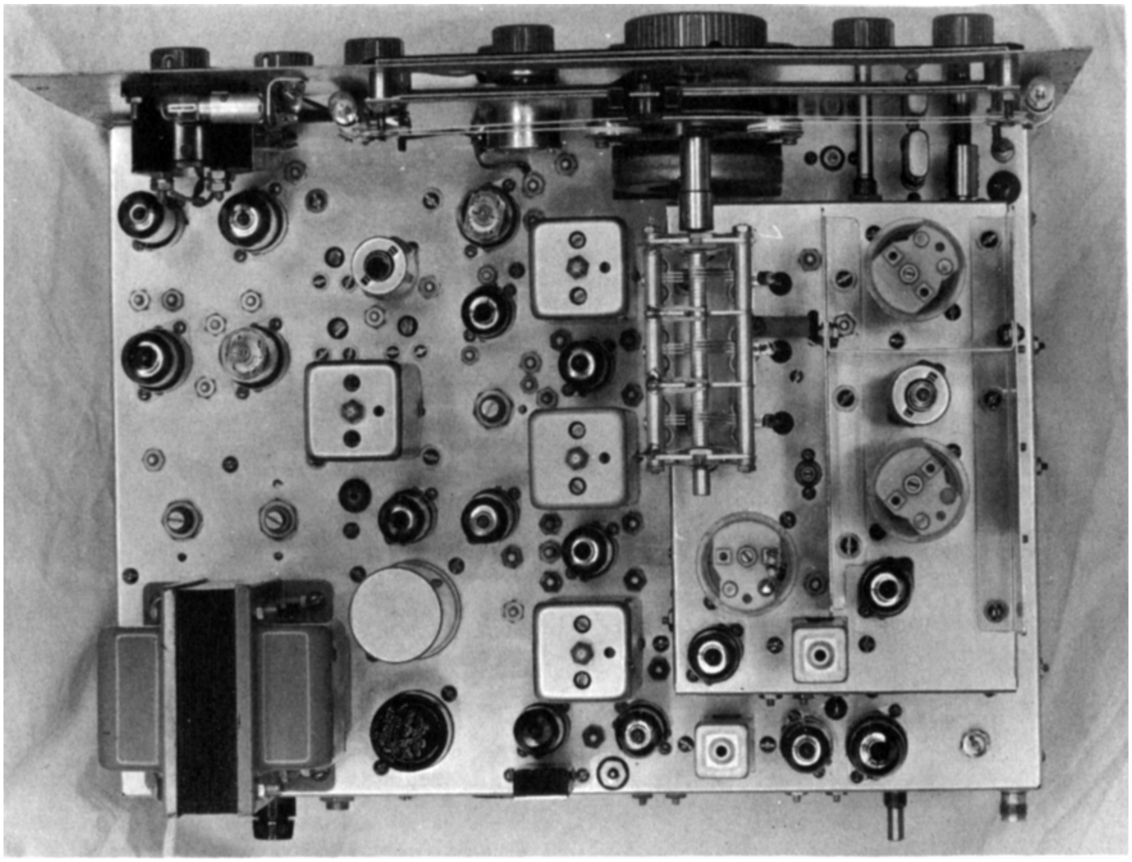


Figure 53

TOP VIEW OF RECEIVER

Major above-chassis components may be seen in this photograph. Directly behind the S-meter (upper left) are the 6AQ5 and 7360 tubes and nearer the power transformer are the 6BC7 and the 12AU7 agc tubes. Adjacent to the power transformer are the two S-meter potentiometers. To the right of the power transformer are the 5V4 rectifier and the dual 40-40 μfd filter capacitor. Next to the capacitor (towards the panel) are the OA2 regulator and the 6CB6 S-meter tubes and the agc test-point jack. Closer to the panel is the bfo transformer (T_6) with the bfo tube between it and the panel. Down the center of the chassis (rear to front) are the 1.7-MHz crystal, 6C4 oscillator, 85-kHz transformer (T_3), i-f amplifier 6BJ6 (V_9), transformer T_4, i-f amplifier 6BJ6 (V_{10}), and transformer T_5 (near panel). To the left of transformer T_5 are the 12AU7 (V_{12}) and the 6AL5 (V_{11}). The a n l control (R_8) is to the side of transformer T_4.

Along the rear of the chassis (at right) are the slug of coil L_4 (in the corner), 12AX7 (V_8), 6BJ6 (V_5), transformer T_8, and 100-kHz test point. At the front of the chassis (between the subchassis and the panel) are the 100-kHz crystal and associated components. Note that the tuning capacitor is coupled to the dial with an inflexible (rigid) coupling and short shaft extension. The flat ground strap on the main tuning capacitor may be seen passing through a slot to the under-chassis area where it is grounded.

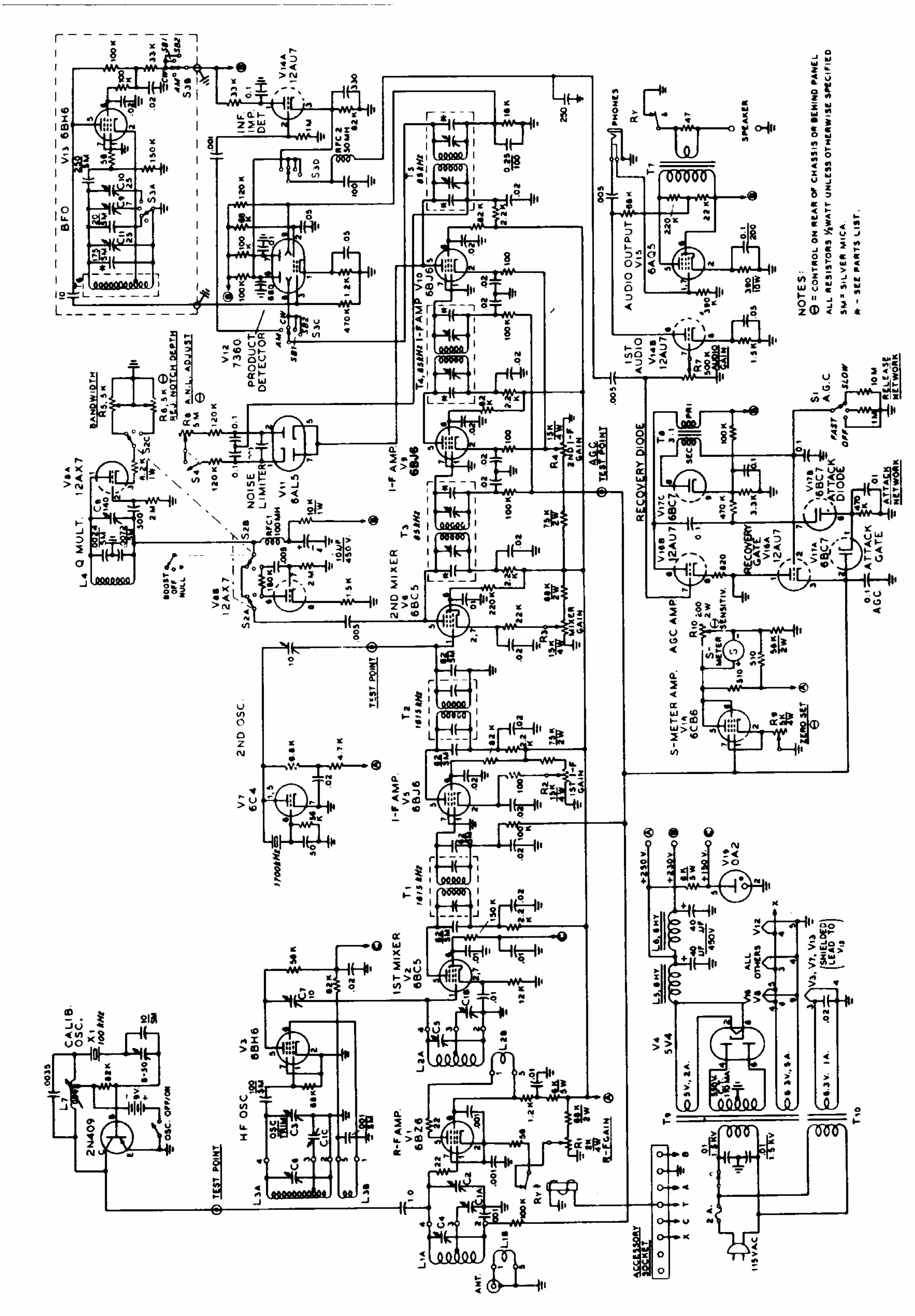


Figure 50

SCHEMATIC OF HBR RECEIVER

CHART 1.

VOLTAGE CHART FOR RECEIVER

Measurements made with VTVM. All controls ½ advanced except r-f gain which is fully advanced. Q-multiplier on boost, Function switch on SB2, avc on fast, Noise limiter on.

TUBE	1	2	3	4	5	6	7	8	9
V_1	−0.4	0.9	6.3	0	125	125	0.9	—	—
V_2	0	4.25	6.3	0	240	125	4.25	—	—
V_3	−4.1	0	6.3	0	50	88	0	—	—
V_4	—	250	—	280	—	280	—	250	—
V_5	−0.3	31	6.3	0	235	215	0	—	—
V_6	0	31	6.3	0	240	220	31	—	—
V_7	110	—	6.3	0	110	−15	0	—	—
V_8	230	0	2.8	0	0	−0.7	−0.5	0	6.3
V_9	−0.26	31	6.3	0	240	225	31	—	—
V_{10}	−0.26	31	6.3	0	240	225	31	—	—
V_{11}	240	165	6.3	0	240	0.12	240	—	—
V_{12}	7.6	110	−1.8	6.3	0	76	24	20	20
V_{13}	−34	0	6.3	0	150	72	0	—	—
V_{14}	230	0	16	0	0	74	0	2.7	6.3
V_{15}	0	12.8	6.3	0	235	235	0	—	—
V_{16}	0	−0.7	−0.3	0	0	235	0	7	6.3
V_{17}	0.13	−0.3	0	6.3	0	0.13	13.2	−7.6	9.1
V_{18}	−0.26	4.1	6.3	0	235	235	4.1	—	—

-30-