

Product Review Column from *QST* Magazine

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Ten-Tec Model 425 Titan HF Linear Amplifier

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Power amplifiers are one of the few products in Amateur Radio that you can "buy American" and still choose from almost every available model. Ten-Tec, operating from the heart of the "Tennessee Technology Corridor" offers up the Model 425, the Titan, for your consideration.

According to Greek mythology, a titan was one of a race of giant gods. Webster's says a titan is "one that is gigantic in size or power." Given this definition, the Ten-Tec Titan has a tall reputation to live up to.

The "gigantic power" part certainly applies. The Titan uses a pair of EIMAC 3CX800A7 high-mu triodes to deliver more than 1500-W output on the 160- through 10-meter amateur bands. It is rated at 1000-W output, continuous duty, for RTTY or SSTV operation. Features include a vacuum relay for QSK, a pi-L tank circuit for excellent harmonic suppression and a ducted forced-air cooling system using a centrifugal blower for quiet, cool operation. But, "gigantic size"? Not exactly. Thanks to a separate power supply, the Titan RF deck is a relative lightweight that takes up about as much bench space as a transceiver.

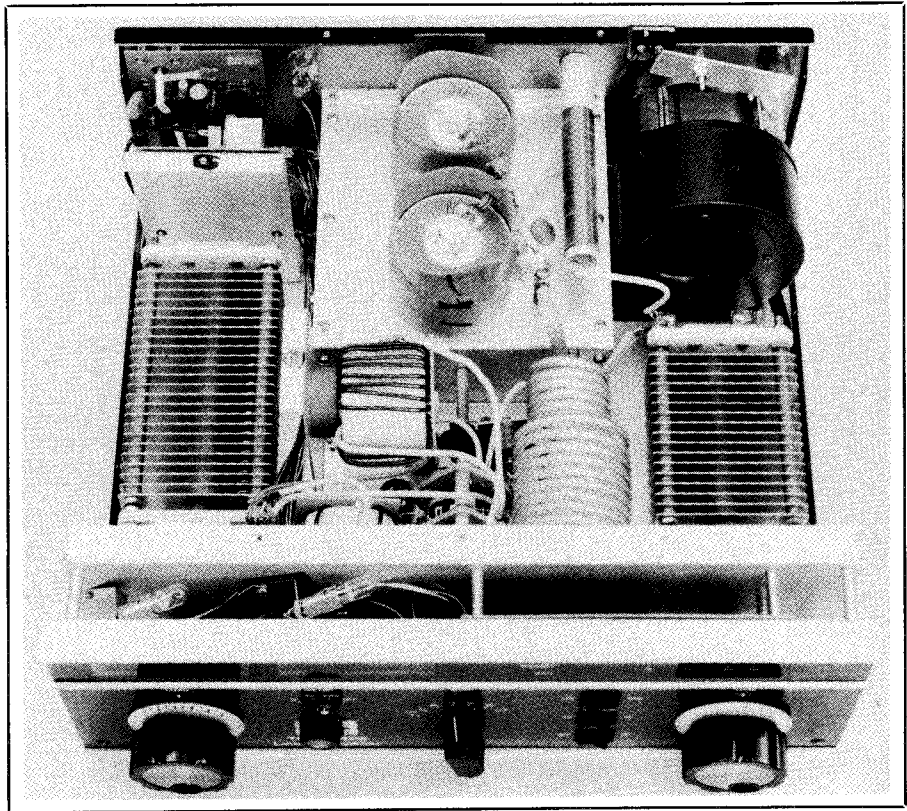
Inside the RF Deck

One of the first things you notice upon removing the RF deck lid is that the tubes are so small for the performance they deliver. Don't let the looks fool you; each 3CX800A7 offers 800 W of plate dissipation. The tubes are mounted on a 2-3/8-inch-high subchassis along the center of the rear wall of the amplifier. The blower draws air through slots in the sides of the cabinet and blows it directly into the subchassis that supports the tubes. The only way for the pressurized air to exit is through slots cut directly below the tubes. Neoprene chimneys direct the airflow through the 3CX800A7 anode coolers, and duct the warm air out screened holes in the cabinet top.

A tuned input circuit is used to provide best linearity and drive characteristics. The input circuitry is mounted on a PC board underneath the subchassis that holds the tubes. Input band switching is accomplished by a rotary switch that is mounted on the board and driven by an extension shaft from the main band switch. Another PC board for the ALC and bias circuitry is also located under the tube subchassis. Access to these PC boards and to the tube sockets is provided through a panel on the bottom cover.

The band switch, a heavy-duty three-section ceramic model, offers eight positions. There are two 160-m positions, separate 75- and 80-m positions, and one position each for 40, 20, 15 and 10 meters. The low bands rate two positions each to switch in different amounts of fixed loading capacitance for best operation over the entire band.

The tank circuit, a pi-L network on all bands, features a 300-pF air-variable capacitor for tuning and a 500-pF air variable for loading. Various fixed-value, transmitting type doorknob capacitors are switched in



parallel with the loading capacitor for operation on the different bands. An additional 400 pF is switched in parallel with the tuning capacitor for 160-m operation.

A somewhat unusual feature of the Titan is that low-capacitance doorknob capacitors are switched in *series* with the tuning capacitor on 20, 15 and 10 meters to *lower* the overall tuning capacitance. This is how Ten-Tec gets around the "touchy tuning" problems that many amplifiers suffer on the higher bands because the minimum capacitance of the tuning capacitor is too high (which raises the

Q). The Titan's tuning is as broad and smooth on 10 meters as on the other bands.

The pi inductor for 40-10 meters is wound from silver-plated, 1/4-inch copper tubing. A toroidal inductor is added for 160 and 75-80 meters. The L coil is a single, tapped toroidal inductor.

As supplied from the factory, the Titan will not operate on 10 meters. If you send a copy of your amateur license to Ten-Tec with the warranty registration card, however, they will send you a sheet showing how to make the simple 10-meter modification. Basically, this

Ten-Tec Titan Model 425 HF Linear Amplifier, Serial No. 00268

Manufacturer's Claimed Specifications

Frequency coverage: 1.8-2.0, 3.0-4.7, 5.0-8.0, 9.0-15.0, 18-22 MHz (24-30 MHz for export model).
Power output: 1500 W SSB or CW, 1000 W continuous RTTY and SSTV.
Drive power required: 80 W typical for 1500-W output.
Efficiency: 50-65%, depending on frequency, drive level and load.
Distortion: -35 dB from 1-kW output level.
Harmonics and spurious emissions: -50 dB, typical.
Primary power requirements: 220-250 V ac at 20 A maximum.
Color: Gray.
Dimensions (height, width, depth):
Amplifier, 5.25 x 15.25 x 15 in.
Power Supply, 8.25 x 13.4 x 10.25 in.
Weight: amplifier, 17 lb; power supply, 45 lb.

Measured in ARRL Lab

As specified.

See Table 1.

See Table 1.

See Table 1.

Not measured.

See Fig 1.

As specified.

Table 1
ARRL Laboratory Measurements

Ten-Tec Titan Model 425 HF Linear Amplifier, Serial No. 00268

| Band (MHz) | Plate Current (A) | Plate Voltage (V) | Power Output (W) | Drive Power (W) | Input SWR | Efficiency [†] (%) |
|------------|-------------------|-------------------|------------------|-----------------|-----------|-----------------------------|
| 1.8 | 1.2 | 2100 | 1500 | 59 | 1.3:1 | 57 |
| 3.5 | 1.05 | 2120 | 1500 | 60 | 1.9:1 | 64 |
| 7.0 | 1.0 | 2200 | 1500 | 49 | 1.3:1 | 66 |
| 14 | 1.1 | 2150 | 1500 | 52 | 1.6:1 | 61 |
| 21 | 1.07 | 2150 | 1500 | 50 | 1.5:1 | 63 |
| 28 | 1.15 | 2150 | 1500 | 70 | 1.2:1 | 58 |

$$^{\dagger}\text{Efficiency} = \frac{\text{Output Power} - \text{Drive Power}}{\text{Input Power}}$$

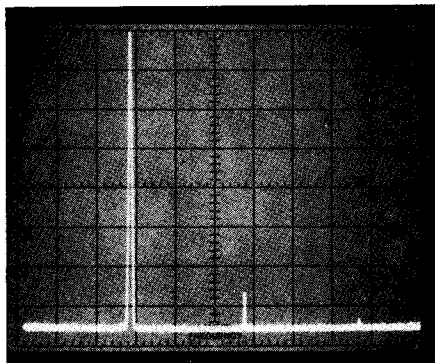


Fig 1—Worst-case spectral display of the Ten-Tec Titan Model 425 HF linear amplifier. Power output is 1500 W at 14 MHz. Horizontal divisions are each 5 MHz; vertical divisions are each 10 dB. All spurious and harmonic emissions are at least 66 dB below the fundamental output. The Titan meets all current FCC spectral purity requirements.

operation involves loosening collars on the band-switch and loading-capacitor shafts and shifting the position of mechanical stops that limit the movement of these two controls. Once the cover is removed, the whole operation can be completed in less time than it took you to read this paragraph.

The review Titan was produced early in 1985, well before 24-MHz (12-m) band operation was authorized for amateurs. Our review model sort of worked on 12 meters with the band switch in the 10-meter position. The performance was far inferior to that on the other bands, however. A call to Ten-Tec revealed that a modification for improved 12-meter operation is being built into all units currently in production and that the factory would retrofit our older unit without charge.

Control Circuitry

Ten-Tec has built some nice features into the Titan to help protect your investment. Most noticeable is the three-minute delay you must endure while the 3CX800A7 heaters warm up. During the warmup period, it's impossible to place the Titan in the transmit mode. You must stand by until the red WAIT light goes out and the green OPERATE light comes on. Although this delay might be annoying, it's absolutely necessary to prolong the life of those expensive tubes.

When the cover is removed, a microswitch cuts power to the coil of the control relay that energizes the power-transformer primary, and a shorting bar falls across the high-voltage connector. These two features make it dif-

ficult to hurt yourself if you remove the cover before making sure that the high voltage is removed.

The front panel features two analog meters, as well as two LED displays, to allow you to monitor several parameters at once. The meter on the left is a dedicated 1.5-A plate-current meter. The meter on the right is a multimeter that can be switched to display grid current, plate voltage, forward power and reflected power. In use, the forward- and reflected-power meter readings closely tracked those of a Bird Model 43 wattmeter.

Any analog meter movement is a bit slow for accurately tracking voice peaks, so Ten-Tec included a row of LEDs on the right side of the front panel to display peak output power. Calibration points are 100, 500, 1000 and 1500 W, and we found the readings to be 100 to 200 W higher than those recorded on a Bird digital peak-reading wattmeter. Nevertheless, this display is a useful feature, and the flashing LEDs are reassuring for those operators who like to see the meters fly on voice peaks.

The fourth indicator is the red OVERDRIVE LED. This one lights up if you exceed the 120-mA, safe grid-current rating specified in the manual. This feature is especially handy on SSB because the analog meter is too slow to track the peak grid current. The manual is clear on use of the OVERDRIVE light: "If this indicator is flashing under voice modulation, regardless of what the grid current meter reading indicates, *reduce drive immediately.*"

CW operators will like the Titan's QSK feature. You can use the Titan in a 1500-W full-break-in system if your exciter is up to it. A Kilovac vacuum relay handles the output RF switching chores, and a PC board full of components sequences the TR switching events in the proper order. To prevent damage to the relay contacts from hot switching, protective circuitry senses the presence of RF on the amplifier input and will not switch the TR relays if more than 100 mW is present.

Power Supply

A rather plain box houses the Titan power supply. This unit is intended to reside, unseen, under your operating bench. The front panel is blank. The rear panel sports two fuse holders, a ground lug, a short primary power cord, and a multipin connector and a high-voltage connector for interconnections to the RF deck.

The power-supply interior is just as businesslike. A 1.8-kVA CCS, tape-wound Hypersil® power transformer dominates the interior. Secondary windings include 13.5 V for the 3CX800A7 filaments, 28 V for the relays and control circuitry, and a high-

voltage winding switchable between 1370 V and 1920 V for high- or low-voltage operation. The full-wave bridge rectifier for the high-voltage supply, consisting of strings of individual 1000-PIV devices, is contained on a PC board along with most of the control circuitry. Filtering is accomplished by eight 400- μ F, 450-V computer-grade electrolytics connected in series for a total filter rating of about 50 μ F at 3.6 kV. The filter capacitors and their bleeder resistors are mounted on the power-supply PC board.

Ten-Tec included several protective features of note. The power supply features a primary interlock switch and a high-voltage shorting bar, actuated by cover removal, identical to those in the RF deck. The primary circuitry incorporates resistors to limit the inrush surge current through the diodes at turn on, as well as a relay that automatically switches the protection out of the circuit after a short interval. Following EIMAC recommendations, Ten-Tec has included a 10-ohm, 25-W resistor in series with the B+ line to limit current to a safe value in case of a high-voltage short circuit.

According to the front-panel meter, the power supply delivers about 2450 V in the high-voltage mode and about 1700 V in the low-voltage mode under no-load conditions. These drop to about 2150 V at 1500-W output in the high-voltage position, and 1500 V at 1000-W output in the low-voltage position.

The Titan Arrives

Our Titan arrived in three cartons—one each for the RF deck, power supply and power transformer. The transformer is shipped separately to minimize the potential for damage during handling. During initial inspection, we found three problems with the RF deck. When we first opened the box, we noticed that the two plastic trim pieces that mount on either side of the front panel had broken off. In addition, neither of the vernier drives for the output tuning or loading capacitors worked properly. Both slipped and exhibited excessive backlash, making amplifier tuning impossible. More serious, a cover-off inspection revealed that L4, a toroidal inductor in the output tank circuit, was floating loose near the high-voltage points. The head of one of the nylon screws that secure L4 had broken, allowing the inductor to come free from its mount. We replaced the nylon screw with a brass screw; problem solved! This experience reaffirms that it's good practice to look inside any power amplifier or high-voltage power supply before using it for the first time after shipment. A problem such as we found could be dangerous.

We contacted the selling dealer for warranty repair information. We found out that Ten-Tec handles these repairs at the factory, so we called for authorization and returned the unit directly to them. They repaired the unit without charge, and it has performed perfectly since then.

We believe that the problems we experienced were caused by rough handling during shipment. Even so, the factory took care of everything for us promptly and without complaint. It's easy to see why Ten-Tec enjoys a reputation for exceptionally good customer service!

Hookup

Installation of the power transformer takes

less than half an hour. First, unpack the power supply and unbolt the transformer from its shipping container. Remove the 20 screws that secure the power-supply cover and lift the cover off (this move takes a little finesse to clear the lips on the bottom edge of the cover). Clear the cabling out of the way and lower the power transformer into the power-supply case. Bolt the transformer in place, join two sets of multipin connectors, replace the top cover, and you're in business.

Ten-Tec supplies a 234-V, 20-A power cable plug. An amplifier in this class draws 15-20 A from a 234-V line; at 117 V, the requirement is a whopping 30-40 A! Accordingly, the manual says that 117-V operation is *not* recommended, and gives no information on converting the power supply for 117-V use. Take the hint and run a 234-V, 20-A line to your station before purchasing an amplifier such as this.

Interconnecting the Titan with the rest of the station is easy. Ten-Tec supplies all the control cables. The manual offers several configurations, depending on whether you want to use conventional VOX or PTT operation, CW QSK or fast VOX, or set up to switch between these two keying options.

Operation

I enjoyed using the Titan during the 1985 fall operating season. In addition to routine operating, I used it during the CQ World Wide DX Contests, the ARRL November Sweepstakes and the ARRL 10-Meter Contest. It was perfectly content loafing along at

1500-W output on SSB or CW for hours at a time. Tuning is exceptionally smooth, even on 10 meters. As long as the procedure outlined in the manual is followed, tune-up is a snap.

The amplifier never complained under any operating conditions. In fact, the first time we tuned it up in the ARRL Lab for measurements, we increased the drive too quickly and accidentally drove the Titan to more than 2000-W output into the dummy load. It didn't even flinch.

According to the manual, the Titan is rated for 1000-W continuous duty on RTTY and SSTV. Ten-Tec recommends using the low-voltage power-supply setting for best efficiency. The hardest test I put the amplifier through was the Worked All Europe RTTY Contest. During this event, I operated the amplifier at between 700 and 1000 W for the better part of a weekend. The Titan took on this task without complaint, and kept on working perfectly and efficiently long past the point where lesser amplifiers would have given up. Best of all, at this output power level the drive required is only 40 to 50 W, so the exciter can run cool at half power.

Those CW operators who use QSK will enjoy the Titan's break-in capability. The review amplifier proved to be a good match for a Kenwood TS-940S transceiver; I had no problem making the two units QSK together.

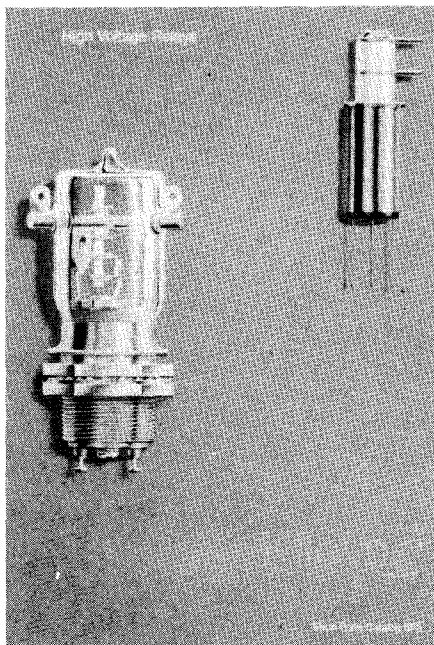
There's one caveat: It's necessary to keep an eye on the grid-current and the OVERDRIVE indicator. As the manual explains, "It is imperative that the RF drive

power always be adjusted to a level appropriate for the way the amplifier has been tuned up. Grid current falls off rapidly when drive is too low, and soars abruptly when drive power is too high." This behavior is characteristic of the 3CX800A7 and other high-mu triodes. They offer legal-limit output for relatively low drive levels, but the grid is capable of dissipating only a few watts. It's highly unlikely that you'll hurt the tubes with excessive plate current, but the grids are another story. If you have a typical transceiver capable of delivering 100 W (almost twice the power required to drive the Titan), you must follow the manufacturer's tune-up instructions carefully and keep a watchful eye on the grid-current meter. Properly treated, these tubes could well last you for your entire amateur career. Mistreat them, and in short order you'll be writing out a check for more than \$500 to your favorite tube supplier.

The Titan is a fine amplifier in every respect. It is rugged and reliable, yet operation is smooth and easy—like a finely tuned sports car. There is still plenty of reserve horsepower, even when it's operating at the legal limit. Coupled with Ten-Tec's outstanding after-sale customer support, these features make the Titan a serious contender for your dollars if you're in the market for a linear amplifier.

Price class: \$2685. Manufacturer: Ten-Tec, Inc., Highway 411 East, Sevierville, TN 37882, tel 615-453-7172.—*Mark Wilson, AA2Z*

New Products



KILOVAC CORPORATION RELAY CATALOG

□ Kilovac Corporation has published an eight-page, condensed catalog on their expanded line of high-voltage relays. A primary feature of the catalog is the introduction of a family of miniature ceramic vacuum relays. Available in a variety of fail-safe and latching configurations, the relays offer voltage isolation to 10-kV dc and carry currents of 15-A dc or 60-Hz ac.

The catalog contains applications notes, specifications, product photographs and a simple product-selection table. For your copy, contact Kilovac Corporation, PO Box 4422, Santa Barbara, CA 93103, tel 805-684-4560.—*Paul K. Pagel, N1FB*

COMMUNICATIONS SPECIALISTS SS-32 HB CTCSS ENCODER

□ This small encoder (claimed to be the smallest in the industry) measures only 0.15 × 0.5 × 1 in (HWD). The unit may be programmed for any of the 32 standard subaudible tone frequencies by bridging solder pads on the PC board. Price class: \$30. For more information, contact Communications Specialists, Inc., 426 West Taft Ave, Orange, CA 92665, tel 1-800-854-0547, or 714-998-3021 from California. A free catalog is available on request.—*Paul K. Pagel, N1FB*

