

Yaesu FT-990 160-10 Meter Transceiver

Reviewed by James W. ("Rus") Healy, NJ2L

Not long after the FT-1000 arrived on our shores, Yaesu introduced a sort of little brother to their top-end radio: the FT-990. Obviously intended for hams who want the best features of the FT-1000 on a somewhat smaller scale, the FT-990 represents the newest mid-range radio in Yaesu's line. Clearly in competition for your radio dollars with the ICOM IC-765, Kenwood TS-850S and Ten-Tec Omni V, the FT-990 falls in the same price range as these radios and offers a similar collection of features. To help you choose the one that's best for you, here's a look at the FT-990 in comparison to its big brother, which we reviewed in March 1991 *QST*. Many of the features that the FT-990 shares with the FT-1000 won't be detailed here, since they were covered in the FT-1000 review. For further comparison, see the reviews of the IC-765, TS-850S and Omni V in December 1990 *QST*, July 1991 *QST* and November 1990 *QST*, respectively.

Standard Features and Options

Unlike the FT-1000, which has base and deluxe models, the FT-990 is available in only one version. The '990 comes standard with an automatic antenna tuner, an iambic keyer with adjustable weighting, an internal switching power supply, a 500-Hz CW filter, and a hand-held microphone. Also included are plugs to match all the radio's jacks. Options include a 250-Hz CW filter for the 455-kHz IF, a 2-kHz SSB filter for the 10.9-MHz IF, a desk microphone, a headset, an external speaker with audio filters (with or without its optional phone patch), the DVS-2 digital voice recorder/player (reviewed with the FT-1000 in March 1991 *QST*), a temperature-compensated crystal oscillator, and the FIF-232C computer interface.

Not surprisingly, the FT-990 bears a strong physical resemblance to the FT-1000. The '990's front panel gives away some of the differences between it and the '1000, but others aren't visible from that viewpoint. I suggest that you read March 1991 *QST*'s FT-1000 review for background before reading on. Here's an overview of how the FT-990 and FT-1000 differ:

- The FT-1000 has two sets of receiver RF/IF stages (for simultaneous reception on different modes and/or frequencies); the FT-990 has only single-frequency/mode receive capability.
- The '990 puts out 100 W to the '1000's 200 W.
- The FT-990 has 90 multifunction



memories; the '1000 has 100. The '990's memories store all the corresponding information held by those in the '1000.

- The '990 has two AGC speeds (fast/slow) with defeatable automatic selection based on mode (slow for SSB and fast for all other modes); the '1000 has fast/medium/slow AGC constants that must be manually switched.

- The '990 has a 20-dB front-end attenuator; the '1000 has a three-position attenuator (6/12/18 dB) and a selectable receiver preamplifier.

- The '990's only optional CW filter is a 250-Hz unit for the 455-kHz IF; without that filter, the narrowest available receiver IF bandwidth is 500 Hz, via a filter in the 10.9-MHz IF. (No 500-Hz filter is available for the 455-kHz IF.)

- Like the '1000, the '990 has selectable CW offset (400-700 Hz in 100-Hz increments)¹ with tracking sidetone and spotting pitch. The '990's CW-offset selection method is better than that of the '1000, requiring the setting of only two DIP switches instead of several.

- The FT-990 provides no method of monitoring your transmitted SSB audio; the FT-1000 includes a monitor circuit.

- The FT-990 shares the FT-1000's silky-smooth controls (especially the well balanced main-tuning knob).

- The '990, like the '1000, has no low-level transmitter output that can be used

to drive a transverter. You can, however, attach the receive-converter output to the '990's receive-antenna-input jack, which eliminates the possibility of transmitting into it and frying the receive converter's mixer or post-mixer amplifier.

- The '990 has two major features not included in the '1000: an RF-frequency-shifted speech processor and a switched-capacitor audio filter (details later).

- The '1000 has two major receiver features not included in the '990: an audio-peak filter and continuously variable IF bandwidth.

Highlights

Yaesu kept some of the FT-1000's best features in the FT-990. For instance: the smooth, quiet, automatic antenna tuner; the pleasant digital display and excellent multifunction analog meter; simple direct frequency entry and single-key band selection; front-panel selectable external receive antenna (or receive-converter input); a CW-spotting oscillator that matches the CW offset; the smooth RIT/XIT and memory-channel operation; the use of separate connectors for packet radio and RTTY (for simple mode-changing); and front- and rear-panel key/paddle jacks.

One outstanding feature of the FT-990 is its very clean (low third- and fifth-order products) transmitted audio (see Fig 2). Even though the rig has a 13.8-volt-operated final amplifier, like the Kenwood TS-850S, the '990's audio betters that of many radios with higher-voltage finals. It's in the same class as the TS-950S and IC-765, both of which turn in *excellent*

¹March 1991 *QST*'s FT-1000D review inaccurately stated that radio's CW-offset range as 400-800 Hz; it's actually 400-700 Hz, in 100-Hz steps, like the FT-990.

Table 1**Yaesu FT-990 160-10 Meter Transceiver, Serial no. 1F040219****Manufacturer's Claimed Specifications**

Frequency coverage: Receive, 0.1-30 MHz; transmit, 1.8-2, 3.5-4, 7-7.5, 10-10.5, 14-14.5, 18-18.5, 21-21.5, 24.5-25, and 28-29.7 MHz.

Modes of operation: AM, CW, FM, FSK, LSB, USB.

Power requirement: 100-117 or 200-234 V ac. Receive, 60 W max; transmit, 470 W max.

Receiver

Receiver sensitivity (2.4 kHz bandwidth): SSB, and CW, 10 dB S + N/N: 0.1-0.25 MHz, 4 μ V (-95 dBm); 0.25-0.5 MHz, 1 μ V (-107 dBm); 0.5-1.8 MHz, 2 μ V (-101 dBm); 1.8-30 MHz, 0.25 μ V (-119 dBm).

AM (10 dB S/N, 6 kHz bandwidth): 0.1-0.25 MHz, 10 μ V (-87 dBm); 0.25-0.5 MHz, 2 μ V (-101 dBm); 0.5-1.8 MHz, 4 μ V (-95 dBm); 1.8-30 MHz, 1 μ V (-107 dBm).

FM, 12 dB SINAD: 29 MHz, 0.5 μ V (-113 dBm).

Receiver dynamic range: Not specified.

Third-order input intercept: Not specified.

S-meter sensitivity (for S9 reading): Not specified

CW/SSB squelch sensitivity (1.8-30 MHz): Less than 2 μ V.

FM squelch sensitivity: Less than 0.32 μ V.

IF notch filter attenuation: Not specified.

Receiver audio output: More than 2 W at 10% distortion with a 4- Ω load.

Receiver IF/audio response: SSB, 400-2600 Hz at -6 dB.

Transmitter

Transmitter power output: 100 W max on SSB, CW, FSK and FM; 25 W max on AM.

Transmitter duty cycle: 100% at 100 W on CW, SSB; 50% on FM and RTTY (3 min TX, 3 min RX).

Spurious-signal and harmonic suppression: >50 dB below peak power output.

Third-order intermodulation distortion products: Not specified.

CW-keying waveform: Not specified.

Transmit-receive turnaround time (PTT release to 90% audio output): Not specified.

Composite transmitted noise: Not specified.

Size (height, width, depth): 5 x 14.5 x 14.6 inches; weight, 29 lb.

†Unless noted otherwise, blocking dynamic range and third-order IMD dynamic range measurements were made at the ARRL Lab standard signal spacing of 20 kHz.

‡Test-equipment limitations inhibit ARRL Lab measurement of notches deeper than approximately 30 dB.

Measured in the ARRL Lab

As specified (except transmit, 28-30 MHz).

As specified.

Not measured.

Receiver Dynamic Testing

Minimum discernible signal (noise floor) with 500-Hz (2nd IF) and 250-Hz (3rd IF) filters: 1.8 MHz -133 dBm; 3.5 MHz, -133 dBm; 14 MHz, -129 dBm.

10 dB S + N/N (6-kHz IF filters, signal 30% modulated with a 1-kHz tone, preamp on): 1 MHz, -111 dBm; 3.8 MHz, -121 dBm; 14.2 MHz, -117 dBm.

12 dB SINAD, -118 dBm.

Blocking dynamic range (250-Hz IF bandwidth):† 3.5 MHz, noise limited at 130 dB; 14 MHz, noise limited at 131 dB.

Two-tone, third-order intermodulation distortion dynamic range (250-Hz IF bandwidth):† 3.5 MHz, 94 dB; 14 MHz, 92 dB.

3.5 MHz, 8 dBm; 14 MHz, 9 dBm.

At 14 MHz: 158 μ V.

As specified.

As specified.

More than 30 dB.‡

2.18 W at 10% total harmonic distortion (THD) with a 4- Ω load.

At -6 dB: SSB (2.4-kHz IF bandwidth), 2103 Hz; CW (250-Hz IF bandwidth), 283 Hz.

Transmitter Dynamic Testing

112-126 W (CW, SSB, FSK, FM—output is typically more than 115 W and varies slightly from band to band); AM, as specified. Minimum output: 8-9 W.

Not measured.

As specified except on the 24.9-MHz band. See Fig 1.

See Fig 2.

See Fig 3.

S1 signal, 18 ms; S9 signal, 18 ms; AGC off, 17 ms.

See Fig 4.

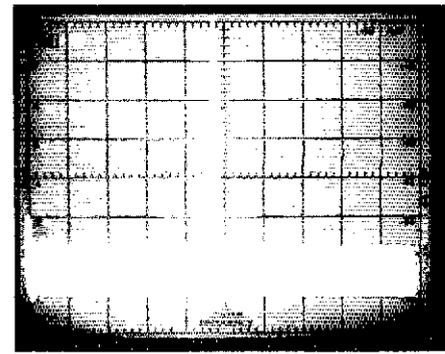


Fig 1—Yaesu FT-990 worst-case spectral display. Horizontal divisions are 500 kHz; vertical divisions are 10 dB. Output power is approximately 100 W at 24.89 MHz. All harmonics and spurious emissions are at least 49 dB below peak fundamental output. The FT-990 complies with current FCC specifications for spectral purity for equipment in this power-output class and frequency range.

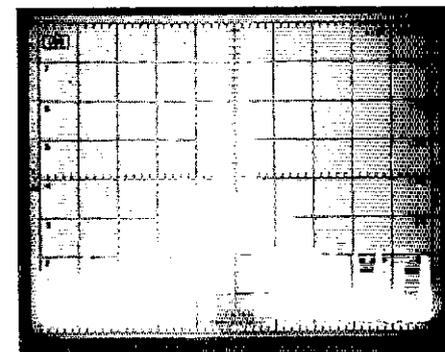


Fig 2—Worst-case spectral display of the FT-990 transmitter during two-tone intermodulation distortion (IMD) testing. Third-order products are approximately 38 dB below PEP output, and fifth-order products are approximately 47 dB down. Vertical divisions are 10 dB; horizontal divisions are 2 kHz. The transceiver was being operated at 100 W PEP output on 3.9 MHz.

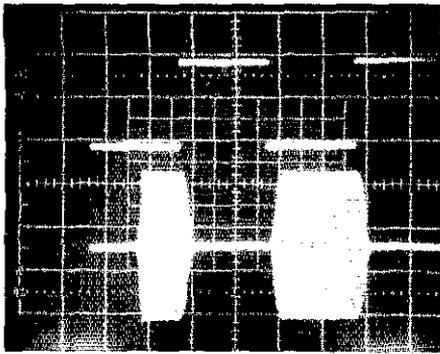
You can use this to shift the transmitted-audio passband (-300 to +500 Hz) relative to the suppressed-carrier frequency, emphasizing either high- or low-frequency speech components. Independently adjustable for LSB and USB, the FSP makes a significant difference in SSB-signal intelligibility, especially with the FT-990's stock microphone. Because the FT-990 has no transmitted-SSB-signal monitor, though, you can't easily adjust the RF FSP to suit your taste without a second receiver or a friend's help.

A Digital Filter?

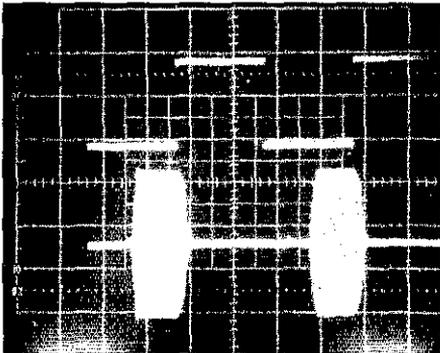
Transceivers have sported all kinds of audio filters over the years, but never before has a major manufacturer included an externally adjustable audio filter as effective as the FT-990's "digital" filter. *Digi-*

transmitter-IMD performance. It's refreshing to see that it's possible to make a 100-W MF/HF radio with low-voltage finals and such low-distortion transmitter performance.

On the subject of transmitted SSB audio, the FT-990 includes an innovative RF speech processor that Yaesu calls *RF FSP*, for *RF frequency-shifted speech processing*; in effect, "SSB-transmit IF shift."



(A)



(B)

Fig 3—CW-keying waveforms for the Yaesu FT-990 in the semi-break-in mode (A) and the full-QSK mode (B). The upper traces are the actual key closures; the lower traces are the RF envelopes. Horizontal divisions are 10 ms. The transceiver was being operated at 100 W output on 14.25 MHz. The FT-990's CW keying shaping is good, but the first keyed element is truncated in both modes, and all the keyed elements are shortened in QSK mode. QSK-mode element shortening can be effectively dealt with by adjusting keyer weighting (or you can build an interface such as that described in F. A. Bartlett, "A CW Keying Interface," *QST*, Apr 1987, pp 51-53). The external-amplifier keying relay has no effect on the keyed RF waveforms.

tal is in quotes in the last sentence because Yaesu pushes the limits of acceptable marketing practices by calling this filter "digital." With modern digital-signal-processing (DSP) techniques, it's possible to construct very effective audio filters, such as JPS Communications' NIR-10 filter reviewed in October 1991 *QST*. The FT-990's "digital" filter, however, *does not use DSP*; rather, it's a conventional switched-capacitor filter (SCF), more along the lines of the MSC Smart Filter, also reviewed in *QST* last month. Although switched-capacitor filtering provides very good skirt selectivity and ultimate attenuation—with no audible ringing—the only thing that's digital about the FT-990's filter is that you adjust it with your fingers!

Semantics aside, the FT-990's SCF is very effective, especially at getting rid of the hiss produced by the radio's IF-amplifier chain (see "Rough Edges").

Table 2

FT-990 Switched-Capacitor-Filter Performance

IF Bandwidth	Minimum Discernible Signal (MDS)		Minimum IF + Audio Bandwidth†	
	Without Filter	With Filter	Without Filter	With Filter
2.4 kHz	-129 dBm	-139 dBm	2103 Hz	213 Hz
500 Hz	-125 dBm	-135 dBm	535 Hz	200 Hz
250 Hz	-127 dBm	-137 dBm	283 Hz	125 Hz

Note: The audio filter was adjusted to the minimum bandwidth that resulted in a desired-signal decrease (at filter center) of not more than 1 dB.

†Response at -6-dB points.

Because the radio's only optional 455-kHz-IF filter is a 250-Hz unit, the SCF provides filtering, albeit outside the AGC loop, that's sometimes needed to deal with the unwanted stuff that gets through a single IF filter, especially on SSB. As you might expect, the SCF can improve receiver sensitivity, as shown in Table 2. Consider, though, that much of the MDS improvement we measured when adjusting the filter for minimum bandwidth results from elimination of IF noise. Also note that because we used a CW signal for the tests, you won't see the same kind of MDS improvement on SSB signals because the resulting audio bandwidth is too narrow for satisfactory SSB-signal reception.

The Manual

Yaesu continues to impress me with the outstanding quality of its documentation. Clearly written, well illustrated and sensibly organized, the FT-990's instruction manual makes learning and using this radio easy. Numerous sidebars cover individual topics. A detailed table of contents helps you find information you're seeking. With the FT-1000, FT-650 and FT-990, Yaesu has begun a tradition of excellence in transceiver documentation that every manufacturer should use as an example.

On the Air

In terms of basic receiver performance, the FT-990 isn't far from the FT-1000's mark. It is quite sensitive and has decent dynamic range and good AGC. The '990's AGC is better, in fact, than that of the FT-1000: The overshoot that plagued our review FT-1000 is pleasantly absent in the FT-990. *QST* Senior Assistant Technical Editor Dave Newkirk, WJ1Z, points out that the FT-990's fast AGC is about equivalent to most radios' medium AGC constants, which makes it comfortably usable even on SSB.

In the dynamic-range department, the FT-990 does reasonably well, but it's not quite in the same class as the FT-1000. For instance, the '990's blocking dynamic range (BDR) is limited (at around 130 dB) by internally generated synthesizer noise. This is good BDR for modern transceivers, but is more than 20 dB less synthesizer-noise-free dynamic range than the best radios we've tested. The rig's third-order-IMD dynamic range (IMD DR) is very good,

easily allowing for weak-signal reception among many closely spaced strong signals on the low ends of 40 and 80 meters.

The '990's optional 250-Hz CW filter is quite effective when teamed with the 500-Hz filter, IF shift and audio SCF. Although useful, the FT-990's IF shift lacks the dramatic effectiveness of the FT-1000's outstandingly good IF-shift circuit. I really missed the FT-1000's tremendous audio-peak filter, too.

The FT-990's TR relays are quiet, which makes for pleasant SSB VOX and QSK CW operation. The internally switchable external-amplifier keying relay adds noticeably, but not objectionably, to the rig's TR-switching noise, and doesn't adversely affect the keyed waveform (see Fig 3).

The rig runs cool, even during CW contest operation, with its massive internal heat sink and blower working together to carry heat away from the finals and out the back of the radio.

Rough Edges

In addition to the many good characteristics the FT-990 shares with its big brother, the FT-1000, it also exhibits some of the '1000's weaker points. Here are a few shared characteristics (and some that belong only to the FT-990) that I found bothersome.

The receiver-audio intermodulation distortion (IMD) we found in the FT-1000 is also present in the FT-990. With two strong CW signals or a very strong SSB signal in the passband, audio IMD noticeably muddies received signals. Also, the '990's audio rolls off at high frequencies, which is particularly annoying when you're listening to shortwave-broadcast signals with the wide AM filter in line. Table 1 hints at this characteristic in the receiver's IF/audio response: Even when you select the 2.4-kHz IF filter, the audio is down 6 dB from its maximum at only 2313 Hz (about 290 Hz below that given in the radio's specifications). The SCF can be used to tailor received AM audio to make this effect less pronounced (by cutting bass), but you do so at the expense of even more audio bandwidth. On a related note, the radio's IF and AF amplifiers emit moderately annoying high-frequency hiss, only the IF part of which can be filtered out by the SCF.

The FT-990's receiver audio is noticeably peaky, accentuating low-frequency compo-

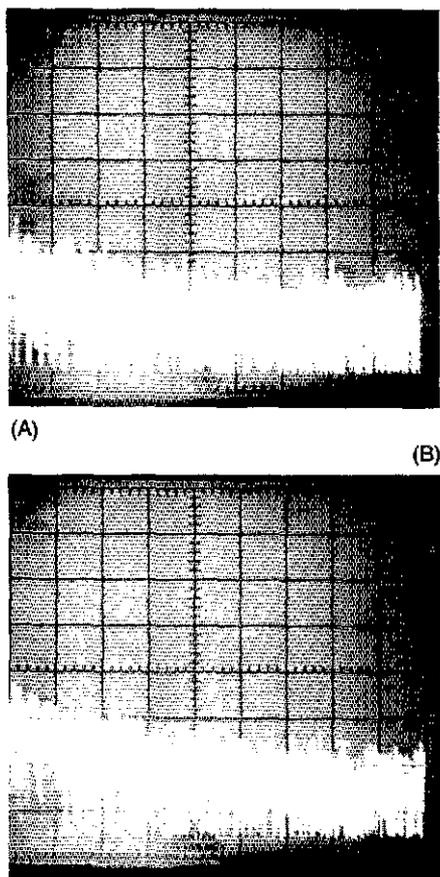


Fig 4—Spectral display of the FT-990 transmitter output during composite-noise testing. Power output is 100 W at 3.52 MHz (A) and 100 W at 14.02 MHz (B). Vertical divisions are 10 dB; horizontal divisions are 2 kHz. The scale on the spectrum analyzer on which these photos were taken is calibrated so that the log reference level (the top horizontal line on the scale) represents -60 dBc/Hz and the baseline is -140 dBc/Hz. Composite-noise levels between -60 and -140 dBc/Hz may be read directly from the photographs. The carrier, off the left edge of the photographs, is not shown. These photographs show composite transmitted noise at frequencies 2 to 20 kHz offset from the carrier.

nents during CW reception with the 500- or 250-Hz filter in line and the SCF disabled. Solution: Operate with the SCF enabled all the time—generally with it set for maximum bandwidth. This minimizes the AF- and IF-amplifier hiss and flattens the receiver's audio response without sacrificing bandwidth.

The supplied hand microphone's bassy audio elicited complaints from many stations I worked using it. I found that the FT-990's RF frequency-shifted speech processor can be used to alleviate this by setting it for a $+200$ - to $+300$ -Hz offset. Different microphones (I used a Kenwood MC-60A desk mike and a Heil headset) also brought good reports without the RF FSP circuit enabled, so the problem isn't in the radio's audio circuit.

Even when the two-position front feet

are set for their maximum height, it's hard to read the FT-990's control labels along the lower edge of the front panel; they're blocked by knobs higher on the panel. I found that raising the radio high enough to see the labels clearly at normal viewing angles required placing the radio too high for me to comfortably tune it. This is a minor annoyance, especially after you've learned to use the radio, but I found myself repeatedly selecting the notch filter when I intended to turn on the SCF.

Adjusting the VOX controls requires a screwdriver. This is a hassle if you use different microphones and/or frequently adjust the VOX controls to accommodate changing room noise.

Artifacts of a less-than-spectacular synthesizer chain, several thumps occur as you tune across the FT-990's receiver spectrum. The most annoying of these is a loud pop that appears as you tune across 28.016 MHz, which is right in the middle of the IF range for 144- and 432-MHz moonbounce (EME) operation. A number of relatively weak spurious receiver signals (birdies) are also present, although most are too weak to hear when an antenna is connected to the radio.

I mentioned in March 1991 *QST* that Ken Wolff, K1EA, had plans to support the FT-1000 (compatible with the FT-990) in his popular contest program, *CT*. But when he found that it takes *four seconds* to read the radio's status via the interface—during which time most of the radio's front-panel functions lock up—he decided that it wasn't worth the work. The snag is that you can't read only one of the rig's parameters at a time (namely the current VFO's frequency) via the serial interface—the rig sends *all* of its current operating data in response to a status request. Many hams have begun a letter-writing campaign in hopes of prompting Yaesu to revise the FT-1000/FT-990 control software to allow practical support by the authors of major contesting software (such as Ken Wolff and Dave Pruet, K8CC).

A relatively minor complaint: Installing the optional IF filters requires removing the FT-990's plug-in IF unit and soldering the filters to the board, which is less convenient than the now-common plug-in filters used by most manufacturers.

The Bottom Line

The FT-990 has reasonably well-balanced features and performance for the operator who's interested in a good-performing MF/HF transceiver that's not priced in the stratosphere. The '990 definitely gives up some of the better points of the FT-1000, but still provides good enough overall performance to play on the same field, both in price and performance, with the IC-765, TS-850S and Omni V. In selecting a radio in this or any other class, make an effort to use each rig you're considering, and order the instruction manuals

for each one, before making a decision.

Manufacturer: Yaesu USA Corp, 17210 Edwards Rd, Cerritos, CA 90701, tel 213-404-2700. Manufacturer's suggested list prices: FT-990, \$2399; DVS-2 digital voice recorder/player, \$299.95; MD-1C8 desk microphone, \$115; TCXO-2 temperature-compensated crystal oscillator, \$199; 2-kHz SSB IF filter, \$129; 250-Hz CW filter, \$159; SP-6 external speaker, \$149.

Acknowledgments

Thanks to these skilled equipment evaluators who participated in this review: Steve Powlshen, K1FO; Dave Newkirk, WJ1Z; Dave Sumner, K1ZZ; and Mark Wilson, AA2Z.

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Yaesu FT-650 HF/VHF transceiver with 600-Hz CW filter and internal power supply (see Product Review, October 1991 *QST*). Sold as a package only. Minimum bid: \$945.

AOR AR-2500 scanning receiver (see Product Review, September 1991 *QST*). Minimum bid, \$295.

JPS Communications NIR-10 DSP audio filter (see Product Review, October 1991 *QST*). Minimum bid, \$295.

j-Com Magic Notch automatic audio notch filter (see Product Review, October 1991 *QST*). Minimum bid, \$72.

Heath IntelliRotor kit* (microprocessor-based rotator-controller kit). Minimum bid, \$202.

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In your bid, please clearly identify the item you are bidding on, using the manufacturer's name, model number, or other identification number, if specified. Each item requires a separate bid and envelope. Shipping charges will be paid by the successful bidder, FOB Newington. The successful bidder will be advised by mail. No other notifications will be made, and no information will be given to anyone regarding final price or identity of the successful bidder.

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