A Regenerative Single-Signal Receiver

An inexpensive amateur-band receiver using IF regeneration for single-signal reception is shown in Fig. 1221.

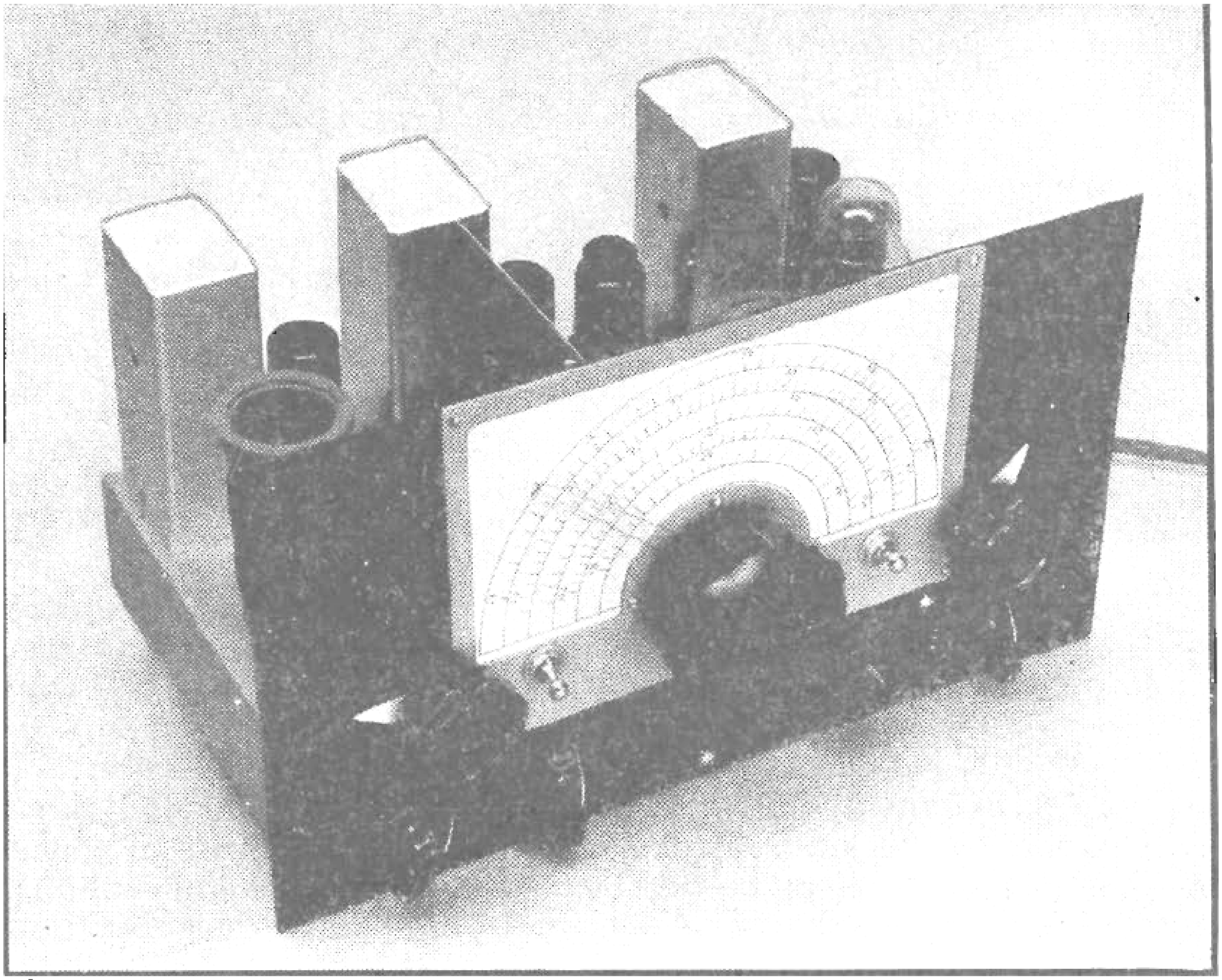


Fig. 1221 - A 7-tube superheterodyne using regeneration in the IF amplifier to give single-signal reception and improved image ratio.
The dial (National ACN) may be directly calibrated for each amateur band.
The chassis is 11 x 7 x 2 inches and the panel 7 x 12 inches. The controls along the bottom edge of the panel are, from left to right, the mixer regeneration control, R_{15}, the IF gain control, R_{16}, the audio volume control, R_{17}, and the beat oscillator vernier condenser, C_{21}. The latter has one corner of one rotor plate bent over so that when the condenser plates are fully meshed the tuned circuit is short-circuited stopping the BFO oscillation.

Fig. 1223 gives the circuit diagram.

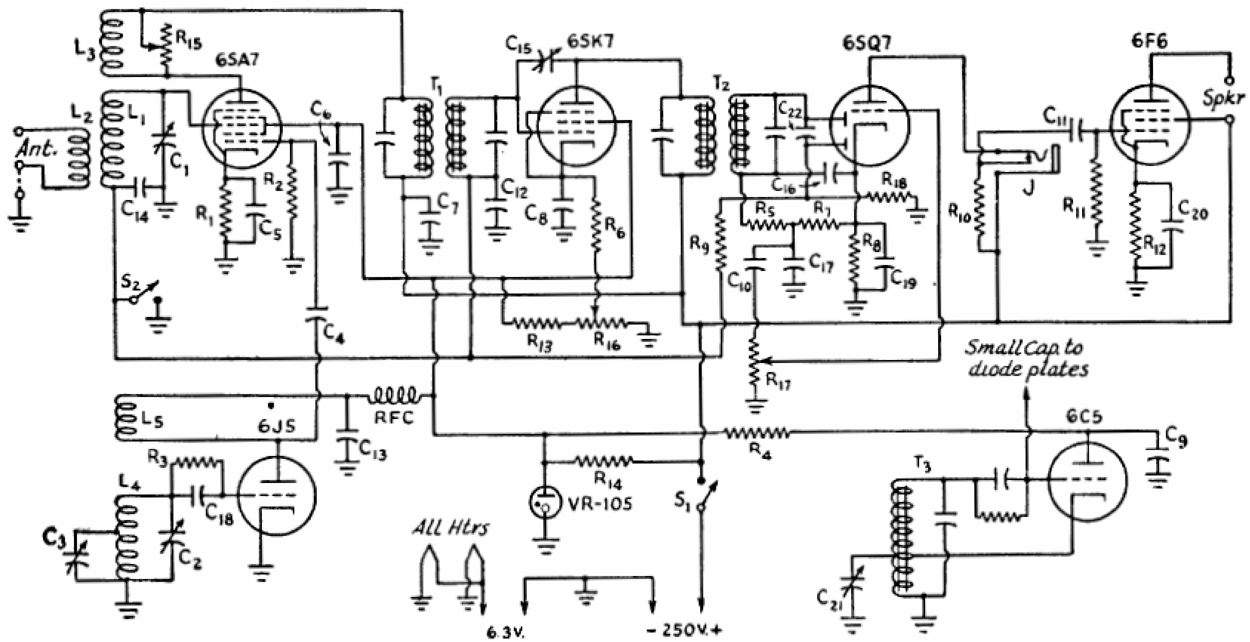


Fig. 1223 — Circuit diagram of the single-signal superheterodyne receiver with regenerative i.f. and mixer stages.

C_1, C_2 — 50-$\mu\mu$fd. variable (Hammarlund MC-50-S).
C_3 — 35-$\mu\mu$fd. variable (National UM-35).
C_4 — 50-$\mu\mu$fd. mica.
C_5, C_6, C_7, C_8 — 0.1-μfd. paper, 600 volts.
C_9, C_{10}, C_{11}, C_{12} — 0.01-μfd. paper, 600 volts.
C_{13}, C_{14} — 0.005-μfd. mica.
C_{15} — 3-30-$\mu\mu$fd. trimmer (National M-30); see text.
C_{16} — 250-$\mu\mu$fd. mica.
C_{17}, C_{18}, C_{22} — 100-$\mu\mu$fd. mica.
C_{19}, C_{20} — 25-μfd. electrolytic, 50 volts.
C_{21} — 25-$\mu\mu$fd. variable (Hammarlund SM-25).
R_1 — 200 ohms, ½ watt.
R_2 — 20,000 ohms, ½ watt.
R_3, R_4, R_5 — 50,000 ohms, ½ watt.
R_6 — 300 ohms, ½ watt.
R_7 — 0.2 megohm, ½ watt.
R_8 — 2000 ohms, ½ watt.
R_9 — 1 megohm, ½ watt.
R_{10} — 0.1 megohm, ½ watt.
R_{11} — 0.5 megohm, ½ watt.
R_{12} — 450 ohms, 1 watt.
R_{13} — 75,000 ohms, 1 watt.
R_{14} — 5000 ohms, 10 watts.
R_{15} — 10,000-ohm volume control (mixer regeneration).
R_{16} — 25,000-lhm volume control (i.f. regeneration).
R_{17} — 2-megohm volume control.
R_{18} — 2 megohms, ½ watt.
T_1 — 460-kc. permeability-tuned i.f. transformer, interstage type (Millen 64456).
T_2 — 460-kc. permeability-tuned i.f. transformer, diode type (Millen 64454).
T_3 — 460-kc. beat-oscillator transformer (Millen 65456).
RFC — 2.5-mh. r.f. choke.
J — Closed-circuit jack.
S_1, S_2 — S.p.s.t. toggle.
L_1–L_5, inc. — See coil table.

Regeneration also is used in the mixer circuit to improve the signal-to-image ratio and to give added gain. This receiver is designed to give the maximum of performance, in the hands of a capable operator, at minimum cost; selectivity, stability and sensitivity are the primary considerations.

- The mixer, a 6SA7, is coupled to the antenna and is separately excited by a 6J5 oscillator.
- There is a single 460-KHz IF stage, using a 6SK7 and permeability-tuned transformers.
- The second detector and first audio amplifier is a 6SQ7, and the audio output tube for loudspeaker operation is a 6F6.
- The separate beat-oscillator circuit uses a 6C5.
- A VR105-30 voltage-regulator tube is used to stabilize the plate voltage on the oscillators and the screen voltage on the mixer and IF tubes.

To make construction easier and to avoid the necessity for additional trimmer condensers on each coil, the mixer and high-frequency oscillator circuits are separately tuned.

- Main tuning is by the oscillator band spread condenser, C_3, operated by the calibrated dial.
- C_2 is the oscillator band-setting condenser.
- The mixer circuit is tuned by C_1.

Regeneration in this circuit is controlled by R_{15}, connected across the mixer tickler coil, L_3.

R_{16} is the IF amplifier gain control, which also serves as an IF regeneration control when this stage is made regenerative.

C_{15} is the regeneration condenser; it is adjusted to feed back a small amount of IF energy from the plate to the grid of the 6SK7, and thus produce regeneration. If the high selectivity afforded by IF regeneration is not wanted, C_{15} may be omitted.

Diode rectification is used in the second-detector circuit. One of the two diode plates in the 6SQ7 is used for developing AVC voltage, being coupled through C_{22} to the detector diode.
The detector load resistor consists of R_5 and R_7 in series, the tap being used for RF filtering of the audio output to the triode section of the tube.

- R_{18} is the AVC load resistor.
- R_9, C_{14}, and C_{12} constitute the AVC filter circuit.

- ***S_2*** cuts the AVC out of circuit by grounding the rectifier output.

The headphones are connected in the plate circuit of the triode section of the 6SQ7. ***R_{17}*** is the audio volume control potentiometer. **NOTE: The headphone jack must be electrically isolated from the chassis. The headphones must be high impedance and you have to be aware that 250 volts is across your ears when using this arrangement. The output from the 6SQ7 is resistance coupled to the grid of the 6F6 and in my receiver I eliminated the headphone jack and used a small audio output transformer to an 8-ohm permanent magnet speaker with very satisfactory results.**

The top and bottom views, Figs. 1222 and 1224, show the layout clearly.

- The bandspread tuning condenser, ***C_3*,** is at the front center;
- at the left is ***C_1*,** the mixer tuning condenser; and
- at the right, ***C_2*,** the oscillator band-set condenser.
- The oscillator tube is directly behind ***C_3***
- The mixer tube is to the left and on the other side of a baffle shield that separates the two RF sections. This shield, measuring 4.25 x 4.25 inches, is used to prevent coupling between oscillator and mixer.
- The mixer coil socket is at the left behind ***C_1*;**
- The oscillator coil socket is between ***C_2*** and ***C_3*.**

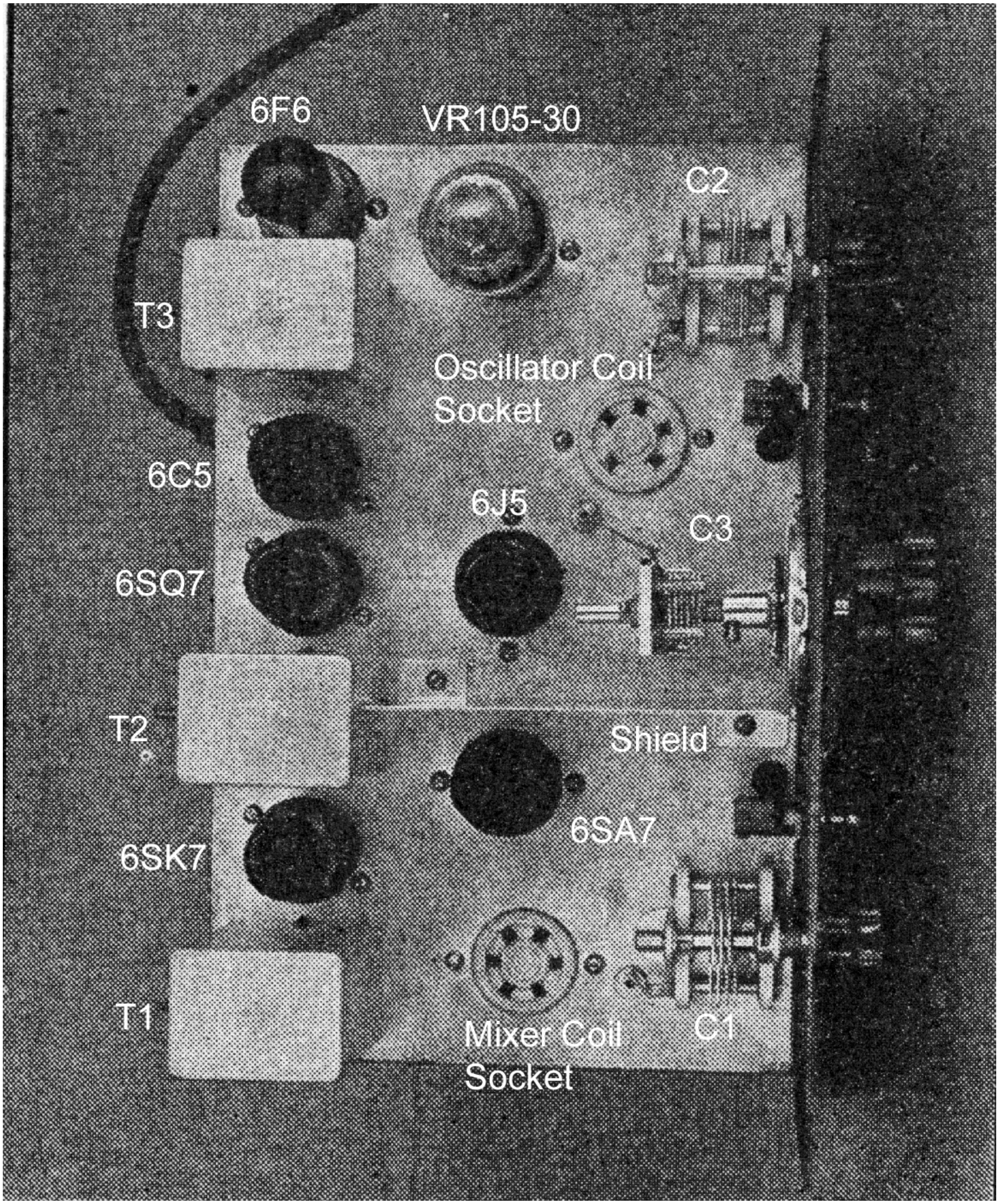
The IF and audio sections are along the rear edge of the chassis.

- The transformer in the rear left corner is ***T_1***;
- Next to it is the 6SK7 IF tube,
- Next to it is ***T_2*.**
- Next in line is the 6SQ7, followed by
- The 6C5 beat oscillator,
- The beat oscillator transformer, ***T_3*,** and finally,
- The 6F6.
- The VR105-30 is just in front of ***T_3*.**

The IF transformers should be mounted with their adjusting screws projecting to the rear where they are easily accessible.

The beat oscillator is coupled to the second detector by the small capacity formed by running an insulated wire from the grid of the 6C5 close to the detector diode plate prong on the 6SQ7 socket. Very little coupling is needed for satisfactory operation.

In wiring the IF amplifier, keep the grid and plate leads from the IF transformers fairly close to the chassis and well separated. Without ***C_{15}***, the IF stage should be perfectly stable and should show no tendency to oscillate at full gain.


6F6
VR105-30
C2
T3
Oscillator Coil
Socket
6C5
6J5
C3
6SQ7
T2
Shield
6SA7
6SK7
T1
Mixer Coil
Socket
C1

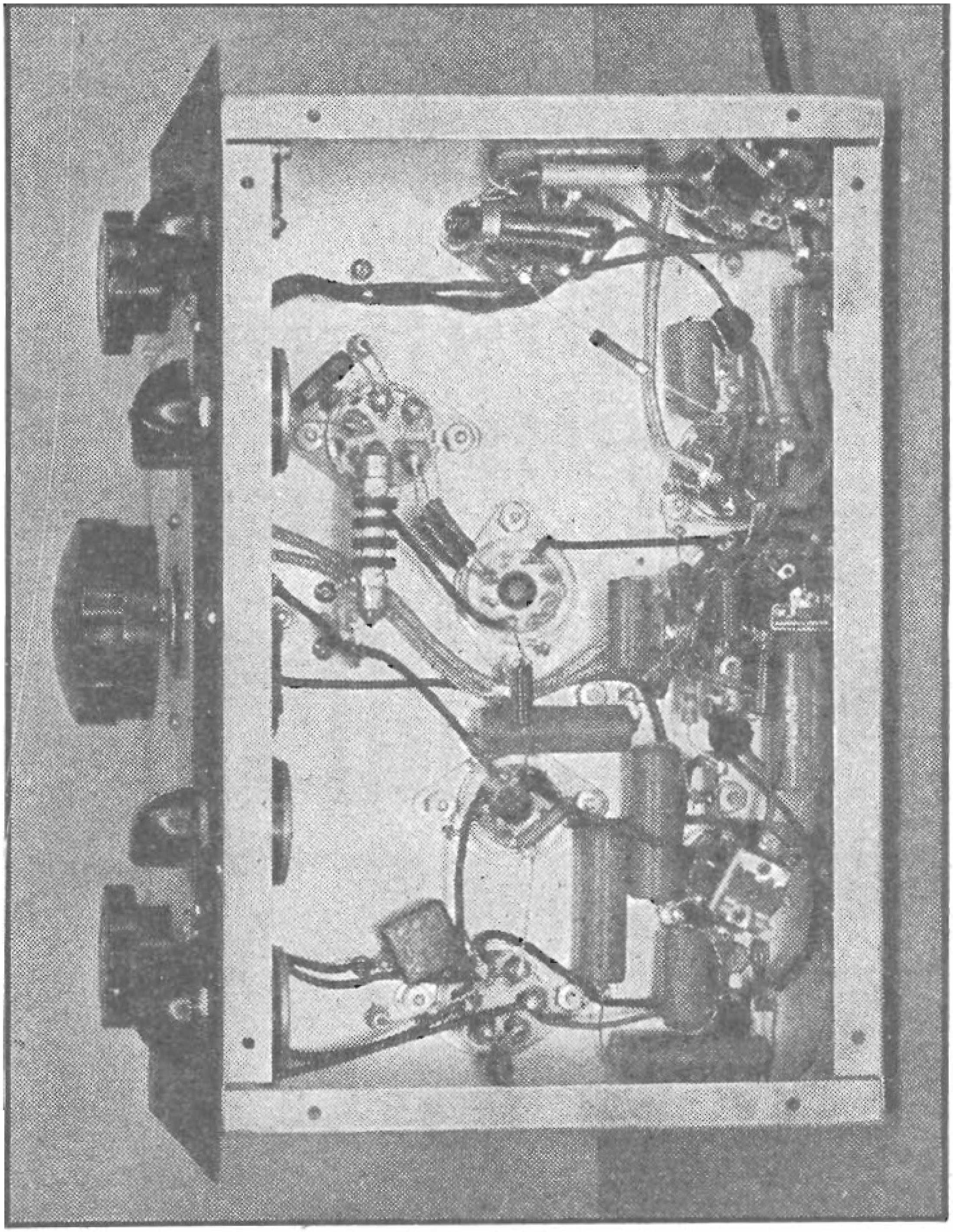


Fig. 1224 — The below-chassis wiring and location of parts is shown in this bottom view of the seven-tube regenerative single-signal receiver.

The method of winding the plug-in coils is shown in Fig. 1225, and complete specifications are given in the coil table.

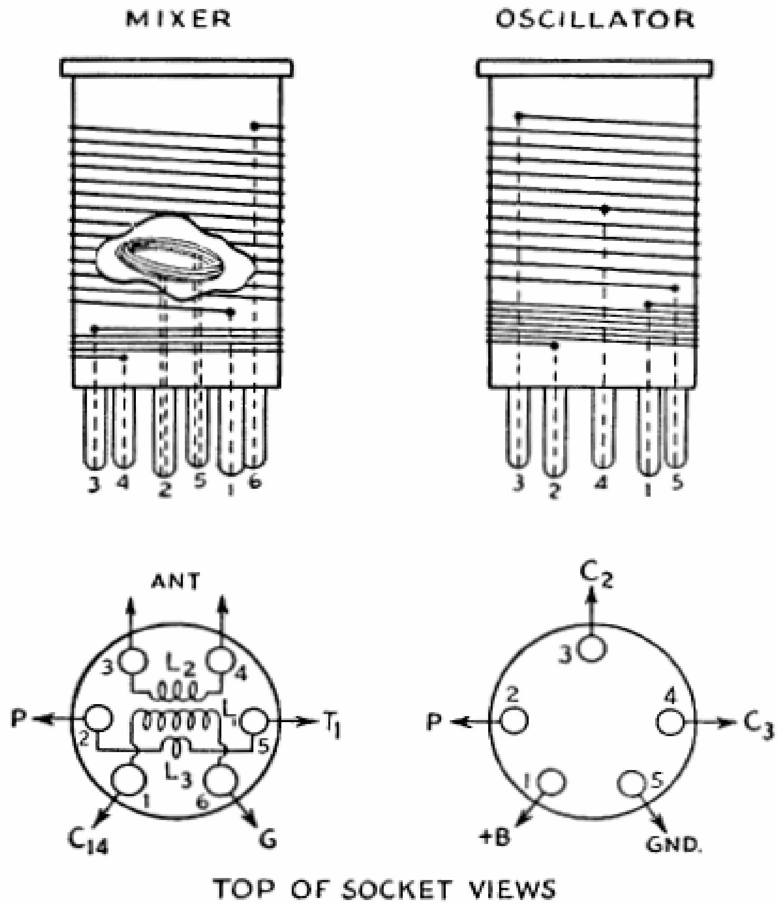


Fig. 1225 — Mixer and oscillator coil and socket connections for the seven-tube superheterodyne receiver.

NOTE – Use the pin outs as numbered in the drawing of the actual MIXER and OSCILLATOR coil forms. In wiring the socket, ignore the pin out view of the socket drawing and wire exactly as you would FROM THE CHASSIS VIEW of the 5 and 6 pin sockets.
Start the winding of the coil from the bottom to the top for each individual segment. This will give a consistency to each band coil and prevent 'reversing' the winding direction.

If the winding is incorrect the radio will not work. This is the primary reason to begin construction at the 6F6 audio output and work backwards. Either an audio signal or modulated 455 KHz signal will verify the wiring of each preceding circuit if you follow this strategy.

COIL DATA FOR 7-TUBE SUPERHET

Band	*Coil*	*Wire Size*	*Turns*	*Length*	*Tap*
1.75 Mc.	L_1	24	70	Close-wound	—
	L_2	24	15	" "	—
	L_3	22	15	——	—
	L_4	22	42	Close-wound	Top
	L_5	24	15	" "	—
3.5 Mc.	L_1	22	35	" "	—
	L_2	22	9	" "	—
	L_3	22	12	——	—
	L_4	22	25	1 inch	18
	L_5	22	10	Close-wound	—
7 Mc.	L_1	18	20	1 inch	—
	L_2	22	5	Close-wound	—
	L_3	22	9	——	—
	L_4	18	14	1 inch	6
	L_5	22	6	Close-wound	—
14 Mc.	L_1	18	10	1 inch	—
	L_2	22	5	Close-wound	—
	L_3	22	7	——	—
	L_4	18	7	1 inch	2.4
	L_5	22	4	Close-wound	—
28 Mc.	L_1	18	4	1 inch	—
	L_2	22	4	Close-wound	—
	L_3	22	1.5	——	—
	L_4	18	3 6	1 inch	1.4
	L_5	22	2 4	Close-wound	—

All coils except L_3 are 1 ½ inches in diameter, wound with enameled wire on Hammarlund SWF forms. Spacing between L_1 and L_2, and between L_4 and L_5, is approximately ⅓ inch. Bandspread taps are counted from bottom (ground) end of L_4.

L_3 for 28 Mc. is interwound with L_1 at the bottom end. L_3 for all other coils is self-supporting, scramble-wound to a diameter of ¾ inch, mounted inside the coil form near the bottom of L_1.

Ticklers, L_3, for the mixer circuit are scramble wound to a diameter which will fit readily inside the coil form (0.75 inch) and mounted on stiff leads going directly to the proper pins in the form. The 1eads should be long enough to bring the coils inside the grid winding at the bottom.

The amount of feed-back is regulated by bending the tickler coil with respect to the grid coil. Maximum feedback is secured with the two coils coaxial, and minimum when the tickler axis is at right angles to the axis of L_1. The position of L_3 should be adjusted so that the mixer goes into oscillation with R_{15} set at one-half to three-fourths of its maximum resistance.

Alignment

The oscillator circuit has been adjusted to make the proper value of rectified grid current flow in the 6SA7 injection-grid (No. 1) circuit on each amateur band. This calls for a fairly strong value of feedback, with the result that, when the band-set condenser is set toward the high-frequency end of its range the oscillator may "squeg”. This is of no consequence unless the receiver is to be used for listening outside the amateur bands, in which case it may be corrected by taking a few turns off the tickler coil, L_5. This can be done only at some sacrifice of conversion efficiency in the amateur band for which the coil was designed, however.

The IF amplifier can be aligned most conveniently with the aid of a modulated test oscillator. The initial alignment should be made with C_{15} disconnected so that the performance of the amplifier in a non-regenerative condition can be checked. Headphones or a loudspeaker may be used as an output indicator.

The mixer and oscillator coils should be out of their sockets, and R_{15} should be set at zero resistance.

Connect the test oscillator output across C_1, which should be set at minimum capacity. Adjust the test-oscillator frequency to 460 KHz. Then, using a modulated signal, adjust the trimmers on T_1 and T_2 for maximum volume.

R_{16} should be set for maximum gain, and the beat oscillator should be off.

As the successive circuits are brought into line, reduce the oscillator output to keep from overloading any of the amplifiers, since overloading might cause a false indication.

After the IF is aligned, plug in a set of coils for some band on which there is a good deal of activity.

Set the oscillator padding condenser, C_2, at approximately the right capacity; with the coil specifications given, the proportion of the total capacity of C_2 in use on each band will be about as follows:

- 1.75 MHz - 90 per cent;
- 3.5 MHz - 75 per cent;
- 7 MHz - 95 per cent;
- 14 MHz - 90 per cent;
- 28 MHz - 15 per cent.

Set the mixer regeneration control, R_{15}, for minimum regeneration – that is, with no resistance left in the circuit.

Now connect an antenna to the input terminals for L_2. Switch the beat oscillator on by turning C_{21} out of the maximum position, and adjust the trimmer screw on T_3 until the characteristic beat-oscillator hiss is heard.

Next tune C_1 slowly over its scale, starting from maximum capacity.

Using the 7-MHz coils as an example, when C_1 is at about half scale there should be a definite increase in the noise level as well as in the strength of the signals that may be heard. Continue on past this point toward minimum capacity until a second peak is reached on C_1; at this peak the input circuit is tuned to the frequency that represents an image in normal reception.

The oscillator in the receiver is designed to work on the high-frequency side of the incoming signal, so that C_1 always should be tuned to the peak that occurs with the greatest capacity.

After the signal peak on C_1 has been identified, tune C_3 over its whole range, following with C_1 to keep the mixer circuit in tune, to see how the band fits the dial. With C_2 properly set, the band edges should fall the same number of main dial divisions from 0 and 100; if the band runs off the low-frequency edge, less capacity is needed at C_2, while the converse is true if the band runs off the high edge.

Once the band is properly centered on the dial, the panel may be marked at the appropriate point so that C_2 may be reset readily when changing bands.

To check the operation of the mixer regeneration, tune in a signal on C_3, adjust C_1 for maximum volume, and slowly advance the regeneration control, R_{15}. As the resistance is increased, retune C_1 to maximum volume, since the regeneration control will have some effect on the mixer tuning. As regeneration is increased signals and noise both will become louder, and C_1 will tune more sharply.

Finally the mixer circuit will break into oscillation, and, when C_1 is right at resonance, a loud carrier will be heard, since the oscillations generated will go through the receiver in exactly the same way as an incoming signal. As stated before, oscillation should occur with R_{15} set at from one-half to three-quarters full scale. In practice, it is best always to work with the mixer somewhat below the critical regeneration point and never permit it actually to oscillate.

On the lower frequencies, where images are less serious, the tuning is less critical if the mixer is made non-regenerative.

In this case, always set the regeneration control at zero, since there will be a range on the resistor where, without definite regeneration, the signal strength will be less than it is with zero resistance.

Should the mixer fail to oscillate, adjust the coupling by changing the position of L_3 with respect to L_l. If the two coils happen to be 'poled' incorrectly, the circuit will not oscillate. This condition can be cured by rotating L_3 through 180 degrees.

It is recommended that the mixer regeneration be tested first with the antenna disconnected, since antenna loading effects may give misleading results until it is known that L_3 is properly adjusted to produce oscillation.

After the preceding adjustments have been completed the IF regeneration may be added.

1nstall C_{15}, taking out the adjusting screw and bending the movable plate to make an angle of about 45 degrees with the fixed plate. Realign the IF. As the circuits are tuned to resonance the amplifier will oscil1ate, and each time this happens the gain control, R_{16}, should be backed off until oscillations cease.

Adjust the trimmers to give maximum output with the lowest setting of R_{16}. At peak regeneration the signal strength should be about the same with this setting, despite reduced gain in the amplifier, as it is without regeneration at full gain.

Too much gain with regeneration will have an adverse effect on the selectivity.

For single-signal CW reception, set the beat oscillator so that, when R_{16} is advanced to make the IF stage just go into oscillation, the resulting tone is the desired beat-note frequency.

Then back off on R_{16} to obtain the desired degree of selectivity. Maximum selectivity will be secured with the IF amplifier just below the oscillating point. The "other side of zero beat" will be much weaker than the desired side.

A useful feature of the bandspread dial is that it can be directly calibrated in frequency for each band. These calibrations may be made with the aid of a 100-KHz oscillator, such as is described below.

Ten-kilocycle points can be plotted if a 10-KHz multivibrator is available, but, since the tuning is almost linear in each band, a fairly accurate plot will result if each 100-KHz interval is simply divided off into ten equal parts when the dial calibrations are marked.

The power-supply requirements for the receiver are 2.2 amperes at 6.3 volts for the heaters and 80 mA at 250 volts for the plates.

Without the 6F6 pentode output stage, a supply giving 6.3 volts at 1.5 amperes and 250 volts at 40 mA would be sufficient. The circuit of a suitable power supply is given in Fig. 1226.

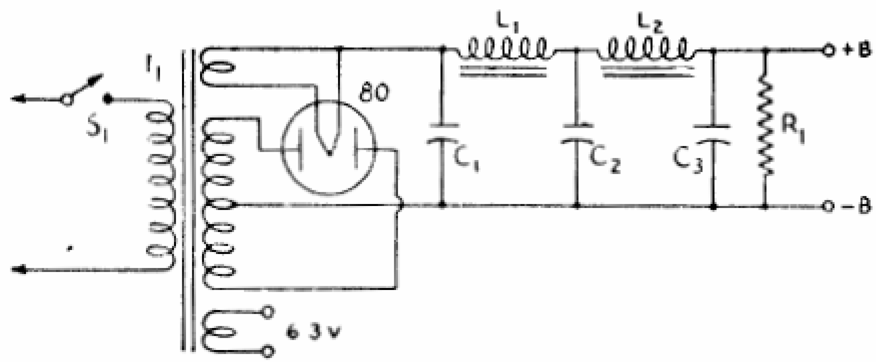


Fig. 1226 — Power-supply for the regenerative superhet.
C_1, C_2 — 8-μfd. electrolytic, 450 volts.
C_3 — 16-μfd. electrolytic, 450 volts.
R_1 — 25,000 ohms, 10 watts.
L_1, L_2 — 12 henrys, 80 ma., 400 ohms.
T_1 — 350 volts each side of center-tap, 80–90 ma.; 6.3 volts at 2.5 amperes or more; 5-volt 2-ampere rectifier-filament winding.
S_1 — S.p.s.t. toggle switch.
Dual-unit electrolytic condensers may be used. This supply will give 275 to 300 volts with full receiver load.

100 KHz oscillator

A crystal-controlled frequency standard, using a special crystal capable of oscillating at either 100 or 1000 KHz, is shown below.

This unit, which can be built at quite small cost, provides check points through the spectrum at 100-KHz intervals, sufficient for marking the edges of the amateur bands and for general calibration purposes.

The frequency of oscillation is shifted between 100 and 1000 KHz by tuning the oscillator tank circuit to the proper frequency. In the unit pictured, a DPDT toggle switch selects the desired frequency by making connection to either of two tank circuits. In the 100-KHz position this switch also connects a small trimmer condenser in parallel with the crystal. As the capacity of this condenser is increased the frequency of the crystal is lowered, so that if the crystal frequency is originally slightly high it becomes possible to set it to precisely 100 KHz, as indicated by checking the 5-MHz harmonic against WWV. In purchasing the crystal it should be specified that any error in frequency be on the high-frequency side of 100 KHz.

The accuracy when the oscillator is operating on 1000 KHz is within 0.05 per cent. However, since this frequency is used only for identification of the 100-KHz harmonics, this amount of error is not important.

The oscillator output is taken through an insulated bushing from which a connecting lead can be run to the receiver input.

***S**$_{W\ 2}$* opens the plate-supply lead when no signal is wanted; the heater is ordinarily left on continuously to keep the tube at operating temperature. Useful output may be obtained at harmonics up to about 30 MHz.

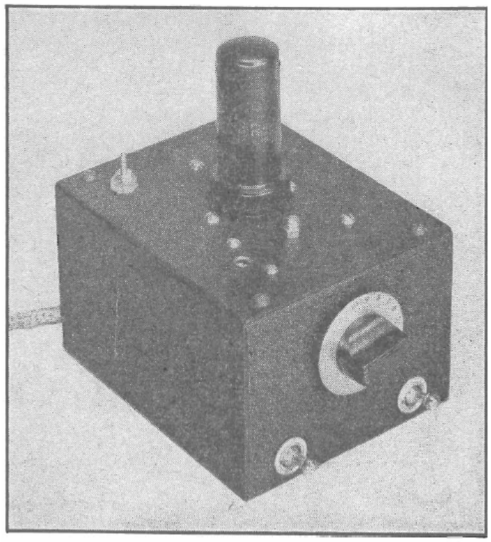


Fig. 1904 — 100–1000-kc. crystal calibrator. Output is taken through the insulated terminal bushing at left rear.

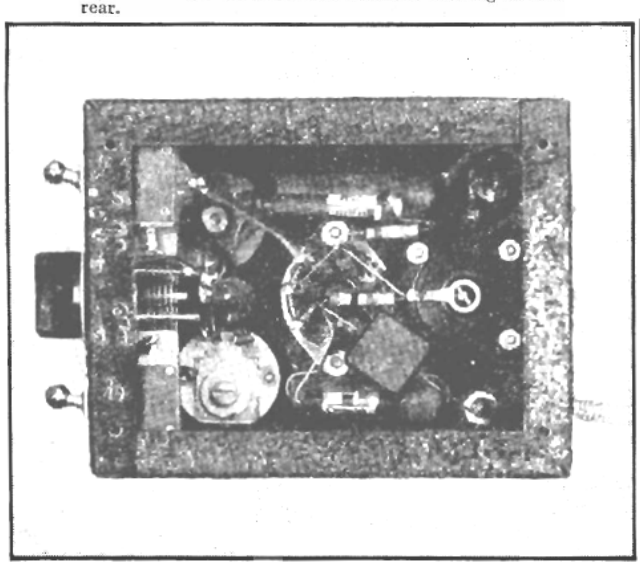


Fig. 1906 — Interior of 100–1000-kc. crystal calibrator. The crystal is mounted at top center, above the socket Trimmer for 1000-kc. plate circuit at lower right, 8 mh choke for 100 kc. at lower left.

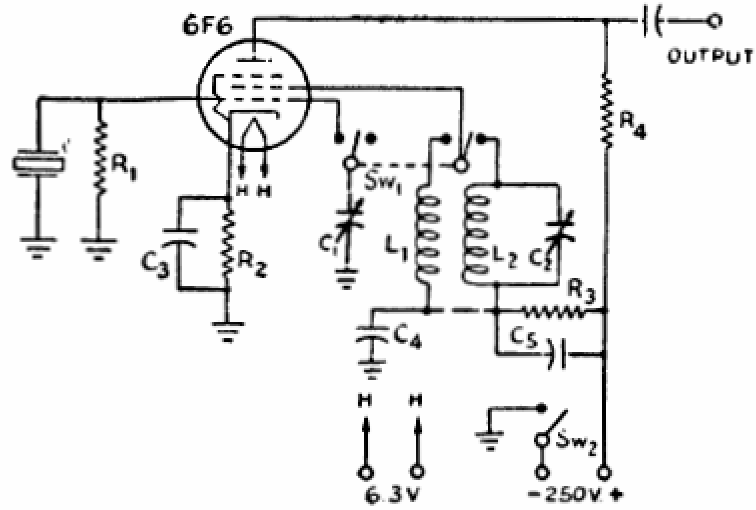
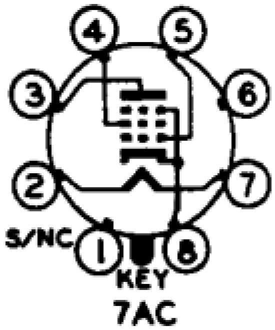
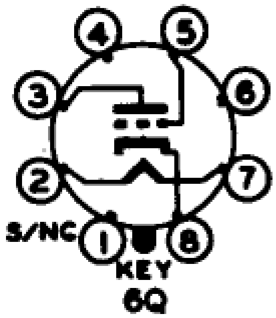


Fig. 1905 — Circuit diagram of a dual-frequency 100–1000-kc. crystal-controlled crystal calibrator.

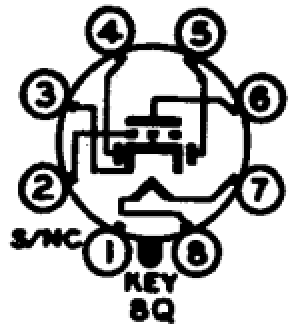
C_1 — 35-μμfd. midget variable (Hammarlund HF-35).
C_2 — 100-μμfd. mica trimmer (Hammarlund CTS-85).
C_3, C_4, C_5 — 0.1-μfd. 400-volt paper.
C_6 — 0.001-μfd. midget mica.
R_1 — 5 megohms, ½-watt.
R_2 — 500 ohms, ½-watt.
R_3 — 25,000 ohms, 1-watt.
R_4 — 0.25 megohm, ½-watt.
L_1 — 8-mh. r.f. choke (Meissner 1920-78).
L_2 — 2.5-mh. r.f. choke (all but one pie removed).
S_1 — D.p.d.t. toggle switch.
S_2 — S.p.s.t. toggle switch.
Crystal — Bliley SMC-100.



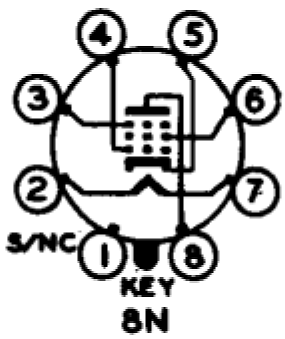
6F6



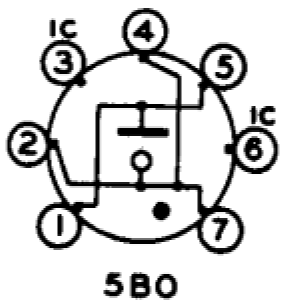
6C5



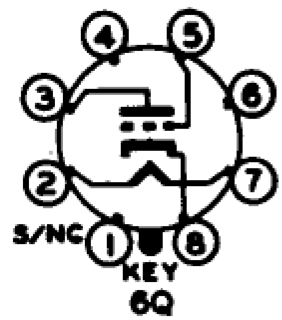
6SQ7



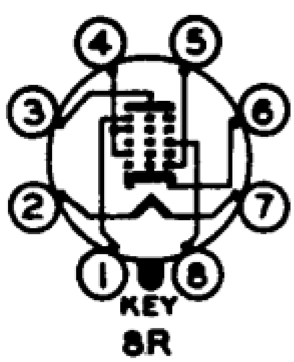
6SK7



0B2



6J5



6SA7