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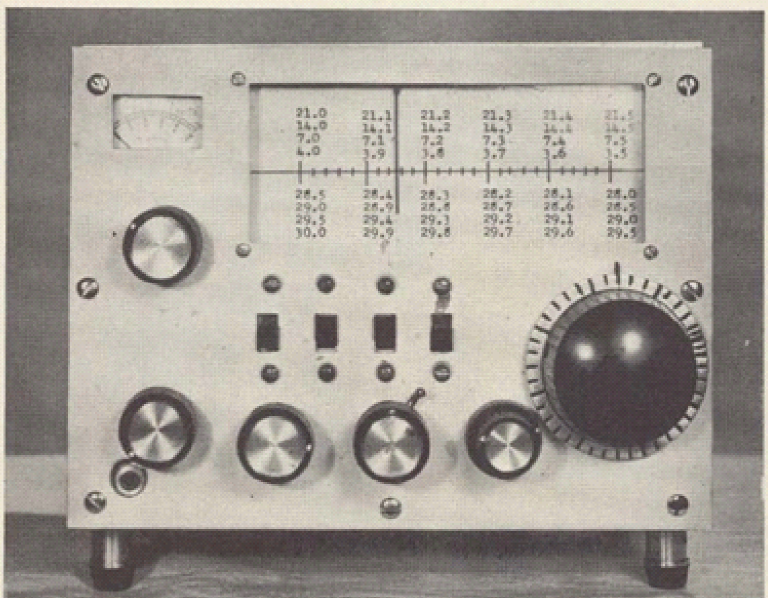
The 2Q Communications Receiver

A 22-transistor design using FET's.

A strong desire to duplicate the popular Drake 2-B receiver in transistor form, prompted the building of the receiver shown. It is the result of over two years of experimental design, building, rebuilding, testing and listening. The block diagram in **Fig. 1** closely resembles that of the Drake, and for that reason I have named it the 2Q.

The completed receiver is a triple conversion superheterodyne, covering all amateur bands 10 through 80 meters. It has excellent sensitivity, selectivity and stability. Cross modulation has been reduced to a minimum by the use of FET transistors in both the rf and first mixer stages. Such features as band-pass tuning, FET detector, S-meter, agc and a 100 kHz crystal calibrator are included.

The circuit shown in **Fig. 2** is actually the result of two that were built. The first design, following the usual transistor circuit theory, matching impedances, etc., resulted in a receiver that lacked the necessary sensitivity and selectivity. Cross modulation was also a problem because bipolar transistors were used in the front end. The second design is the result of a concentrated effort toward obtaining maximum selectivity by the use of small capacity coupling where possible, high Q tuned circuits, and tapping collectors down on the coils to preserve their Q. Cross modulation was reduced to a minimum by using FET transistors in both the rf and first mixer stages and by using a separate rf gain control.



Front view of the 2Q transistorized receiver. Bottom, left to right, are the phone jack, bandswitch, *if* gain, band-pass tuner, selectivity switch combined with rf and volume control, and main tuning. Switches, left to right, are agc S-meter switch, dial light, 100 kHz calibrator and bfo.

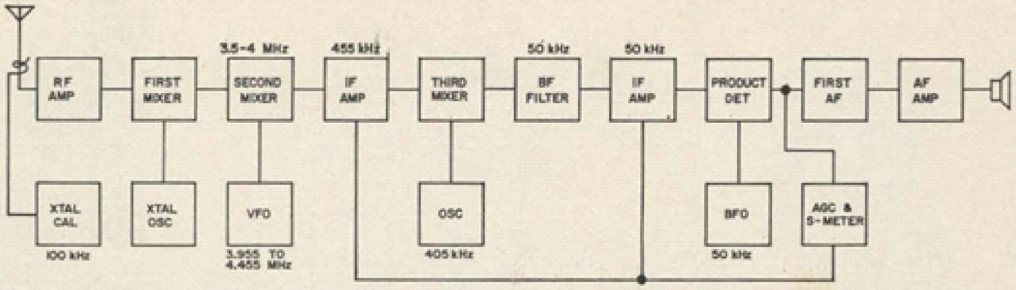


Fig. 1. Block diagram of the 2Q, a completely transistorized communications receiver of modern design using FET's in the front end.

The circuit

Much has been written on transistor circuitry during the past few years so I will be as brief as possible and describe only those points which I think important or unusual.

Capacitive coupling is used throughout the front end (preselector). It uses high-Q toroid coils and slug-tuned coils. The simple switching provides the necessary selectivity and ease of adjustment desirable when compact construction is used. Ami-Tron toroids were not used for the 15- and 10-meter bands due to the lack of space for the necessary trimmer capacitors, but their use is definitely recommended for all bands. The selectivity and stuffing ratio gained by their use is very necessary. The tuning capacitor, a two-gang trf unit, was reduced to 200 pF per section. Space for the rf choke was solved by placing it in the crystal oscillator compartment.

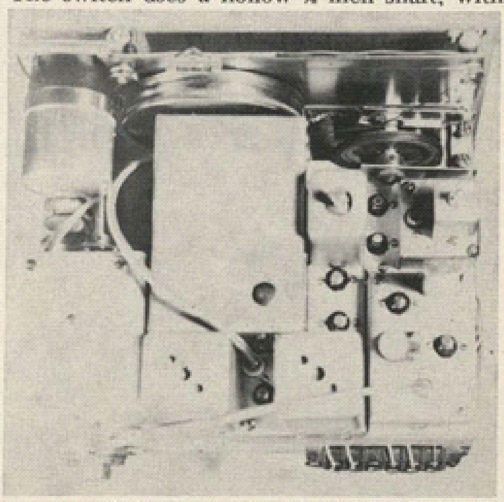
The FET mixer, using source injection, is capacitively coupled to the second mixer. The circuit, possibly of my own design, was preferred to a gate injection circuit. The only FET's available were N-channel 2N3823's, but possibly some of the cheaper ones will work as well.* I intend to try the Motorola MPF 105 FET when I can locate a distributor who stocks them. Alignment of the front end is simply a matter of adjusting turns, spacing, and trimmer capacitors, until the amateur bands are staggered across the preselector dial.

The 3.5 MHz-4.0 MHz variable *if*, mixer and oscillator section, consists of a high-C Colpitts oscillator, and a base injected mixer, with an output at 455 kHz. Only the highest quality components should be used here, since it is a major frequency determining circuit.

Only one stage of amplification was found necessary for the 455 kHz *if* section. The mixer is capacitively coupled with base injection at 405 kHz from a high-C Colpitts oscillator giving a 50 kHz output. Here again the oscillator is a major frequency determining circuit and care should be used in its construction. The 455 kHz *if* coils can be any high-Q center tapped units, preferably using toroids or cup cores. This is a good spot for a mechanical filter; something I intend to try in the near future.

The band-pass tuner was constructed using coils wound on 1" diameter powdered iron toroids from an old telephone company audio filter. The ones I used were blue and numbered A9301572. The tuning is done with a three-gand trf type broadcast tuning capacitor, with a stop added to limit its travel to about 20 degrees, starting from maximum. The switch uses a hollow ¾ inch shaft, with

* 2N3819 FET's seem to work as well as the more expensive 2N3823's. With the 2N3819, the only circuit changes were in the rf amplifier—the source was grounded and B+ changed to 14 V. Motorola MPF-103's have been tried too. At 90¢ each they seem to work as well and their specs are almost identical.



Top view of the 2Q receiver, showing the layout of the various parts.

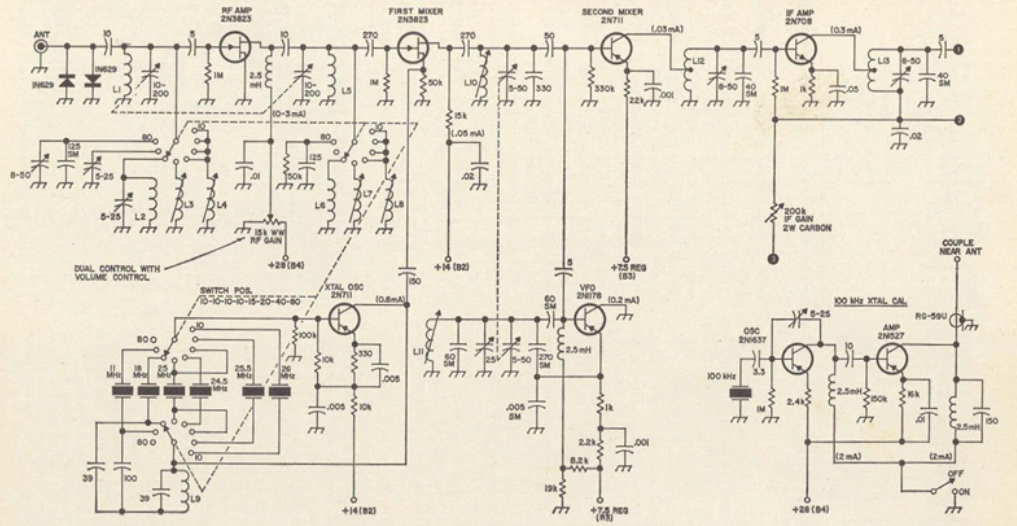
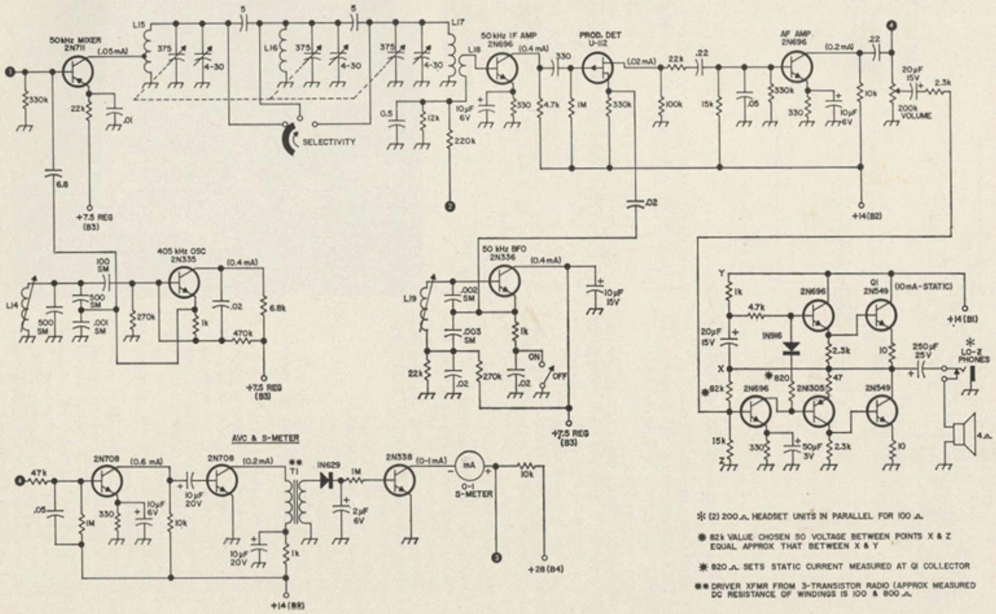


Fig. 2. Schematic diagram of the 2Q communications receiver. The currents shown in parenthesis are the collector currents for each stage. The rf chokes used were 3-pi types on 1/8-inch iron cores taken from a surplus computer board although miniature 2.5 mH units should work ok. Coil values are given in Table I. Later experimentation by W5ETT indicates that the bias network used with the 2N708 455 kHz *if* amplifier was not too tolerant to different transistors. He recommends removing the 1M base-bias resistor and replacing it with a 330k resistor *and* a 27k resistor from base to ground.

*T-68-2 and T-50-6 toroid cores may be purchased from Ami-tron Associates, 12033 Otsego Street, North Hollywood, California. Price 50¢ each plus postage.



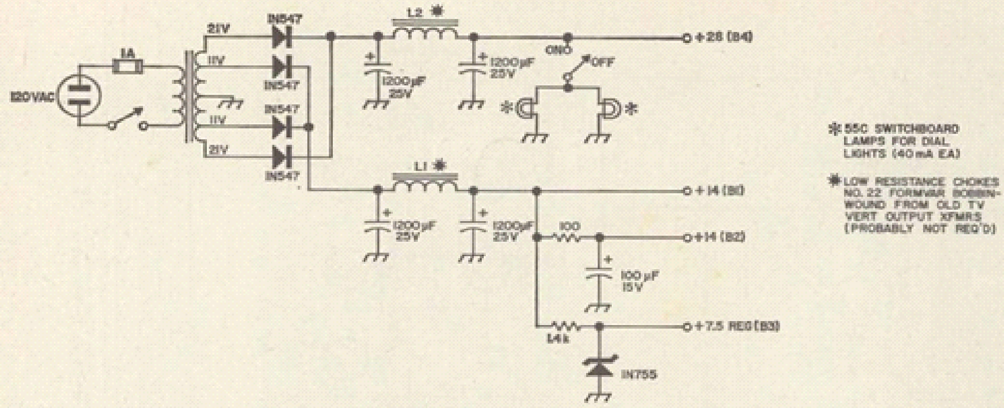


Fig. 3. AC power supply for the 2Q communications receiver.

the TC shaft being operated through it.

The FET detector using a P-channel U112 or 2N2497 has plenty of bfo injection and works very well on SSB.

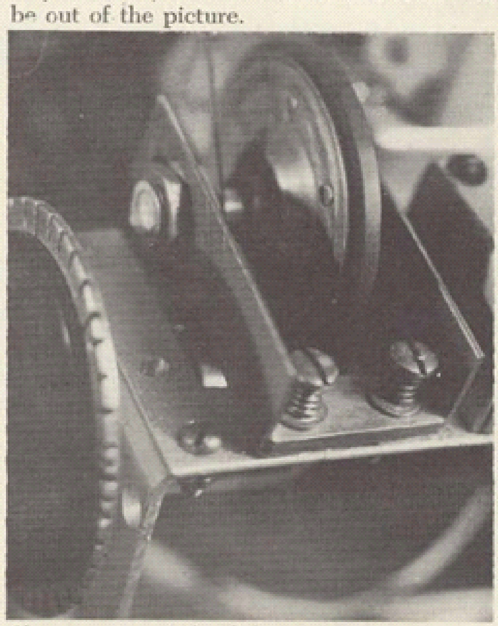
Good S-meter action and a certain amount of gain control is provided by the circuit shown by simply reducing the amount of voltage applied to the *if* transistors.

I had some trouble getting the 100 kHz crystal calibrator aligned with WWV, so it was necessary to devise the circuit shown. WWV may be received on the receiver, during daylight hours here, by putting it on 7 MHz and tuning the preselector to minimum capacity.

Table 1. Coils for the 2Q receiver.

L1	32 turns #22 Formvar on T-68-2 toroid core.
L2	20 turns #22 Formvar on T-50-6 toroid core.
L3, L4	20 turns #22 Formvar, ¼" diameter with last 6 turns spaced to take a ½" long powdered-iron core.
L5	Same as L1 except 33 turns.
L6	Same as L2 except 23 turns.
L7	Same as L3 except 23 turns.
L8	Same as L3 except 23 turns.
L9	30 turns #24 enameled, ¼" diameter.
L10	22 turns #24 enameled on ¼" slug-tuned form.
L11	15 turns #24 enameled on ½" form, spaced diameter of wire. ⅜" powdered-iron slug.
L12, L13	110 turns, 6-strand Litz wire, tapped at 55 turns. Pi wound on ½" diameter ferrite cupped core 1½" long. Three cups stacked to obtain necessary length after grinding out center of middle core.
L14	120 turns, 6-strand Litz wire, pi wound on ¼" slug-tuned form.
L15, L16, L17	330 turns using 3 strands #29 enameled wire wound on powdered-iron toroid 1" diameter, #A930157-2. Toroid cores from old telephone equipment will work. L15 tapped 50 turns from ground end.
L18	10 turns #22 Formvar wound over L17.
L19	800 turns, 6-strand Litz wire, layer wound 1" long on ¼" slug-tuned form.

From this point, the rest of the receiver is simply audio, six transistors in all, with a transformerless audio circuit taken mostly from a GE transistor manual. The power supply, one left over from another project, is no doubt overfiltered. Any well-filtered dc source of 14 V and 28 V will do. The receiver draws 20-125 mA depending on volume. The dial lamps use an additional 40 mA each. The receiver will work well on only 12-14 V, but the S-meter and AGC will be out of the picture.



Close up view of the dial tuning mechanism.

Choice of transistors

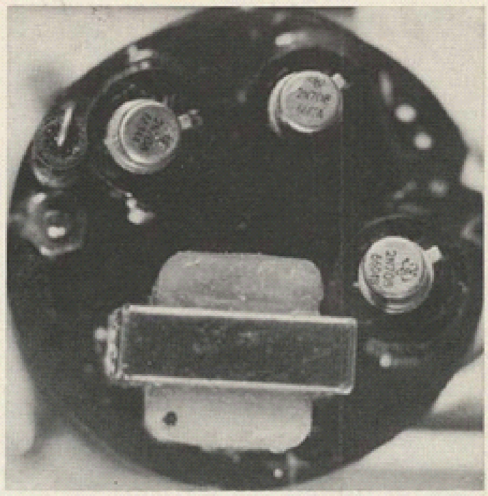
The transistors used are by no means the only ones which will work in the receiver. My choice was made largely from tests with the ones which were available in my transistor junk box. Either PNP or NPN will work in most circuits, NPN being preferred in most cases for *if* and oscillator traisistors. Oscillator types should be those that have no internal connections to the case. The use of sockets for all transistors is highly recommended.

Construction

The receiver cabinet measures 8½" long x 6½" high x 6½" deep. The receiver is divided into a number of sub-assemblies mounted on a main chassis, made of 14-gauge aluminum. The sub-chassis are of 21-gauge aluminum.

Only the 50 kHz *if* amplifier and audio stages were built on the main chassis. The S-meter and agc circuitry were mounted on the back of the S-meter. **Fig. 4** is a rough layout of the front panel.

The slide rule dial has a tuning rate of 45:1 or 45 turns of the tuning knob to cover 500 kHz. This gives at least 25 revolutions on the 40 and 20 meter bands. The mechanism consists of a weighted knob on a ¼" shaft driving a 2" rubber tired wheel (Jenson #J1490-01) on a ¼" shaft driving a dial cord to a 3½" dial drum on the tuning capacitor. The dial scale was made on white paper (pasted to a piece of stiff cardboard) using a black ball point pen and a typewriter. The dial drum was made from a reinforced, nickle-plated lid from a peanut butter jar.



Back view of the S-meter. One of the 2N708's (Q15) was replaced with a 2N338 after this photo was taken for better agc and S-meter action.

Conclusion

No wild claims shall be made for this receiver except to say it is the best homebrew receiver I have ever owned. Only 5 feet of wire strung up in the shack has been found necessary for good reception. Many hours were spent just listening and hearing signals that I could never hear with my old 14-tube homebrew receiver. I would like to thank Jim Miles W5KWJ for his comments and encouraging me to write this article.

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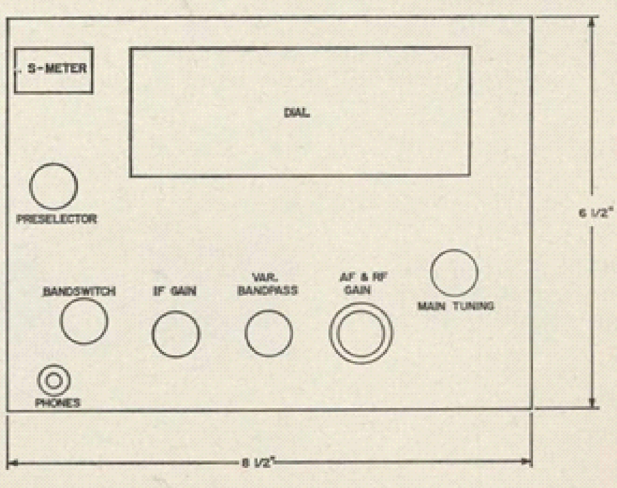

Fig. 4 Front panel layout used by W5ETT in the original model of the 2Q receiver.