

A REGENERATIVE RECEIVER FOR BEGINNERS

A modern version of the classic regenerative receiver is shown in Fig 17.75. This project was designed and built by Charles Kitchin. This kind of receiver is easy (and fun) to build and has been used by many generations of hams to learn radio basics. It provides good general-coverage reception of the short-wave bands from 1.6 to 25 MHz, which includes the 80, 40, 30, 20, 17, 15 and 12-m ham bands. It offers good sensitivity and selectivity and is very portable, powered by two 9-V batteries. It has provision for operating on an external ac supply and can be user modified to provide any desired band spread on the amateur bands. A low-cost frequency counter may be added for a display. The circuit is designed to use series connected (64 Ω) Sony "Walkman" stereo headphones, which are commonly available. A 50-ft length of wire run to a nearby tree will suffice as the antenna.

which operates as a regenerative detector (see Fig 17.76). The circuit is basically an "Armstrong" oscillator that is user adjusted to operate just below the threshold of oscillation for AM signals, and just above for CW and SSB. The input signal (tuned by L2, C8, and C9), is amplified by Q3. Tickler coil L3 provides regenerative (in-phase) feedback so that the input signal is amplified over and over, providing very high gain in a single stage. In addition to increasing the gain, regeneration also greatly increases the selectivity or "Q" of the circuit. C12 controls the amount of regeneration. C6 allows the user to adjust the detector loading so that the signal is not detuned as regeneration is increased. This allows razor sharp regeneration adjustment without premature oscillation. The detector operating voltage is regulated by a Zener diode, D1, which helps keep the detector oscillation frequency from drifting when receiving SSB or CW transmissions.

The detector is preceded by an RF stage that provides gain and, more importantly, isolates the detector from the antenna, pre-

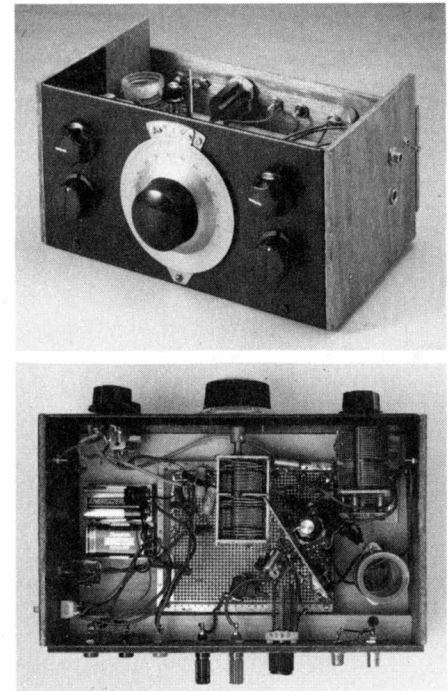
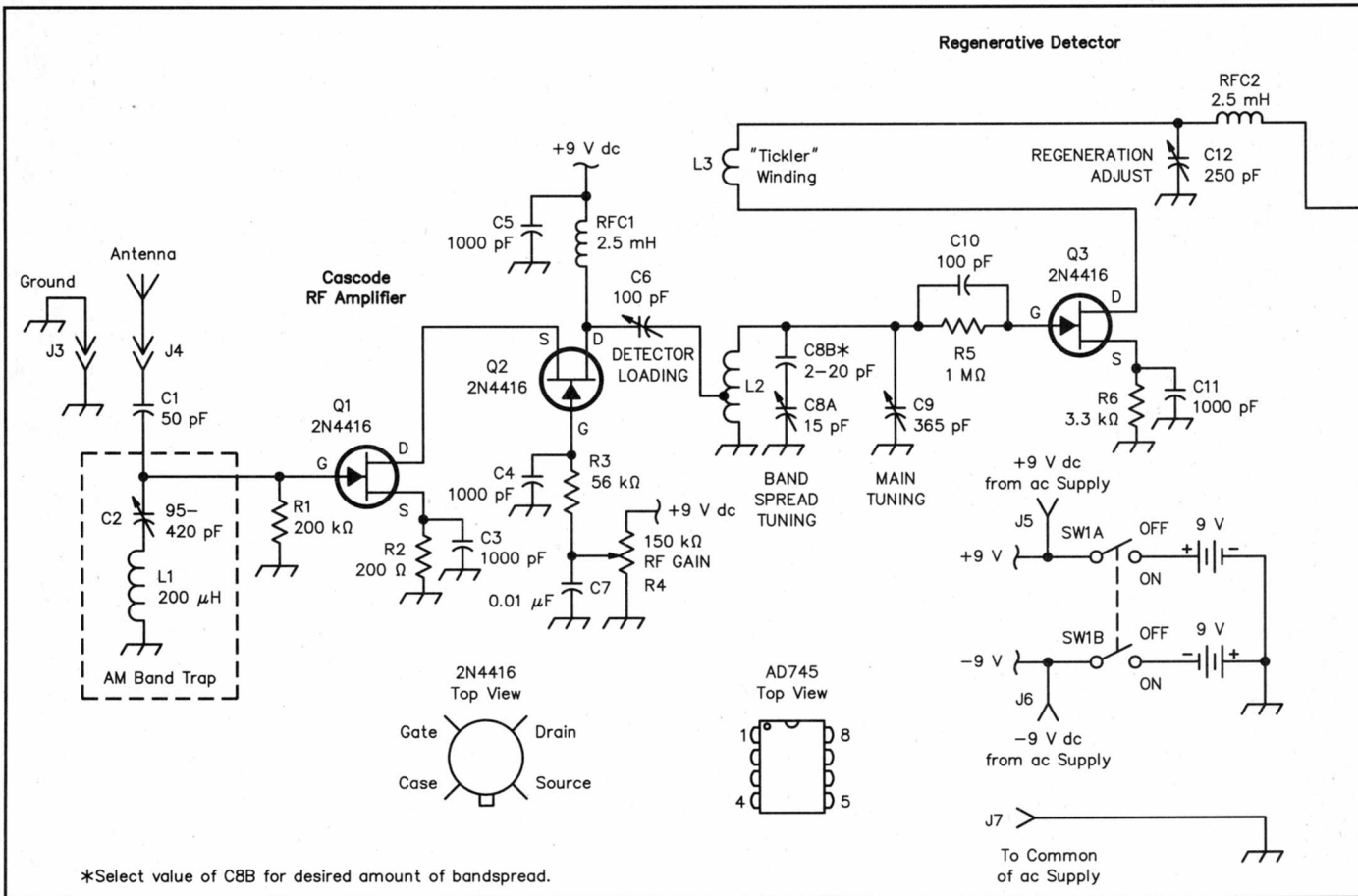


Fig 17.75—Photos of the prototype regenerative receiver.

Circuit Description

The heart of this circuit is JFET Q3,



venting its oscillations from interfering with other receivers in the area. An optional AM band trap can be tuned to reject interference from any nearby AM broadcast stations.

The audio stage uses an Analog Devices AD745 op amp that replaces the usual two stages of audio amplification and an output transformer. This op amp has enough output current capability to directly drive series connected "Walkman" type head-

phones to high levels with low distortion, and yet it only draws 8 mA from the batteries.

Construction Details

The prototype receiver was built on a wooden chassis. This makes construction much easier, reduces loading effects caused by placing metal objects too close to the main tuning coil, and provides a nice looking receiver. The base is a piece of

$\frac{3}{4}$ ×10×6-inch poplar. The sides and back are $\frac{1}{4}$ -inch plywood. The two side pieces are $6\frac{1}{4}$ × $5\frac{1}{4}$ inches. The back panel is 10×4 inches and is braced to the base with a $10\times1\frac{1}{2}\times\frac{3}{4}$ -inch piece of poplar and wood screws.

The front panel is the black-wrinkle finished steel U-shaped top from a $10\times5\frac{1}{4}\times3\frac{1}{2}$ -inch metal cabinet. If desired, the front panel can also be made of plywood as long as the metal frames

Fig 17.76—A regenerative receiver for beginners. Part Suppliers: OSE = Ocean State Electronics; AES = Antique Electronics Supply; FRS = Fair Radio Sales; NE = Newark Electronics; RS = Radio Shack. Look at the ARRL Address List in the References chapter for current addresses (OSE, AES, FRS). NE and RS are chain stores, look for them in your local yellow pages.

- C1—50-pF mica capacitor.
- C2—95-420-pF mica trimmer capacitor (RS# 272-1336).
- C3, C4, C5, C11—1000-pF mica capacitor.
- C6—100-pF air variable capacitor.
- C7, C17, C18—0.01- μ F disc ceramic capacitor.
- C8A*—15-pF air variable capacitor.
- C8B—Small mica capacitor to set desired band spread: 2-20-pF.
- C9*—10-365-pF air-variable capacitor.
- C10—100-pF mica capacitor.
- C12*—250-pF air-variable capacitor.
- C13—10- μ F, 16-V tantalum or

- electrolytic capacitor.
- C14—0.1- μ F disc ceramic or Mylar capacitor.
- C15, C16—33- μ F, 16-V tantalum or electrolytic capacitor.
- D1—1N4736A 6.8-V Zener diode (OSE).
- J1—Phono jack.
- J2—Stereo headphone jack—note that the common terminal is not connected.
- J3, J4—Five-way binding posts for antenna and ground connections,
- J5, J6, J7—Banana jacks.
- L1—200- μ H RFC (OSE).
- L2, L3—Plug-in coils (see Fig 17.77 for winding data).

- Q1-Q3—2N4416 Motorola VHF N-channel JFET (NE).
- R1—200-k Ω $\frac{1}{8}$ -W 5% carbon composition resistor.
- R2—200- Ω $\frac{1}{8}$ -W 5% carbon composition resistor.
- R3—56-k Ω $\frac{1}{8}$ -W 5% carbon composition resistor.
- R4—150-k Ω potentiometer.
- R5—1-M Ω $\frac{1}{8}$ -W 5% carbon composition resistor.
- R6—3.3-k Ω $\frac{1}{8}$ -W 5% carbon composition resistor.
- R7—1.5-k Ω $\frac{1}{8}$ -W 5% carbon composition resistor.
- R8—100-k Ω potentiometer.
- R9—1-k Ω $\frac{1}{8}$ -W 5% carbon composition resistor.
- R10—330-k Ω $\frac{1}{8}$ -W 5% carbon composition resistor.
- R11—680- Ω $\frac{1}{8}$ -W 5% carbon composition resistor.
- R12—51- Ω $\frac{1}{8}$ -W 5% carbon composition resistor.
- RFC1, RFC2—J. W. Miller #70F253A 2.5-mH RF choke (OSE).
- S1—DPST toggle switch.
- U1—Analog Devices AD745JN low-noise op amp (NE).

Miscellaneous:

Vernier dial (OSE) or vernier reduction drive (OSE) (FRS) or use "Jackson" drive.

Vector #4112-4 plug board (NE) or low-cost $4\frac{1}{2}$ ×6-inch standard and copper clad board (RS).

*C6, C8, C9, and C12—available from (AES),(OSE),(FRS).

Measured Parameters

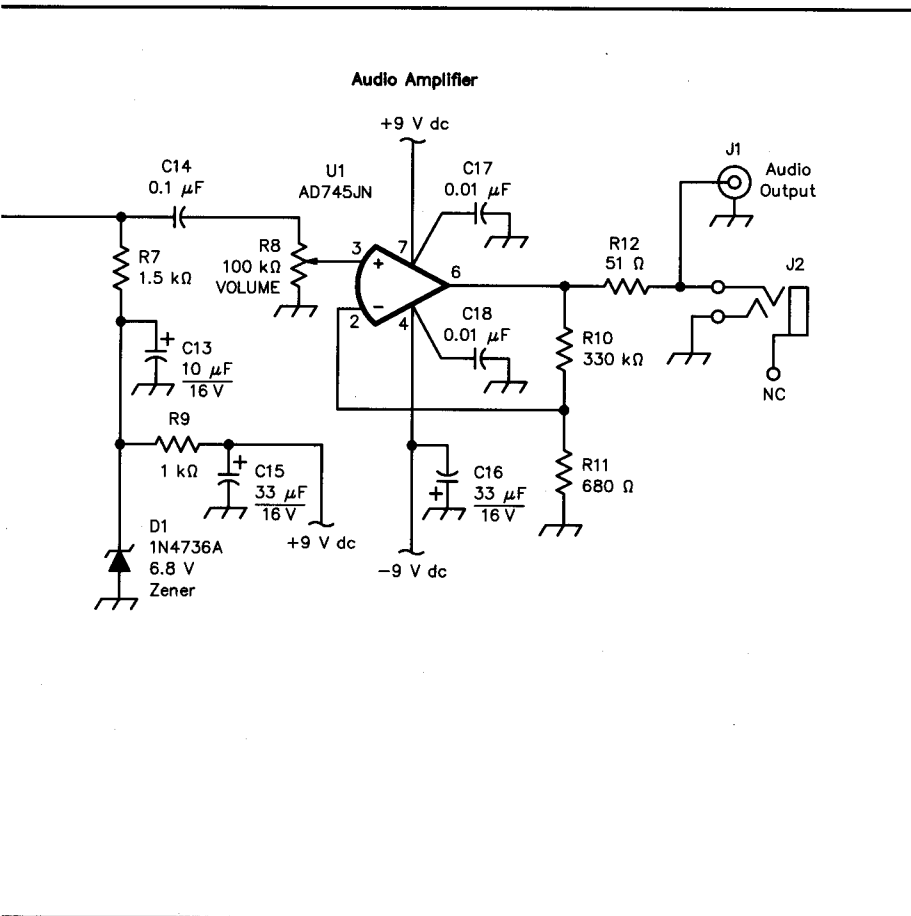
50- Ω input termination, Sensitivity (discernible 1-kHz audio output for 100% modulated RF input level)

Sensitivity:

CW & SSB (detector oscillating) 0.3 μ V
AM (detector not oscillating) 1 μ V.

Selectivity:

Variable, depending on setting of C6 from approximately 10 kHz to a few hundred Hz at critical regeneration.



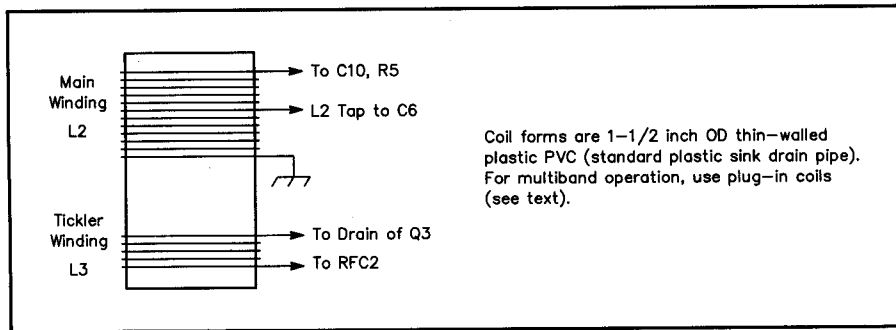


Fig 17.77—Details and winding data for L2/L3.

Coil Data for the Regenerative Receiver

Turns required for use with a 10 to 365-pF tuning capacitor, #20 enameled wire and a 1 1/2-inch OD coil form.

Frequency Range (MHz)	L3 turns (μH)	L2 turns (μH)	L2 tap turns (% of L2)
1.6 to 5.5	8(3.9)	30(30.0)	10(30%)
3 to 12	4(1.1)	13(8.6)	4(31%)
8 to 25	2(0.3)	5(1.7)	1(20%)

of the tuning and regeneration capacitors and the shaft of the volume control are grounded to the circuit board through short leads.

The circuit was built on a Vector 4112-4 predrilled fiberglass breadboard with a metal ground plane on one side. The board was cut to 5 1/4 x 4 1/2 inches. All ground leads are short and made directly to the ground plane, which is on top.

The detector and RF stages are located on the left side of the board, the main tuning capacitor, C9, is screwed directly onto the top center of the board (grounding it directly), and the audio amplifier section is located on the right-hand side. Wiring is point to point, using the shortest leads possible. The metal front panel is grounded.

It is a good idea to build receiver circuits backwards. That is, audio stage first, then detector, then RF stage. Test each stage to be sure it functions before you start the next. Note that the headphone jack common terminal is not connected, so don't mount the jack through a grounded panel. In the receiver shown, the jack was mounted through the right-hand wooden side panel. The audio output jack is mounted just above it.

An optional RF shield was used between the detector and RF stages. It consists of a 5 3/4 x 3 1/4-inch double sided PC board mounted vertically with both foils soldered to the ground plane of the main board (thus making a double shield). A small one-inch-square window was cut at the bottom edge of the shield to pass wiring between the stages. The ground lug of the RF GAIN control is

soldered to the RF shield to hold the control in place. This control could also be placed on the front or side panels of the receiver and connected to the RF section using shielded wire.

The REGENERATION ADJUST control, C12, is located on the top-left side of the front panel with the DETECTOR LOADING capacitor directly below it. Because the DETECTOR LOADING capacitor must be isolated from ground, a small piece of insulated board was attached to the capacitor frame. This allows it to be screwed down onto the wooden base. The shaft of the loading capacitor passes through an oversized hole in the front panel.

The shaft of the MAIN TUNING capacitor is attached to a vernier dial. This receiver uses a vintage 4-inch "velvet vernier" dial (from the 1930s), which was purchased at a local hamfest. Although smaller and of lesser quality, new vernier dials can be purchased from several suppliers as can the vernier drive mechanism itself (without the front plate and knob—see parts list). The VOLUME control is located at the top right-hand side of the front panel; the BAND-SPREAD TUNING capacitor, C8A, is located below it. C8B is a small fixed capacitor selected to provide the desired band spread. For general-coverage use, the vernier dial should be used on the main tuning capacitor. For maximum bandspread on the amateur bands, use the vernier on the band spread capacitor and a large knob for the main tuning. In all cases, plastic knobs are best for all the controls; they prevent hand capacitance effects.

On the back panel, two five-way binding posts provide ANTENNA and GROUND connections and three banana jacks allow connection of an optional ac power supply. The ON/OFF switch, HEADPHONE jack and AUDIO OUTPUT jack are mounted on the right-side panel.

This receiver can use a single fixed coil form for L2 and L3 to cover a single range of frequencies or it can use plug in coils to cover several bands (Fig 17.77). For fixed coils, standard 1 1/2-inch thin-wall PVC pipe (plastic sink drain pipe) is easy to find, and it works well. Use #20 enameled wire to wind both L2 and L3 in the same direction. To avoid detuning effects, wind L3 on the bottom (ground end) of L2, with a 1/4" space between windings as shown in the figure.

When winding the coils on a PVC form, first drill two small holes at the beginning of each winding. Next, feed the wire into the pipe through the first hole and out again through the second. Tie a knot at the point in the wire where it enters the form—this will hold the wire securely. Wind the coil tightly onto the form. When you reach the proper number of turns on L2, where the tap is placed, simply sand off a small amount of insulation from the wire and solder a lead to it. When the winding is finished, drill two more holes and tie a knot at the end to hold the coil in place. Be sure to leave enough extra wire at both ends of the winding to make connections, and clean the ends of the leads before soldering. Plug-in coil forms may be purchased from Antique Electronics Supply (see the References chapter Address List).

Plugs for the coils may be easily made from the bases of 4, 5, 6 or 8-pin vacuum tubes (tube bases can be purchased, or old tubes can be "cannibalized" by removing the glass envelope and "innards"). After winding the coil, push a tube base inside the PVC coil form, drill a couple of holes through both, and fasten them together with small machine screws and nuts. Four-pin tube bases fit perfectly into 1 1/2-inch PVC. Others, such as common octal bases, may need a couple wraps of electrical tape for a snug fit. When using four-pin bases, a separate banana plug and jack can serve as the fifth pin that connects the L2 tap to C6. You can also make plug-in coils by attaching standard chassis connector plugs to plastic pill-bottle coil forms: Drill a small hole through the center of the plug and the bottom center of the pill bottle. Again, hold the two together with small machine screws and nuts.

With any plug-in coil, run the wires from each winding inside the coil form and solder them to one of the pins on the plug, ensuring that all the coils are wired exactly the same. The completed coil form then plugs into a companion socket that is screwed to the wooden base. Be sure to locate the coil at least one inch away from any metal object.

Circuit Testing

Test the audio stage by installing the batteries, plugging the headphones into J2, turning the VOLUME control half way up and placing your finger on the center terminal (wiper) of the control. If you hear a buzz (the buzz is power-line noise picked up by your body), it's working. Test the detector by setting C6 for minimum capacitance and then slowly increase the capacitance of the REGENERATION control, C12, until the detector oscillates, producing a hiss or squeal in the headphones. If the detector does not oscillate, carefully check the wiring for errors. If the wiring seems okay, try swapping the wires to the tickler winding, L3. Once the detector is oscillating, temporarily connect an antenna to the input (Q2) side of C6 and tune in a strong station that doesn't fade. Adjust C6 and C12 for best reception.

Test the RF stage by connecting the antenna to C1 and adjusting the RF GAIN control, R4, for maximum volume. If the received station now comes in weaker than it did using just the detector, recheck the RF-stage wiring. If a strong AM broadcast station is being received, it will be necessary to install the optional AM band trap; adjust C2 to tune out the offending station. An alternative to the AM trap is a low-pass filter (built from a standard TV balun transformer—see Fig 17.78) to restrict reception below 5 MHz. If the balun is used, make C1 a variable capacitor and adjust it for best sensitivity. The balun is cheaper and easier to find than the 200- μ H choke used for the AM trap, but the receiver's sensitivity will be reduced and it will not cover the 80 and 160-m bands.

In the time honored tradition of Amateur Radio, simply experiment with the number of turns on coil L2 to get the exact range of frequencies desired. That is, simply add turns to lower the range of reception frequencies or remove turns to raise it. Accordingly, 150 or 250-pF variable capacitors can be substituted for the 365-pF main tuner and likewise, 1 or 2-inch coil forms can be used instead of the 1½-inch diameter specified, as long as the number of turns on L2 and L3 are changed to provide the desired range of frequencies and degree of regeneration.

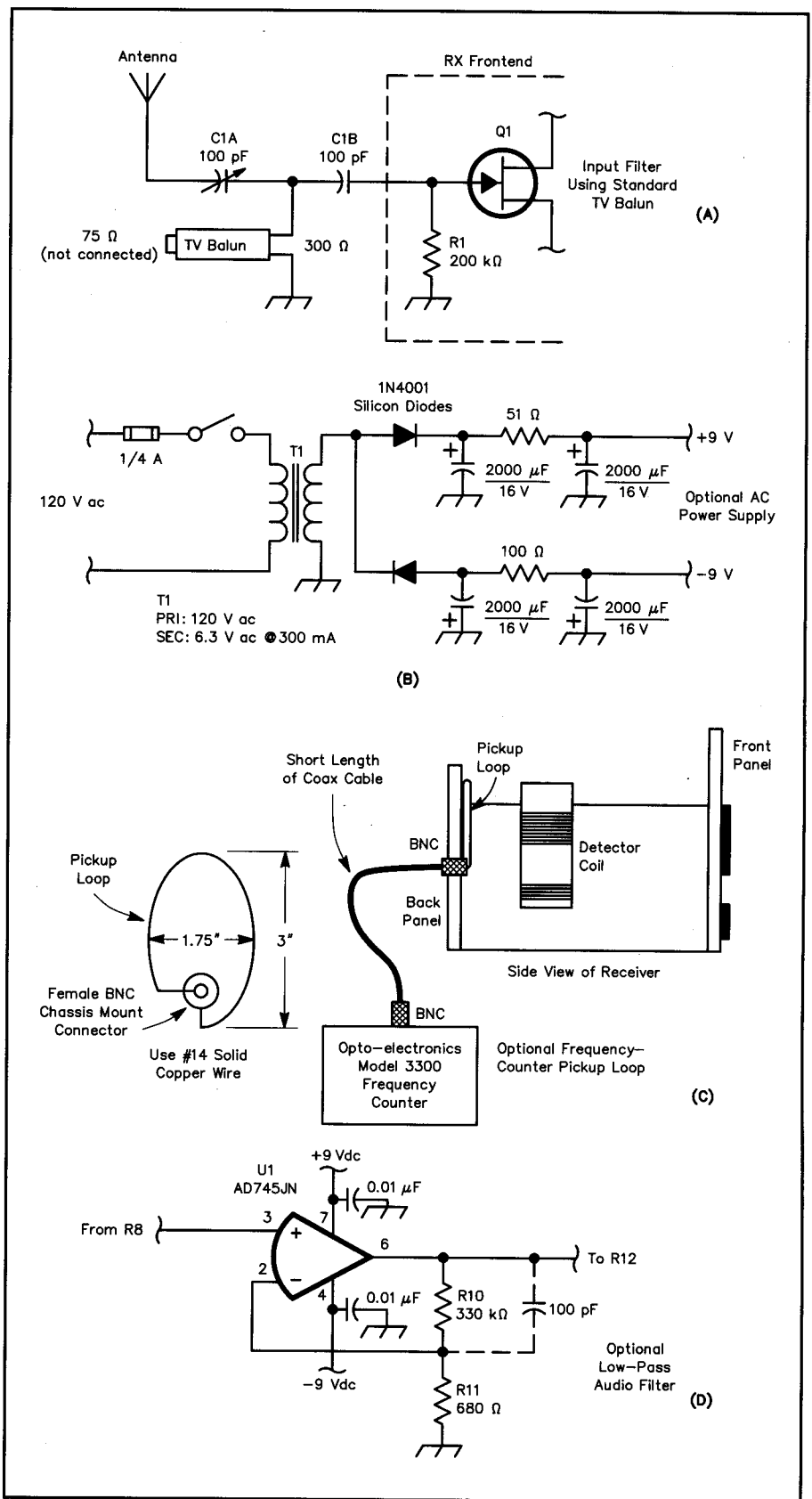


Fig 17.78—Optional modifications for the regenerative receiver. A shows a 5-MHz high-pass filter that uses a TV balun as an inductor. This filter is less expensive than the AM broadcast trap, but it lessens sensitivity and prevents reception of the 160 and 80-m ham bands. B is an ac power supply; keep the supply isolated from the receiver (see text). The pickup loop at C couples some of the detector signal to a frequency counter for use as a display. D is an audio low-pass filter.

(Calculated inductance values for the coils are given in Fig 17.77.)

If you build the optional ac power supply (Fig 17.78), be sure to build it on a separate wooden board and use a long three-wire cable (telephone wire works well)—2 ft long, or more, to physically isolate the power supply from the receiver. If you use an external supply other than that shown, be sure that it is well filtered. Other options include a low-pass filter to reduce the audio bandwidth and a pickup loop to drive a frequency counter display. (The display will only work when the detector is oscillating.)

Tuning Tips

Use two hands when operating the receiver, one for tuning, the other to adjust regeneration. For maximum sensitivity,

the regeneration level needs to be maintained at a point just below (for AM signals) or just above (for CW and SSB) the threshold of oscillation. When the detector is oscillating, as when receiving SSB or CW transmissions, it will tend to lock onto the center of strong RF signals and prevent or “block” tuning to either side of the carrier—this can make SSB difficult to receive. To avoid blocking, set the detector loading control for less capacitance and increase the level of regeneration. Very high sensitivity can be achieved, for receiving very weak AM signals, by operating the detector just above oscillation and zero beating the carrier. This is known as “autodyne” reception.

The correct adjustment of the DETECTOR

LOADING capacitor, C6, is critical to the operation of this receiver because it decouples the detector from the RF stage and permits very high selectivity, which helps to separate stations on a crowded band. Its adjustment is a trade-off: less coupling (less capacitance) reduces the loading and provides higher selectivity but it also reduces the signal level coming from the RF stage and therefore the receiver’s sensitivity.

Space limitations do not permit us to show a companion super regenerative receiver for the VHF and UHF bands. If you’re interested, look at “The Lost Technology of Super Regeneration” by Charles Kitchin in the fall 1994 *Communications Quarterly*.