CQ REVIEWS:

The Yaesu FT-736R All-Mode VHF/UHF Transceiver

BY STEVE KATZ*, WB2WIK

The new Yaesu FT-736R is an attractive, lightweight (20 pounds) transceiver which offers some amazing features in a desktop package. Intended to replace the popular FT-726R, the new rig includes several features not found in its predecessor.

Boasting 64 front-panel controls (knobs and switches), many of which are dual-function, the 736R offers its operators an incredible variety of functions. Contrary to rumor, the rig will not cook your breakfast. However, I understand the engineers at Yaesu are working on that one, and the "food" option may become available in the future (only kidding).

Where can I begin an assessment of such a complex product? Let's start with band coverage, power output, and general features of interest to the largest cross-section of readers.

The FT-736R as it is normally supplied ("stripped," so to speak) provides 25 watts output power on the 144 and 432 MHz bands in SSB, CW, and FM modes. Coverage on two additional bands (of three available: 50, 220, 1260 MHz) is provided for by expansion slots which accommodate optional "band modules." These optional modules are essentially transverters, each of which includes its own phase-lock-loop circuit, LO, mixers (TX and RX), buffers, drivers, power amplifier (TX), RF stage (RX), requisite bandpass filtering, and antenna switching circuitry. The 736R's receiver functions as a double-conversion superheterodyne on 6 and 2 meters, and as triple-conversion on the higher three bands. The "band modules" are not interchangeable between the FT-726R and the FT-736R, and the 23 cm module will not work in the older rig. Sorry about that.

"Exceptional digital integration and control," says the operating manual, is provided by an 8-bit CMOS main microprocessor and 4-bit I/O coprocessor. The rig features selectable tuning rates or mode-dependent channelized tuning and a variety of scanning methods. Further, the 736R includes many features normally found only on HF transceivers, such as adjustable IF shift and notch, a noise blanker that really works, all-mode VOX, three-speed selectable AGC, four separate amplifier/accessory key lines, rear-panel PTT input, optional narrow CW filter and electronic keyer, and a high-stability temperature-compensated crystal reference (synthesizer) oscillator. As if that weren't enough, the FT-736R contains provision for an optional (TV-736) fast-scan ATV unit which plugs into the 1.2 GHz "band module."

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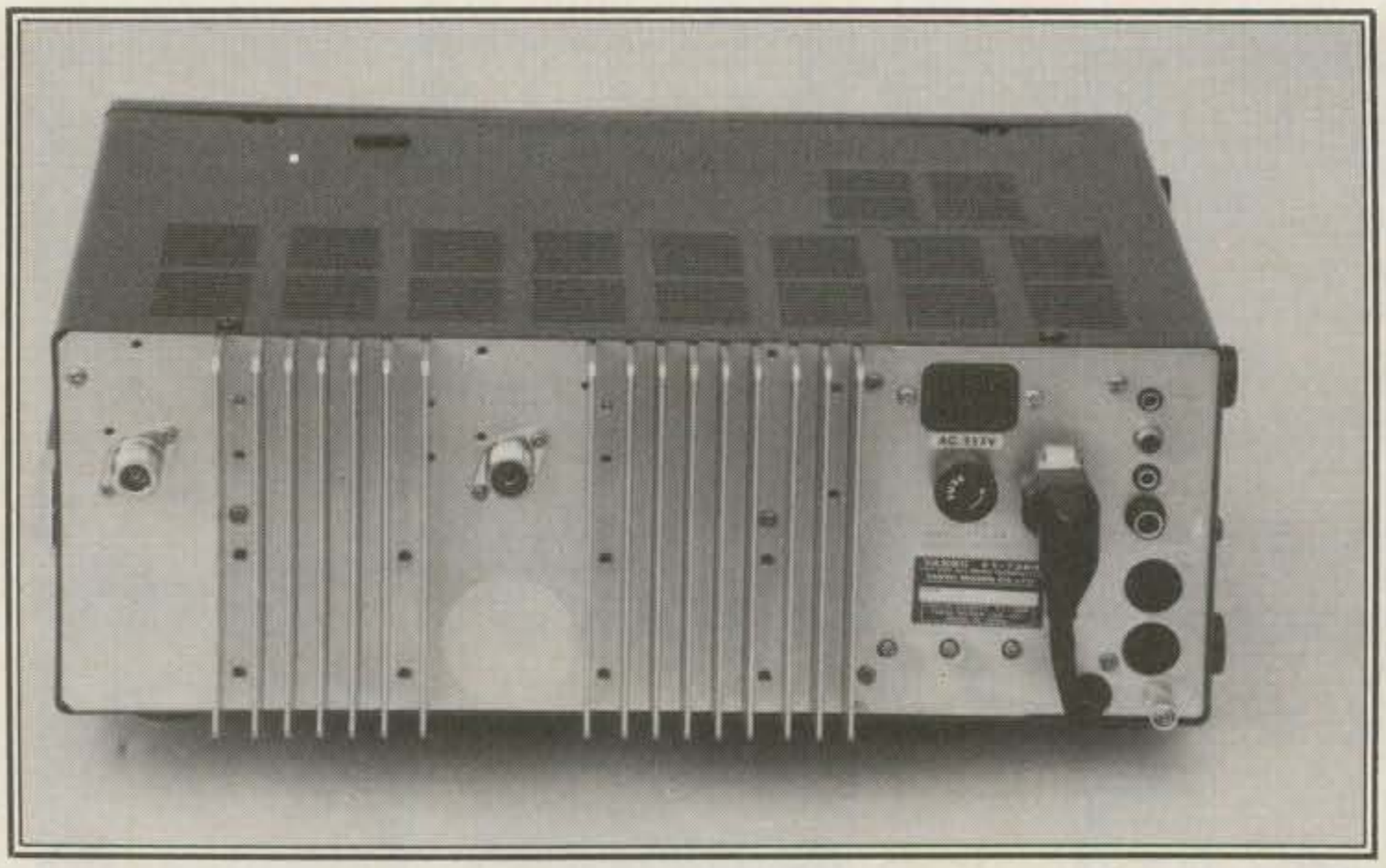
The rather imposing front panel of the FT-736R becomes friendly as you get to know it.

Frequency tuning/programming is accomplished several ways: 1 MHz steps may be tuned by depressing the large **MHz/CH Down/Up** keys; smaller increments may be tuned by turning the large main tuning knob, or by depressing the large **Down/Up** keys just above the main tuning control, or by depressing keys of the same function on either of the optional PTT microphones, or by turning the **Channel** knob (lower right of the main tuning); or, any frequency may be programmed by strokes made to the numeric keypad **(Function)** on the right side of the front panel. For rapid QSY to a frequency not already stored in one of the 736R's 115 memories (!), I found the keypad fast and easy to use. However, the keys are not backlighted and may be somewhat difficult to see in a dimly lit room.

In case you thought there was a typographical error in the previous paragraph, let me restate this rig as having 115 memories. It depends on how you view a "memory." Per Yaesu's discussion of the subject, "The memory system includes one hundred general purpose memories plus ten full duplex cross-band memories, one global call channel memory that can be recalled from any band or mode, and up to four band-specific call channel memories, all of which store mode and receive and transmit frequencies independently. That gives you one hundred fifteen memories storing up to two hundred thirty frequencies. In addition," the discussion continues, "fourteen VFO's are provided: two general purpose plus one PMS (Programmable Memory limit Scanning) on each band, two special-purpose full duplex VFO's, and up to four clarifier (RX offset) memories, one per band."

Confused enough? It takes some getting used to, but all this stuff actually works. For example, the FT-736R has no **RIT** (**R**eceiver **I**ncremental **T**uning) control—an alarming omission, until you discover that depressing the **CLAR** (Clarifier) button in the lower left corner of the **Function** keypad instantly changes the main tuning function to a smoothly operating RIT, allowing you to tune 9.999 kHz above or below your transmit frequency, which remains stored in memory the moment you enable the clarifier. Maybe a separate RIT knob would be



The FT-736R's rear panel is mostly heatsink. Two more coaxial receptacles are accommodated below the two shown when optional band modules are installed.

better, but I must admit that using the large knob and slow, precise rate of the main tuning control makes this the nicest RIT I've ever used. And the 100 Hz resolution frequency display reverts to showing the TX frequency every time the PTT or key is depressed.

The FT-736R is a satellite operator's joy. The designers included several satellite-specific circuits and controls, including two full-duplex VFOs mentioned earlier. Each of these VFOs can be selected so that its RX and TX frequencies and modes are displayed and tuned independently or linked to tune synchronously in opposite directions—ideal for satellite operations.

I've also enjoyed using the rig on FM, where its splendid modulation has accounted for a number of "This is the best you've ever sounded!" reports. Use of the standard-equipment "Narrow FM" filter has allowed me to receive weak signals directly adjacent to extremely strong, fully-modulated signals with no trace of interference. (Minor problem: Switching to the "Narrow FM" mode restricts the bandwidth of both the TX and RX, causing very narrowband transmission that may sound undermodulated. This can be surmounted by readjusting the front-panel **MIC** control, which changes deviation on FM.)

Yaesu designers included an internal switched-mode power supply to allow operation directly from the AC mains for convenient home station operation. This supply produces 13.8 VDC regulated at up to 8 amperes, and its connection to the rig is via a rear-panel jumper cable which may be removed for mobile/portable operation from an external DC source. The power supply, shown as "PS Unit FP1274A" in the FT-736 schematics (with no component details given), runs very cool even after long periods of key-down service.

While I'd like to offer some discussion of the front- and rear-panel controls and connections, even a cursory description would consume pages of text. After all, this rig has 64 front-panel knobs and switches (some of which are dual-function), plus a minimum of ten receptables on its rear panel. The FT-736R operating manual discusses the functions of all these parts in sufficient detail to consume ten printed pages in its Section 2. Despite this overwhelming complexity, the rig can be quite simple to use if you choose to ignore the majority of its unique features and simply operate it as a common VFO-controlled transceiver. This is to say, you needn't know much about the rig's controls or functions—or anything at all about its internal workings—to get on the air and begin having fun. And this is exactly what I'd recommend any new owner do. I was on the air, first on 2 meters and then on 70 cm, for a couple of weeks before I studied the manual in any depth.

Let's look a bit at the circuitry, beginning with the receiver. The FT-736R's front end on 2 meters is an AGC-controlled 3SK121 dual-gate MOSFET the output of which is filtered by a 144–148 MHz bandpass circuit before driving an IC mixer, the output (first receive IF) of which is 13.69 MHz. This IF signal passes through a 2-pole crystal filter, then a 3SK122 dual-gate MOSFET first IF amplifier before it leaves the "144 MHz Main Unit" PCB (printed circuit board) to be routed to the "RX Unit" PCB where it is buffered by a 2SK125 grounded gate JFET and further filtered by another 2-pole crystal filter at 13.69 MHz. A second output from the JFET buffer supplies a signal to the electronic noise blanker circuit, which consists of cascaded bipolar differential amplifiers (the second input of which is from an AGC amplifier specifically part of the noise blanker), driving a high-gain Noise Blanker Control amplifier (cascaded 2SC458's)—which in turn supplies the bias signal for the Noise Gate, three 1S1588 diodes arranged as a fast switching modulator between the 2SK125 buffer and balanced JFET second mixer (a pair of 2SK241's). Whew!

The output of the second mixer at 455 kHz is then filtered by any one of four possible switch-selected multipole bandpass filters: the "standard" SSB/CW filter (2.2 kHz bandwidth); the "narrow" CW filter (600 Hz); the "normal" FM filter (12 kHz); or the "narrow" FM filter (8 kHz). Only the narrow CW filter is optional, the other three being included in all units. The 455 kHz IF signal is then further amplified (or buffered) by two tuned bipolar stages before it is further filtered and limited to drive the diode discriminator for FM reception.

For SSB/CW reception, the signal from the appropriate IF filter is amplified by an AGC-controlled 3SK74 dual-gate MOSFET before it is routed through the IF notch filter and another 3SK47 AGC-controlled IF amplifier to be demodulated by an integrated product detector (uP1037). A second output from Q3036, the second 3SK47 IF amp, drives a buffer amplifier and AGC amplifier, then the SSB squelch circuit and S-meter amplifier. (On FM, the S-meter amplifier signal is supplied by a second output from Q3020, the post-filter IF buffer amplifier.)

I haven't mentioned the various LO (local oscillator) sources to this point, but they deserve some comment. The first LO is a tunable signal of 157.69 to 161.69 MHz providing "high side" injection to the integrated first mixer, an ND487C. The tunable oscillator that produces the 159.69 MHz (nominal) injection signal is, of course, a frequency synthesizer which is programmed in various tuning increments by a number of possible sources, including the main tuning knob or the Channel dial. The synthesizer is so complex that without some written description provided by Yaesu (there isn't one), it would be difficult to discuss in any depth. It appears to begin with a 20.5 MHz VCXO (voltage-controlled crystal oscillator) the two outputs of which drive (1) a times 7 multiplier whose 143.5 MHz output is filtered, buffered, and mixed down to 14.18–18.18 MHz (on RX; on TX, the range is offset +100 kHz), then filtered, amplified, and applied to the MC145155 PLL (phase lock loop) circuit which produces the 157.69–161.69 MHz (again, offset by +100 kHz on TX) signal discussed earlier; (2) a buffer and mixer the output of which at 21.47–24.28 kHz is filtered then applied to an integrated phase detector (TC5081); this stage's other input at 21.42–24.28 kHz is derived from a "144 MHz Sub VCO unit" whose frequency divided output at 2.4–2.72 MHz is further divided by a 1/112 stage (TC9122). Double whew! And, of course, that is by no means a complete description of the synthesizer, since I've omitted the source of PLL data and any discussion of the 430 MHz PLL!

Suffice it to say that the synthesizer appears very stable, resettable, and of low enough internally generated noise that the end product is a pleasure to use. I've not measured SSB phase noise, although given enough time, I could make this measurement on the FT-736's transmitted signal and assume the data applies to the receiver as well. Possibly more on this in a future issue.

The transmitter uses circuits contained on three separate PCBs: the "144 MHz Main Unit," the "TX Unit," and the "144 MHz PA Unit." The "TX Unit" contains the low-level stages including the 13 MHz TX PLL and yields a signal at 13.79 MHz which is applied to the "144 MHz Man Unit" PCB where it is mixed with the tunable 157.79–161.79 MHz synthesizer output to derive a signal in the 144–148 MHz range. This transmit mixer is a balanced pair of 2SK241 JFETs the output of which is bandpass filtered before being applied to a 2SC2026 bipolar pre-driver (the keyed stage in the transmitter, incidentally) then a 2SC2053 driver stage. The 2 meter output signal is then applied to the "144 MHz PA Unit" PCB where it

Parameter	144 MHz	432 MHz
Output power, max. CW/FM	28 W	22 W
Output power, max. SSB*	20 W	10 W
Output power, min. any mode	0 W	0 W
Output power vs. meter rdg:		
"1"	2 W	1.8 W
"2"	4 W	3 W
"3"	6 W	4 W
"4"	8 W	6 W
"5"	11 W	8 W
"6"	15 W	10 W
"7"	20 W	15 W
"8"	26 W	20 W
Receiver sensitivity:		
MDS, CW/SSB	−140 dBm	−132 dBm
MDS, FM	−127 dBm	−124 dBm
20 dB qtg (FM)	−113 dBm	−110 dBm

S-meter readings vs. level:	FM/SSB	FM/SSB
S1	−117/−114 dBm	−118/−114 dBm
S2	−109/−112 dBm	−111/−112 dBm
S3	−106/−110 dBm	−108/−111 dBm
S4	−104/−109 dBm	−106/−110 dBm
S5	−103/−107 dBm	−104/−108 dBm
S6	−102/−105 dBm	−103/−106 dBm
S7	−100/−103 dBm	−102/−104 dBm
S8	−99/−99 dBm	−101/−101 dBm
S9	−98/−95 dBm	−100/−97 dBm
S9 + 20	−93/−79 dBm	−95/−80 dBm
S9 + 40	−88/−63 dBm	−89/−64 dBm
S9 + 60	−82/−50 dBm	−84/−50 dBm
Average "S" unit	2.4/2.4 dB	2.3/2.1 dB
Average "dB" above S9	.27/.75 dB	.27/.78 dB

General Data Applying To Both Bands:

Notch depth: 17 dB

IF shift range: 3.3 kHz

Frequency shift for mode change: < 200 Hz USB/LSB
600 Hz SSB/CW
0 Hz SSB/FM

IF bandwidth, −6 dB: 17.1 kHz FM (normal)
11.1 kHz FM (narrow)
2.5 kHz SSB

IF filter shape factor, 6:60 dB: 1.6 FM (normal)
1.5 FM (narrow)
2.5 SSB

AGC decay speed: < 10 mS (Fast)
20 dB/sec (Medium)
4 dB/sec (Slow)

**Note: Peak envelope power output with 1 kHz tone injected at mic input, level adjusted for max. reading on ALC scale, speech processor "on." (This yielded a higher PEP reading than with processor "off.")*

Table I– WB2WIK's lab measurements on the FT-736R receiver and transmitter.

drives the hybrid PA (power amplifier) stage, shown as P/N M57727. No details of the hybrid's internal circuitry are given.

The "PA Unit" also contains the PIN diode antenna switch and output detector circuit which supplies a drive signal to the ALC amplifier and ultimately the front-panel output meter. The "TX Unit" also contains (in addition to those circuits already discussed) the VOX circuitry, microphone preamp, lamp drivers, and (optional) keyer unit.

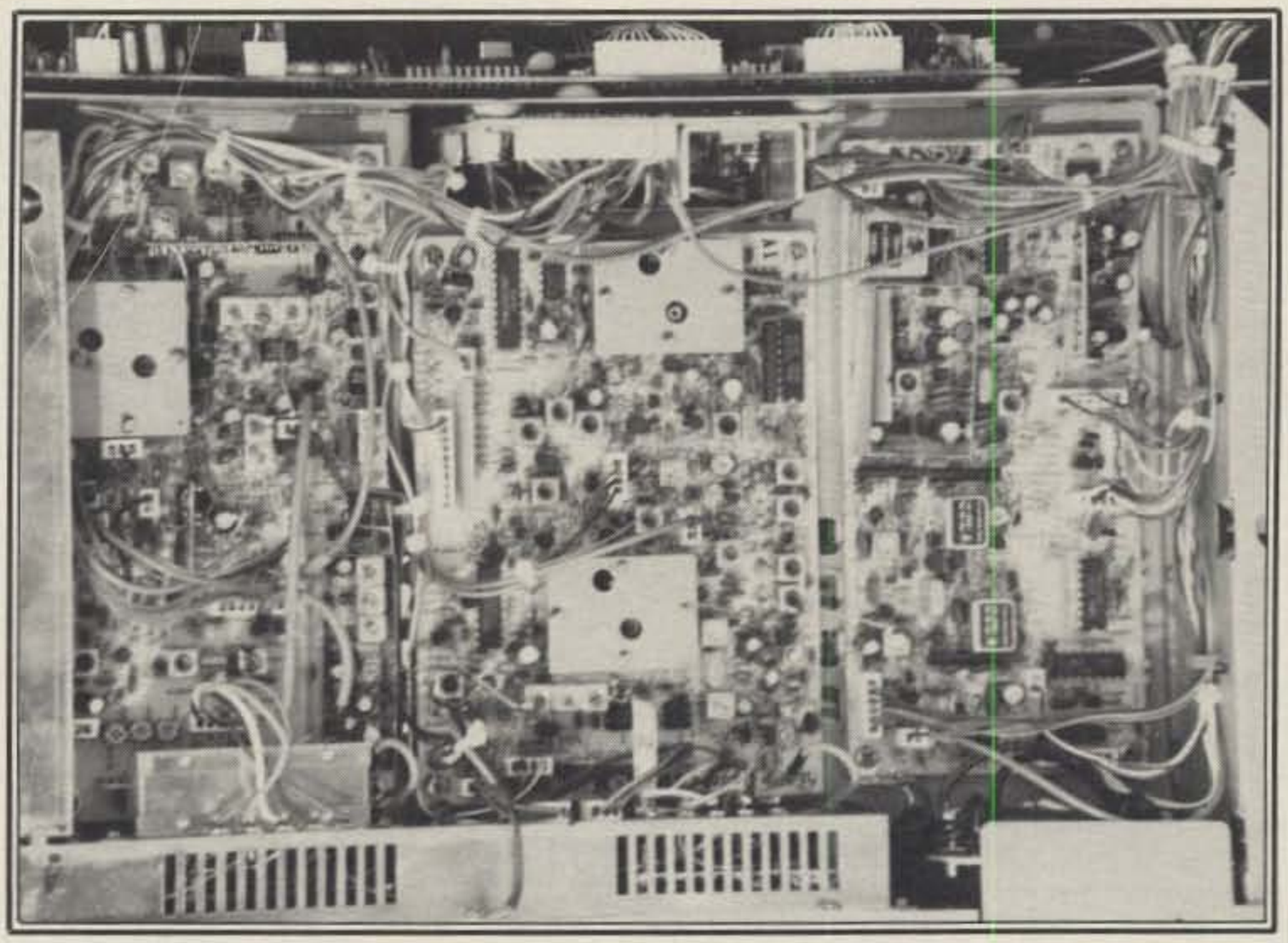
An entirely separate RF Unit—with accompanying PLL Unit, Front End Unit, and PA Unit—is used for 430 MHz. The 13.69 MHz RX IF and 13.79 MHz TX IF systems are shared on both bands, and any other bands the user chooses to install. Major differences in circuitry between 430 and 144 MHz RF systems include the use of a 3SK164 dual-gate GaAsFET RF preamp and mixer stages, and one additional conversion stage (first IF is 47.43 MHz; second IF is 13.69 MHz) for the higher band, plus a different PA hybrid (P/N M57745), also rated for 25 watts output, is necessarily used.

Ample room is provided for the installation of two additional "Band Modules," although three are offered for sale. These band modules, also called "Optional Units" throughout the operating manual, require only a few minutes each for installation. Unfortunately, the review unit was not equipped with any optional units, as I believe none were available back in January when we took delivery. It is assumed their performance is similar to that of the internal RF units for 144 and 432 MHz; however, only the optional 135 cm band module provides 25 watts output power. The 6 meter and 23 cm modules are rated for 10 watts output each.

It is not possible to configure the FT-736R for any four bands of your choice. You are limited to 144, 432, and any two of the remaining three optional bands. So you cannot, for example, equip your transceiver for 50, 220, 432, and 1296 MHz or 50, 144, 220, and 1296 MHz. Small sacrifice for the versatility and performance offered.

The band modules install in the lower part of the rig and the exercise appears simple, based on the instructions in the operating manual. Each module mounts to the rear-panel/heatsink assembly of the rig with four machine screws, then is further secured with one or two (depending on the module) self-tapping screws to the chassis. One single red wire and two multi-pin connectors are installed to complete the electrical connections, and you're on the air!

The operating manual is thorough and well-written, leaving few questions unanswered. There is no operating theory or circuit descrip-



This is the view inside the top cover. The entire rig is of modular construction, with most interconnections made with molded plugs.

tion section, nor are there complete schematic diagrams of the switched-mode power supply and some other "units" contained in the 736R. Even with these omissions, I like the manual. It does an adequate job of explaining the function of each of the rig's panel controls, and even I—the world's worst "appliance operator" who cringes at computers and has spent years fighting off advanced technology—found the rig a breeze to operate after a few days' time.

Now comes the big question: Does the rig really perform? I'd answer with a resounding "Yes!" Even before putting the 736R on the air from the home station, I spent a couple of hours making lab measurements on the receiver and transmitter and offer the tabulated data shown in Table I.

Using the FT-736R on the air is a joy. I've programmed the weak-signal band edges and lots of simplex and repeater frequencies into the memories and found that recalling and scanning the memories is a fast, simple way to find activity of interest. Using the mating MH-1B8 hand-held microphone I've received nothing but outstanding audio reports. Every single station contacted reported that the speech processor made the transmitted signal sound better, cleaner, and crisper—and the oscilloscope reveals the processor also dramatically increases average output power without adding distortion. The receiver sensitivity is good, especially when one considers there is considerable filtering of the input signal prior to the first RF stage. (Really low-noise preamplifiers employ little if any bandshaping, since these circuits have losses which contribute to overall noise figure.) The addition of 1 dB NF (noise figure) GaAsFET preamps ahead of the FT-736R's receiver sections yielded no improvement in sensitivity on 2 meters and a slight improvement on 70 cm. This would imply the 736R's NF is somewhat higher than 1 dB on 432 MHz; the test is probably meaningless on 144 MHz, since with an antenna connected, atmospheric noise typically overrides internally generated noise in modern receivers.

One cannot help trying to draw comparisons between any new piece of equipment and those already on the market. In the case of the FT-736R, I'm hard pressed to do so, because its only competition is other Yaesu rigs like its predecessor FT-726R and the new all-band FT-767, a deluxe HF transceiver with accommodations for VHF/UHF band modules.

The FT-736R has a suggested retail price of $1749.95 as normally supplied for 2 meter and 70 cm coverage. The optional band modules have retail prices in the range of $250 to $300 each. I understand these prices are heavily dependent upon our currency exchange rate with Japan, but discounts are often available. Considering the operating flexibility and performance offered by the 736R, I think the rig is worth its price. It isn't quite the same as having entirely separate stations, but it's close: A push of the "BAND" button, and you're instantly on a new band, with all memories retained from prior use there. Separate RF receptacles (UHF for 50 and 144 MHz, type N for the higher bands) and amplifier keying lines make this rig feel like two (or three, or four) complete stations that just happen to occupy a single box. No question about it, Yaesu has another winner here.

For further information, contact Yaesu USA, 17210 Edwards Road, Cerritos, CA 90701, or your local franchised distributor. CQ