A QRP SSB/CW Transceiver for 14 MHz

Part 1: Exotic circuitry and hard-to-find components aren't necessary if you want to build excellent performance into a home-brew SSB/CW transceiver: Careful design is the key.

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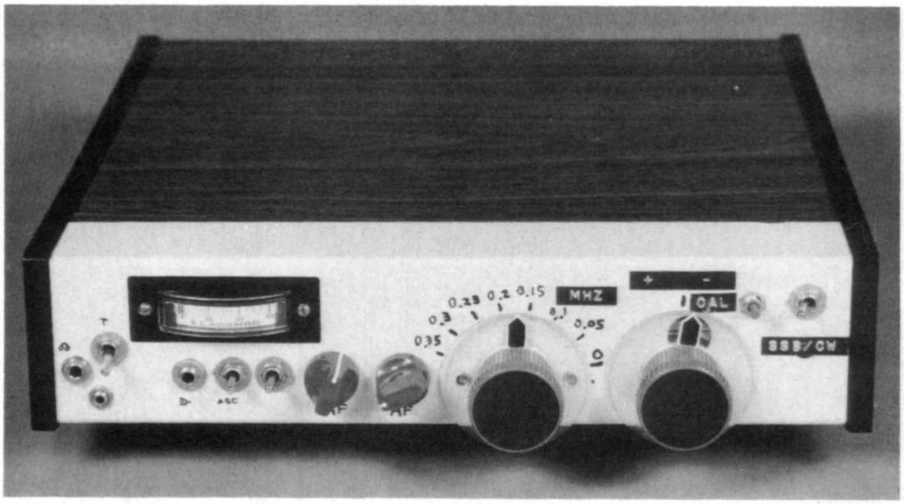

It's hard to justify the construction of a complete SSB/CW transceiver in this "modern" era of readily available commercial equipment. The popular, multiband MF/HF transceivers offer excellent performance, often at a reasonable cost. Still, I feel a twinge of guilt when I use them. They offer nothing of the feeling of exploration that I've grown to expect from Amateur Radio.

The rig described here is not a copy of the usual "appliance." I've used the project as a vehicle to investigate alternative circuits and a block diagram that departs from the traditional. The circuit is simple and modular, with flexibility that allows for later changes.

I present this rig in order to encourage other home-brew enthusiasts to give QRP SSB a try. I'll not dwell on the standard circuits that are already covered in *Solid-State Design* or in *The ARRL Handbook*.[1,2] Rather, I'll emphasize only those circuits that depart from the traditional. This is intended to be an idea article rather than a construction piece. There are no circuit boards or patterns available for this rig. All construction was done using "ugly" methods.[3]

System Architecture

The filter method was chosen for this transceiver. While that is generally considered to be "the only choice," phasing methods should not be overlooked for an experimental transceiver.[4] The block diagram is shown in Fig 1.

The traditional filter transceiver shares one or more crystal filters between the receive and transmit modes. I wanted to avoid the compromises and complexities of filter switching, so I decided to use separate filters for each function. The transmit and receive modules can then be used for completely independent operation. This might be especially interesting for use with, for example, a VHF/UHF station for OSCAR communications.

Commercial crystal filters from my junk box were used in this project. They are all 9-MHz circuits that are, fortunately, well matched to each other. A 5-MHz local oscillator drives both the receiver and transmitter mixers. Budget-minded builders may elect to built their own filters.[5,6]

The Receiver

The receiver is very much like the Progressive Receiver that's been in *The ARRL Handbook* for several years.[7] The front end and VFO are presented in Fig 2. I initially used a VFO variable capacitor with a vernier drive mechanism. Problems occurred with the mounting, however. The VFO was rebuilt without a vernier. Instead, two capacitors were used. One (C1, BANDSET) tunes the entire band, while the other (C2) is a bandspread control with a total range of only 25 kHz. This scheme seems to be practical for a simple transceiver.

The receiver begins with a doubly tuned preselector and a diode-ring mixer (U1, a Mini-Circuits SBL-1). This is followed by a bipolar transistor (Q3, an NEC99532) in a negative-feedback IF amplifier. A ferrite transformer (T4) matches the IF amplifier to the receiver crystal filter (FL1) as shown in Fig 3. The filter I used is similar to the KVG XF-9B. The less-expensive KVG XF-9A was tried in this application and was found wanting for stop-band attenuation.

The crystal filter drives an MC1350P IF amplifier (U2) and a diode-ring product detector (U3, an SBL-1). I would discourage a builder from departing from a diode-ring detector. An NE602 detector was tried, but suffered from severe in-band intermodulation distortion.

The BFO signal is low-pass filtered before driving the detector. A reduced-voltage sample of the BFO energy is routed to the transmit balanced modulator (to be described in Part 2 of this article). Care was taken to extract the sample from a point away from the detector. (The diode-ring detector clips the BFO waveform; clipped carrier-oscillator drive for the balanced modulator is undesirable.)

The audio amplifier (Q6-Q8 and U4) is standard. However, the audio-derived AGC system departs from the usual. U5A (one section of an LM324) amplifies the audio to a level suitable for

[1]Notes appear on page 20.

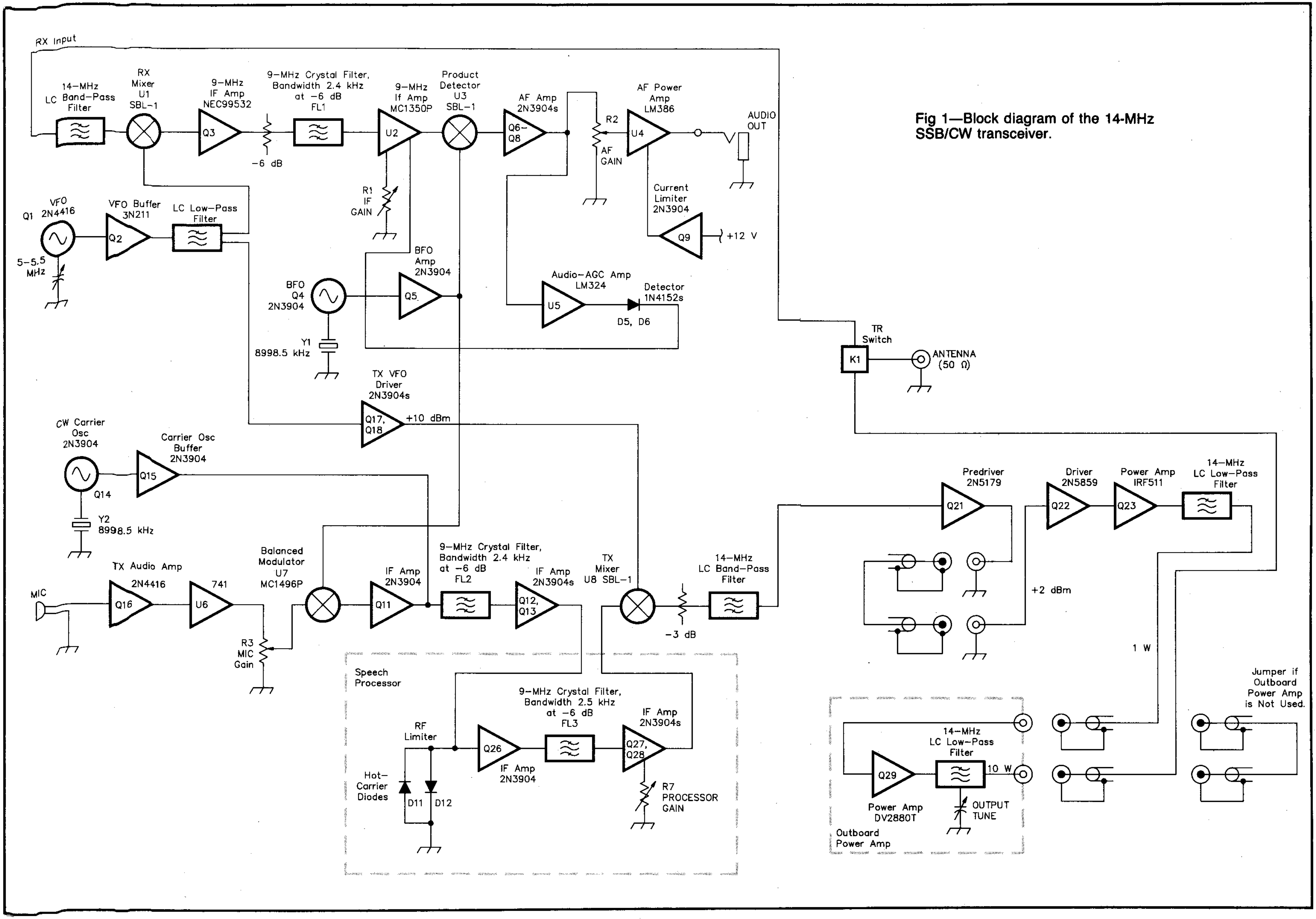

Fig 1—Block diagram of the 14-MHz SSB/CW transceiver.

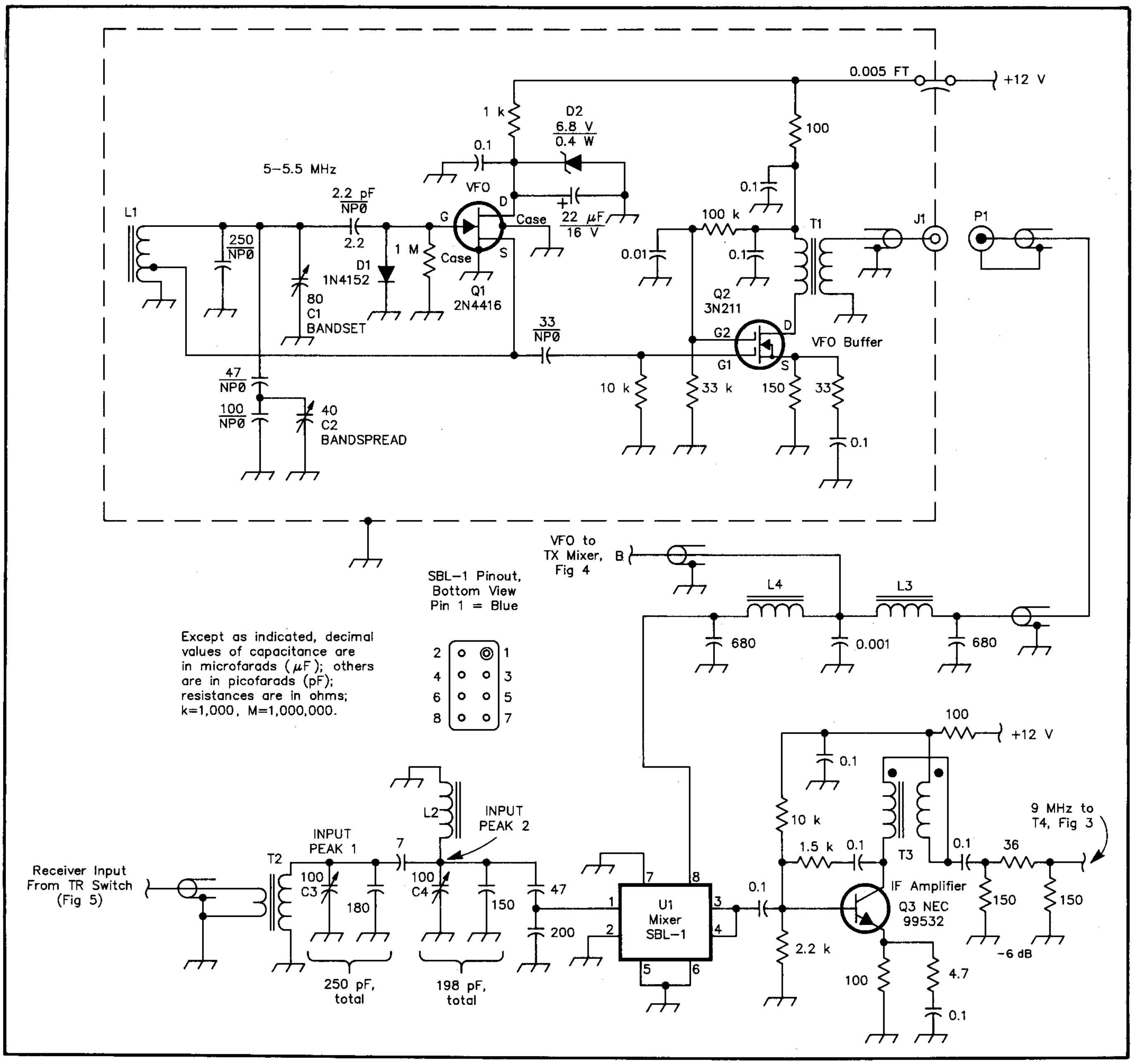

Fig 2—Schematic of the transceiver front end and VFO. Resistors are ¼ W, carbon film; unless otherwise indicated, capacitors are monolithic or disc ceramic. The VFO circuitry is built into a die-cast aluminum box.

C1, C2—Panel-mountable, air-dielectric variable with ¼-inch-diam shaft.
C3, C4—100-pF ceramic- or mica-dielectric trimmer.
J1—Coaxial jack. (The prototype transceiver uses a panel-mount SMB jack here, but a BNC or phono jack is suitable.)
L1—23 turns of no. 22 enam wire on a T-68-6 toroidal, powdered-iron core, with a feedback tap 5 turns from the grounded end of the winding.
L2—11 turns of no. 24 enam wire on a T-44-6 toroidal, powdered-iron core.
L3, L4—25 turns of no. 24 enam wire on a T-37-6 toroidal, powdered-iron core.
T1—Broadband transformer: Primary, 16 turns of no. 26 enam wire on an FT-37-43 toroidal, ferrite core; secondary, 4 turns of no. 26 enam wire wound over the primary.
T2—Narrow-band transformer: Tuned winding, 11 turns of no. 24 enam wire on a T-44-6 toroidal, powdered-iron core; input link, 2 turns of no. 24 enam wire over the tuned winding's grounded end.
T3—Broadband transformer: 10 bifilar turns of no. 28 enam wire on an FT-37-43 toroidal, ferrite core. Observe phasing.

detection by D5. U5D functions as a unity gain inverter to drive a second diode (D6), providing full-wave detection. Each diode operates as a peak detector, providing one sample of the audio level per cycle. Full-wave operation doubles the sampling rate to better approach the Nyquist criterion. The practical result is a simple circuit with better dynamic performance than other audio-derived ones I've tried.

Notes

[1]W. Hayward and D. DeMaw, *Solid-State Design for the Radio Amateur* (Newington: ARRL, 1986).
[2]K. Kleinschmidt, ed, *The 1990 ARRL Handbook*, (Newington: ARRL, 1989).
[3]R. and W. Hayward, "The Ugly Weekender," *QST*, Aug 1981, pp 18-21.
[4]G. Breed, "A New Breed of Receiver," *QST*, Jan 1988, pp 16-23.
[5]W. Hayward, "Designing and Building Simple Crystal Filters," *QST*, Jul 1987, pp 24-29.
[6]W. Hayward, "A Unified Approach to the Design of Crystal Ladder Filters," *QST*, May 1982, pp 21-27; also see Feedback, *QST*, Jul 1987, p 41.
[7]W. Hayward and J. Lawson, "A Progressive Communications Receiver," *QST*, Nov 1981. Also see Feedback, *QST*, Jan 1982, p 47; Apr 1982, p 54; and Oct 1982, p 41. This receiver also appears in the 1982 through 1990 editions of *The ARRL Handbook*.

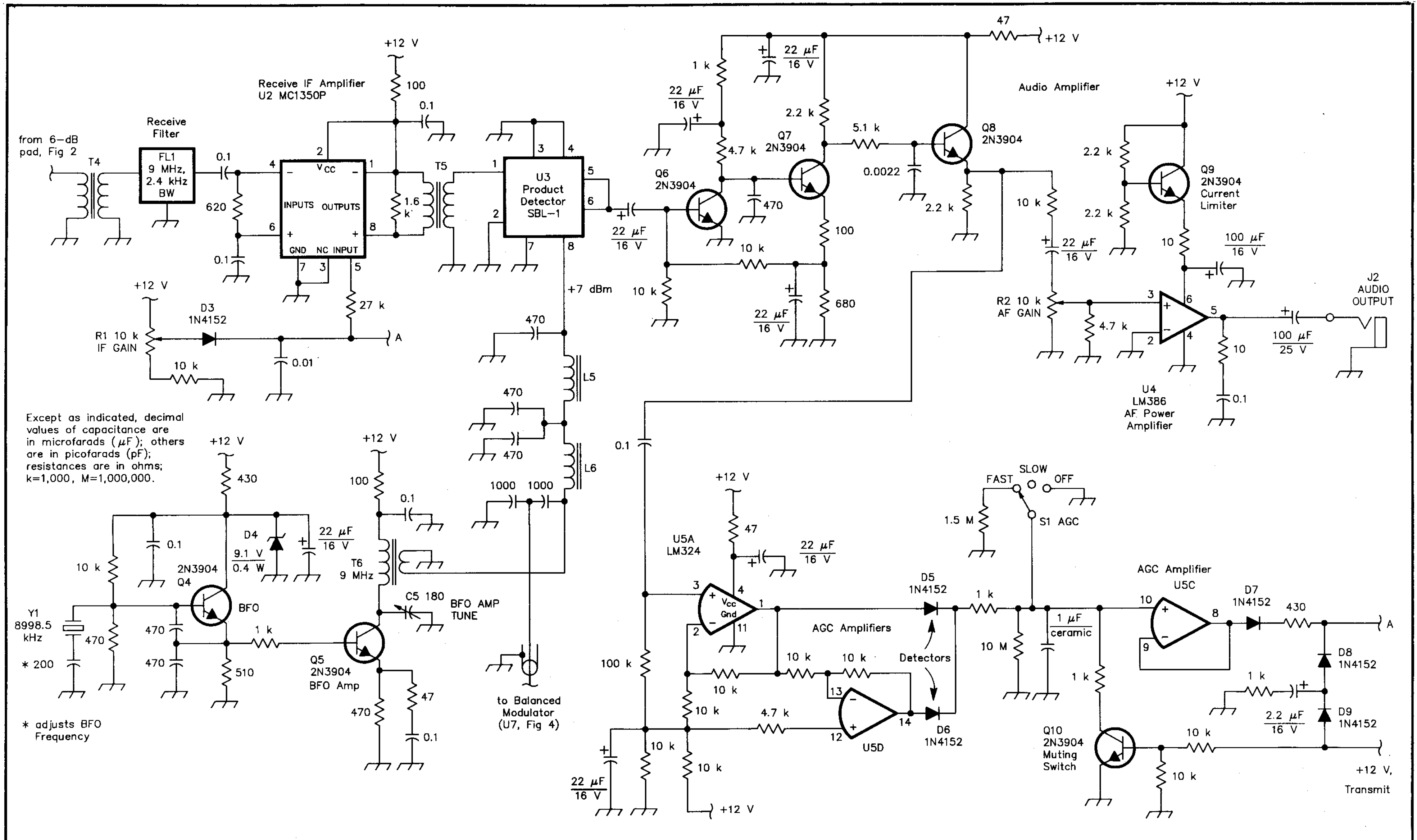

Fig 3—The transceiver receive filter, IF amplifier and detector circuitry. Resistors are ¼ W, carbon film; unless otherwise indicated, capacitors are monolithic or disc ceramic.

FL1—9-MHz crystal filter, 2.4 kHz wide at −6 dB (KVG XF-9B).

L5, L6—22 turns of no. 26 enam wire on a T-37-6 toroidal, powdered-iron core.

T4—Broadband transformer: Primary, 5 turns of no. 26 enam wire wound over the secondary winding; secondary, 16 turns of no. 26 enam wire on an FT-37-43 toroidal, ferrite core.

T5—Broadband transformer: Primary, 20 turns of no. 26 enam wire on an FT-37-43 toroidal, ferrite core; secondary, 3 turns over the primary.

T6—Narrow-band transformer: Primary, 26 turns of no. 24 enam wire on a T-50-2 toroidal, powdered-iron core.

Y1—8998.5-kHz crystal (KVG XF-901 suitable).