



# OWNER'S MANUAL

**TITAN  
425**

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### IMPORTANT NOTICE

The power supply cable is color coded: a GREEN DOT is on the top side of the connector of the AMPLIFIER end of the cable. When plugging this end of the cable into the amplifier, make sure the green dot is UP. Similarly, an ORANGE DOT is on the top side of the power supply end of the cable. **ALWAYS MAKE SURE THE AC POWER CORD IS REMOVED FROM THE WALL SOCKET BEFORE ATTEMPTING TO INSTALL OR REMOVE THE AMPLIFIER POWER CABLES.**

### TEN METER OPERATION OF THE TITAN AMPLIFIER

FCC rules permit a licensed amateur to modify his own amplifier for operation in the 28-29.7 MHz band. If you enclose a copy of your valid amateur radio license with the warranty registration card for your new amplifier, appropriate information will be sent to you without charge.

### OPERATION ON THE 10, 18 AND 24 MHZ BANDS

If and when the FCC permits linear amplifiers to be used on these bands, your TITAN will be capable of 10 and 18 MHz operation with only slight modification. In the unlikely event that high power operation is permitted on 24 MHz, TEN-TEC will make available information to permit safe operation of your TITAN on that band. **ANY ATTEMPT TO OPERATE YOUR TITAN IN THE VICINITY OF 24 MHZ WITHOUT APPROPRIATE MODIFICATION MAY CAUSE SERIOUS DAMAGE .**

## SECTION I

### INTRODUCTION

The TITAN Model 425 is an advanced design linear amplifier which uses two Eimac 3CX800A7 triode tubes in a grounded grid configuration. This amplifier uses a ducted forced air cooling system and operates at rated output power with an efficiency of up to 65%. Maximum input power of 3 KW (2 KW CCS) requires less than 100 watts of drive power. A high-low plate voltage switch assures optimum efficiency at lower power (1 KW output) for tune-up or RTTY and SSTV. Three LED status indicators display Standby, Wait or Operate mode and a fourth LED alerts you when the input is overdriven. Two panel meters provide full time indication of plate current and switch selected choice of plate voltage, grid current, forward power or reflected power. Peak power is indicated on a ten element LED bar graph display. Band coverage of 1.8 through 23 MHz Amateur bands is standard. Export model extends coverage to 29.7 MHz. The power supply is conservatively designed for cool operation under full load and employs a tape wound Hypersil® transformer for minimum weight and size. Primary power of 220-250 volts @ 20 amperes is standard. Fuses are provided for primary circuit and plate current protection. Protective interlocks are provided on the ac and high voltage lines.

### SPECIFICATIONS

- BAND COVERAGE:** 1.8-2.0, 3.2-4.7, 6.5-8.5, 13.4-19.6, 17.6-23 MHz.  
(Export model provides coverage of 17.6-26.5 and 20.6-31 MHz).
- POWER OUTPUT:** 1500 watts ssb or cw, 1000 watts continuous RTTY, SSTV.
- DRIVING POWER REQUIRED:** 80 watts typical for 1500 watts out.
- EFFICIENCY:** 50-65%, depending on frequency, drive level and load.
- INPUT AND OUTPUT IMPEDANCES:** 50 ohms unbalanced, VSWR < 2:1.
- DISTORTION:** -35 dB from 1 KW rf output level.
- HARMONICS:** -50dB typical.
- CW BREAK-IN:** High speed QSK capability when using a QSK exciter.
- TUBE COMPLIMENT:** Two Eimac 3CX800A7 ceramic external anode air cooled triodes in grounded grid circuit.

**COOLING:** Ducted forced air, vertical exhaust, using centrifugal blower.

**METERING:** Full time plate current. Switch selected plate voltage, grid current, forward power or reflected power. Peak power is indicated on a 10 element LED bargraph display.

**ALC:** Negative-going, adjustable threshold.

**STATUS INDICATORS:** Overdrive, Standby, Wait, Operate.

**PRIMARY POWER:** 220-250 VAC @20 A, maximum.

**PROTECTION:** Primary line fuses, plate current fuse, ac line and high voltage interlocks.

**FRONT PANEL CONTROLS:** Power ON-OFF, Mode (Standby-Operate), HV (High-Low), Plate Tune, Loading, Band Switch, Meter Switch.

**SIZE:** Amplifier: HWD 5.25" x 15.25" x 15", (13.3 x 38.7 x 76.8 cm).  
Power Supply: HWD 8.25" x 13.4" x 10.25", (21 x 34 x 60 cm).

**WEIGHT:** Amplifier: 17 lbs, (7.7 Kg).  
Power Supply: 45 lbs, (20.5 Kg).

## SECTION II

### INITIAL SET UP

#### UNPACKING

Carefully remove the amplifier from the packing carton and inspect it for signs of shipping damage. If the amplifier has been damaged, notify the delivering carrier immediately, stating the full extent of the damage. Save all damaged cartons and packing material. Liability for any shipping damage rests with the carrier. Complete the warranty registration form and mail to TEN-TEC immediately.

Save the packing material for re-use in the event that moving, storage, or reshipment is necessary. Shipment of your TEN-TEC amplifier in other than factory packing may result in damage which is not covered under warranty. Accessory hardware, etc. are packed with your TITAN. Make sure you have not overlooked anything.

#### TRANSFORMER INSTALLATION

Remove the screws securing the cover of the power supply using a large phillips screwdriver. Spread the bottom edge of the cover slightly to clear the lips on the bottom edge and lift it off. Remove the screws holding the transformer to the shipping plate. Orient the transformer so that the plugs are facing the center of the supply (Do not bend or twist the transformer wires). In the power supply, move the connectors away from the transformer holes. Carefully lower the transformer into the supply so that the mounting holes are aligned. Using the hardware supplied, install a bolt, lockwasher, and nut at each corner and tighten securely.

Check both pairs of mating connectors visually for proper mating orientation and mate them firmly, pushing until the integral locking tabs click. Do not twist or bend the wires or connectors unnecessarily to avoid damaging them. After mating the connectors, position the harnesses away from the cover and rectifier circuit board. Inspect your work, then replace the cover using the original screws.

#### ELECTRICAL CONNECTIONS

The TITAN amplifier draws as much as 4KW of line power and 120 VAC operation is not recommended.

Power Cable Connection. The power cable plug provided is recommended for 240VAC, 20A service. If another type connector must be used, the green wire of the amplifier power cord is the chassis safety ground. It must always (and ONLY) be connected to the safety ground of the ac mains -- NEVER to one of the "hot" power wires. The black and white wires are interchangeable and connect to the two "hot" service conductors.

Physical Location. Your TITAN must be located so that a supply of cool air is available for the intake along the sides of the chassis, and that the exhaust of hot air from the top of the chassis is not obstructed in any way. A minimum of two inches of clearance should be allowed when placing other pieces of equipment beside the amplifier, and at least six inches should be allowed above the amplifier to permit air circulation. Be careful not to place anything on top of the amplifier which would block the flow of air.

**BLOCKING THE EXHAUST OR INTAKE AIRFLOW IS LIKELY TO  
RESULT IN THE DESTRUCTION OF THE TUBES!!!**

In any installation, it is a good idea to inspect for conditions which would result in recirculation of the exhaust air back to the intake.

Similarly, there are vent holes on the sides of the power supply cabinet. These should not be blocked and the cabinet should be located where it will get free air circulation.

POWER SUPPLY - RF AMPLIFIER INTERCONNECTIONS

Two cable assemblies are supplied with the TITAN which provide interconnection of power and control functions between the supply and the rf amplifier chassis. They are long enough to permit the power supply to remain on the floor while the rf amplifier is placed in a convenient operating location. Disconnect the AC mains plug before installing these cables. Always connect the HIGH VOLTAGE cable first before the POWER SUPPLY multiconductor cable. Make sure that the 12-pin cable plugs are properly oriented before plugging in and that the locking tabs click when properly seated.

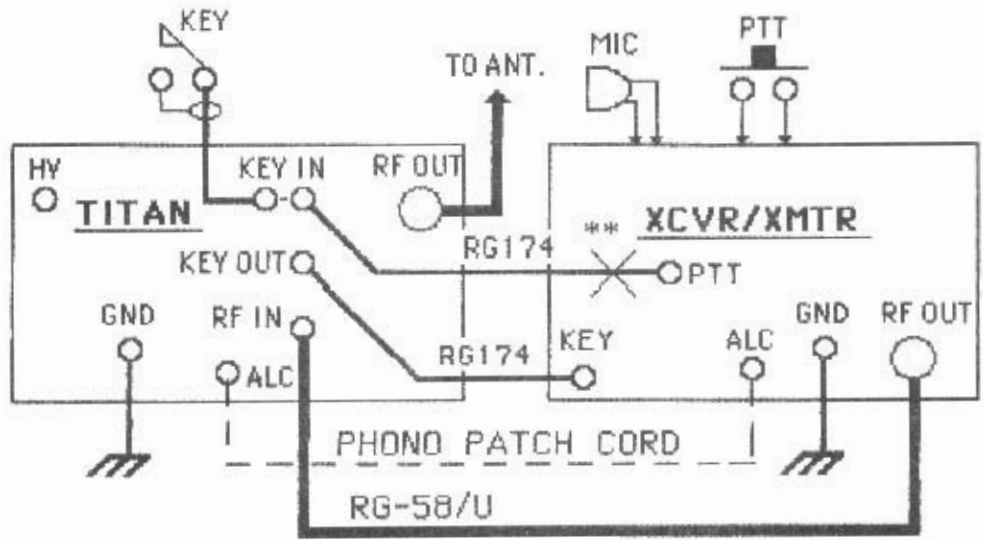
EXCITER INTERCONNECTIONS

The simplest method of connecting any transceiver to the TITAN is shown in Figure 1. This hookup provides smooth operation in both CW and Push-To-Talk SSB modes. If VOX operation is essential, the system shown in Figure 2 may be used. If any switching problems occur, use of Figure 3 will provide improved operation.

Figure 2 shows a method for switching between the QSK cw break-in configuration and the conventional ssb PTT or VOX operation without having to switch cabling. The mode of operation desired is selected by simply setting the external DPDT switch to the appropriate position.

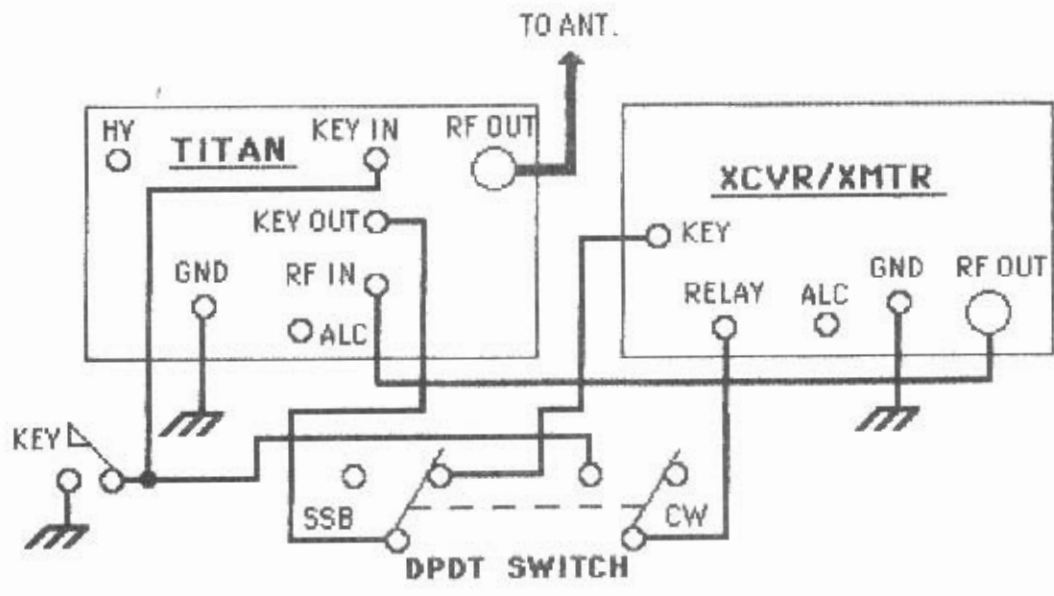
**Important Note:** The hot switch protection system used in the TITAN amplifier will also keep it keyed in the "transmit" condition, even if the T/R control line (KEY IN) is opened, or the amplifier is switched to the standby ( SBY ) position, until the rf drive power to the amplifier is reduced below 100 mW or so. Merely switching the amplifier to STANDBY is not sufficient to switch it out of the rf line unless the rf drive power is completely removed.

**FIGURE 1.** TITAN Recommended hookup for CW or Push-To-Talk SSB operation.



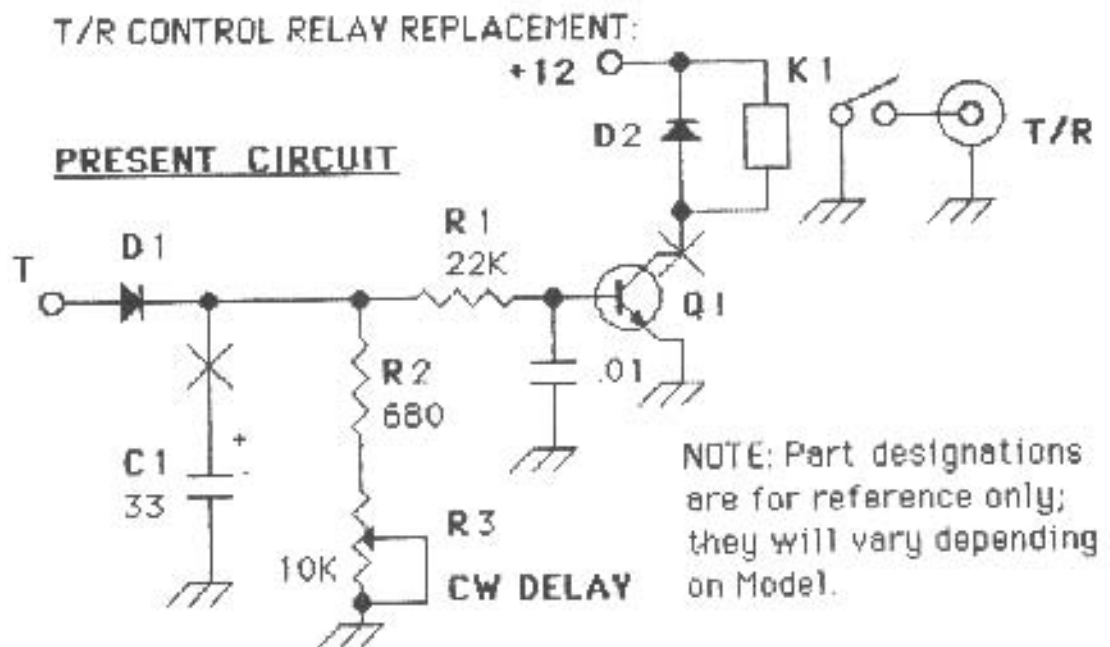
\*\* NOTE: Some transceivers may require a switch to open PTT line when operating CW.

**FIGURE 2.** Easy hookup for SSB PTT or VOX and CW.

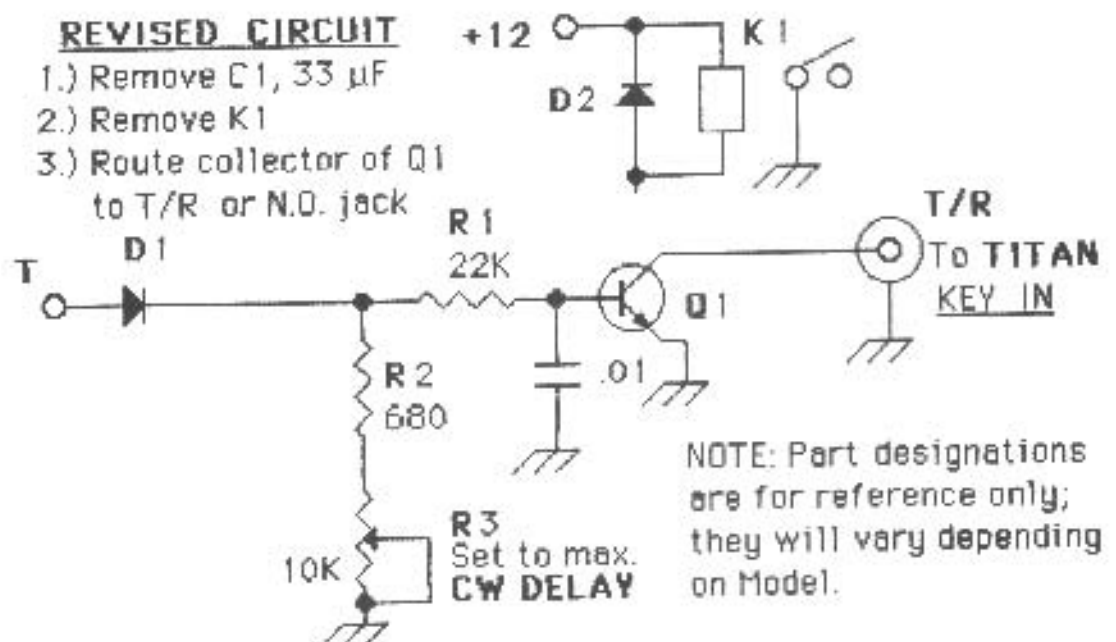




**FIGURE 2A.** Modification of TEN-TEC Transceivers for faster switching.



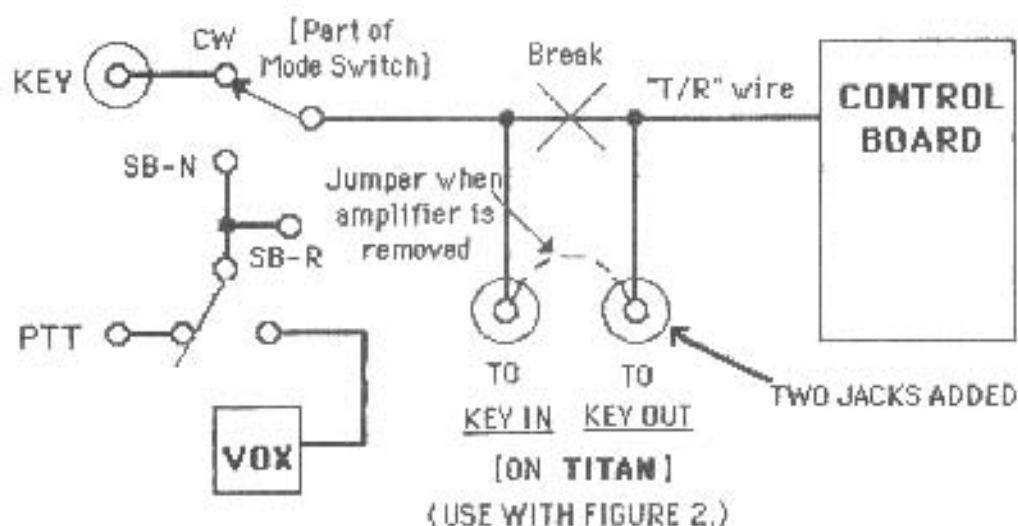
**FIGURE 2B.**



The TITAN QSK system incorporates protective circuitry which senses the presence of rf drive power on the amplifier input line and prevents the amplifier T/R relays from changing state (R to T or T to R) if drive power exceeding 100 mW is present. A few models of transceiver/exciter are known to exhibit T/R sequencing such that they may deliver rf power to the amplifier before their amplifier-controlling relay contacts close. If the easy PTT/VOX hook-up in Figure 2 is used with an exciter with this characteristic, the amplifier may sometimes refuse to switch to "transmit" when the exciter does, because to do so would result in "hot switching" of the amplifier T/R relay contacts and possibly damage them. Typically, the amplifier might then switch to "transmit" after the first brief pause in rf drive power, such as during a syllabic pause in ssb speech, or after the first dit or dah on cw. If the problem occurs and proves bothersome, the arrangement in Figure 3 should be used even for "manual" or "VOX" controlled cw or ssb. If you have trouble locating the correct "T/R" wire in your transceiver, contact the manufacturer for further information and assistance.

TEN-TEC transceivers exhibit this characteristic. Figures 2A and 2B show a possible modification which can be made to TRITON, DELTA, OMNI, or CORSAIR model transceivers to eliminate this effect. The TEN-TEC service department is available for assistance with these modifications if needed. Call (615) 428-0364, 8AM-4PM EST. No collect calls, please.

**FIGURE 3.** Recommended modification of Transceivers for CW and PTT/VOX SSB operation.



### CONNECTOR FUNCTIONS

RF INPUT. A standard PL-259 ("UHF" type) plug and RG-58/U or similar small 50 ohm coaxial cable is required to connect to the station exciter or transceiver's output or antenna jack. This cable should be as short as possible, preferably 2 to 3 feet.

RF OUTPUT. A standard PL-259 plug and RG-8/U or similar large coaxial cable rated for 1.5 KW is used to connect to the antenna system.

ALC. For use with tube-type transmitters/transceivers having negative-going ALC systems. This jack is patched to the mating jack on the transceiver using small coaxial cable and a suitable "RCA" or "phono" type connector. All TEN-TEC transceivers and most other modern, solid state (broadband) transceivers use positive-going internal ALC with a level detector at the rf output point. This internal system normally functions adequately to control SSB drive power to the amplifier. Most solid state transceivers provide no connection for ALC input and it is entirely unnecessary to make any external ALC connection.

KEY IN. This jack controls the TITAN's transmit/receive relay system. For conventional operation, this jack is connected to the transceiver or transmitter "relay", PTT, or T/R contacts which are normally open on receive and closed on transmit.

For cw QSK (break-in) or AMTOR RTTY operation, the key itself is plugged into this jack on the rear panel of the amplifier.

KEY OUT. When configured for QSK operation, this jack passes the key information back to the transceiver. This prevents "hot switching" of the amplifier's relay contacts. This jack is not used in conventional non-QSK T/R operation.

POWER. Connection to the model 425S power supply.

HIGH VOLTAGE. Connection to the model 425S high voltage output.

**DO NOT ATTEMPT TO CONNECT THE HIGH VOLTAGE  
CONNECTORS WHILE THE POWER IS ON. 2200 VOLTS IS LETHAL !**

### ANTENNA REQUIREMENTS

The TITAN amplifier has been designed for use with antennas resonant at the frequency of operation and having impedances within the limits of 25 to 100 ohms, or an SWR of 2:1 or less.

The nominal output impedance of the amplifier is 50 ohms and the SWR of the load should not exceed 2:1. Most antennas exhibit an SWR range over an entire amateur band that exceeds 2:1. For this reason, we recommend using an antenna matching network which will enable the TITAN to work into a 50 ohm load for maximum power transfer to the antenna. The TEN-TEC Model 229-A Tuner and Model 4229 Tuner Kit are suitable companions.

### **CAUTION!!!**

Never attempt to operate the TITAN without first connecting a suitable antenna or 50 ohm dummy load of sufficient power rating or **serious damage may result.**

## SECTION III

### OPERATION

#### CONTROL FUNCTIONS

BAND. Selects the desired frequency range.

TUNE. Controls the amplifier resonant frequency. A chart of the approximate settings is given on page 3-4 of this manual.

LOAD. Controls the amplifier output loading. See chart as above.

POWER. Switch to ON to apply power. Amplifier should power up, WAIT and STANDBY LEDs should light. OPERATE LED will come on after approximately three minutes to allow tube filaments to heat.

MODE. OPERATE places the amplifier in the rf line. Selecting STANDBY, or attempting to operate before the WAIT LED goes out will cause the amplifier to run in the bypassed mode.

VOLTAGE. LO selects low voltage for tuning or continuous duty operation. HI selects high voltage (approximately 2200V) for full power operation.

METER. Ig selects grid current, 150 mADC full scale.  
Ep selects plate voltage, 3000 VDC full scale.  
FWD selects forward power, 2.5 KW full scale.  
REV selects reverse power, 250 W full scale.

#### THE OBJECTIVE OF TUNE-UP

The objective of the tune-up procedure is to adjust the amplifier, and the drive power applied to it, so as to obtain the maximum output at (a) the desired input power level or (b) the maximum available level of drive power, if that is the limiting factor. When the amplifier is adjusted for the maximum attainable rf power output at a specific (fixed) level of carrier drive power from the exciter, it is automatically yielding the best combination of efficiency and linearity possible at that particular drive level. If a greater drive power than that used for tune-up is applied, the result will be flattopping, off-frequency "splatter," and excessive amplifier grid current.

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. Therefore, proper grid current is an excellent indicator of proper drive level. In the TITAN amplifier, the grid current should not exceed 120 mA under normal CW/SSTV/RTTY conditions, nor should the grid current peak swings ever exceed 60 mA under SSB voice modulation. If the grid current reaches these limits before the desired value of plate current is obtained, the drive should NOT be increased further.

The trip point on the OVER DRIVE indicator has been set at 120 mA of grid current. If this indicator is flashing under voice modulation, regardless of what the grid current meter reading indicates, reduce drive immediately.

Play it safe. The grid dissipation is the weakest link in the system. Excess drive power always generates elevated grid current. Either reduce the drive or increase the loading to take advantage of the extra drive to produce more output power.

The manufacturer's **absolute maximum ratings** for a pair of 3CX800A7's in AB2 service are :

DC PLATE VOLTAGE (under load).....	2500 VOLTS
DC PLATE CURRENT ( single tone).....	1.2 AMPERE
PLATE DISSIPATION .....	1600 WATTS
GRID CURRENT .....	120 MILLIAMPERES
GRID DISSIPATION .....	8 WATTS

**IMPORTANT NOTE:** The amplifier meters are average-reading and cannot follow the very rapid peak current variations encountered in SSB modulation. Therefore the PLATE CURRENT meter will not indicate 1+ amperes when this desired level is reached on voice peaks, but will typically swing to about 30 to 50 % of the actual peak value depending on voice and exciter characteristics. The swing may be somewhat greater when speech processing is being used. FCC rules presently limit amateur power in terms of output rather than input power. For this reason, the TITAN amplifier features a peak reading output power indicator. This eliminates the calculations which were necessary under the old rules to stay within the legal power limit. The peak power indicator works in any transmitting mode.

#### CHECKS TO MAKE BEFORE TUNING UP

**CHECK THE LOAD.** Leave the amplifier off or in the standby mode, and use only the exciter power for this test. Use a reliable SWR bridge or wattmeter to determine the VSWR of the load (antenna) connected to the amplifier output. If the reflected power is less than 10% of the forward power, the VSWR is less than 2:1. If the reflected power is 4% or less, the VSWR is 1.5:1 or better.

If a high accuracy external SWR meter is not available, the TITAN's built-in wattmeter can be used. Although it is intended as a tuning aid and power output indicator, this meter has sufficient accuracy for this use. Because the FWD power meter scale is 2500 watts and the REY power scale is 250 watts, for a VSWR of 2:1 or less it is only necessary to check that the meter deflection in the reflected position is less than the deflection in the forward position. Because of the 10:1 ratio of the meter scale factors, this situation indicates 10% or lower reflected power, corresponding to a VSWR of 2:1 or less.

INITIAL TURN-ON. The following steps should be followed when turning on your TITAN:

- 1) Place the MODE switch in the SBY (standby) position.
- 2) Place the METER switch in the Ep position.
- 3) Place the VOLTAGE switch in the LO position.
- 4) Press the POWER switch to ON. If any of the following does not occur, press OFF immediately and investigate before proceeding.
  - a) the meter should promptly show 1800 volts.
  - b) the meter lights should illuminate.
  - c) the blower should start immediately and exhaust air should be detectable from the top cover vents.
  - d) the plate current meter should continue to read zero.
- 5) When the warm-up delay times out (about 5 minutes), the WAIT LED indicator will go out and the STANDBY LFD will come on.

INITIAL TUNE-UP AT LOW POWER = 1KW

- 1) Place the meter switch in the grid current position, Ig.
- 2) Set the BAND, TUNE, AND LOAD controls to the appropriate preliminary settings shown in the table below. The final settings will vary with operating frequency, load characteristics, and drive level.

<u>BAND</u>	<u>TUNE</u>	<u>LOAD</u>	<u>FREQ (MHz)</u>
160A	5.0	8.0	1.8
160B	6.0	8.0	1.9
80	6.6	5.5	3.5
75	5.5	7.5	3.9
40	2.5	5.0	7.1
20	7.0	5.5	14.2
15	4.0	3.6	21.2
10*	1.5	7.5	28.5

(\* export model only)

- 3) Turn the exciter/transceiver drive or rf output control to zero.
- 4) Press the mode switch to OPR. The OPERATE LED should light.

IF AT ANY TIME IN THE FOLLOWING PROCEDURES, THE AMPLIFIER DOES NOT RESPOND AS EXPECTED, REMOVE DRIVE IMMEDIATELY AND CORRECT THE PROBLEM BEFORE CONTINUING.

- 5) Switch the exciter to "tune" or "lock key" and slowly increase the carrier power output from zero until either the PLATE CURRENT METER indicates 0.5 Ampere or the GRID CURRENT meter indicates 50 mA. Carefully adjust the LOAD control for maximum output as viewed on the PEAK POWER LED display, or switch the METER to read FWD power. Then adjust TUNE for maximum rf watts indicated on the meter. Repeat this process of alternately peaking first LOAD, then TUNE, until no further increase in rf output can be achieved ( without increasing drive level ). If the output power at this point is less than the desired level, then slightly increase the drive output. If the rf output power or plate current is more than desired, then slightly decrease the drive output. In either case, repeat the alternate LOAD-TUNE adjustments to obtain maximum forward power. A value of 0.5 Amperes of plate current corresponds to approximately 1KW at the LO VOLTAGE setting.



At this point, your TITAN is properly adjusted for rf output powers up to 750 Watts, which is suitable for FSK/RTTY/SSTV or low power cw/ssb. If your exciter has a variable ALC threshold (TEN-TEC and others), adjust the ALC so that the driver output power is limited at this level. To operate ssb at this power level, simply switch the exciter to the ssb mode and adjust its ssb output power level so that the maximum GRID current swings of the TITAN meter are approximately 30 mA. For further information, refer to the discussion of meter response above.

#### FINAL ADJUSTMENT FOR FULL POWER OPERATION

For high power operation of your TITAN amplifier, first complete the adjustments for the low power tune-up as described above. Then return the exciter to STANDBY or RECEIVE. Press the HI VOLTAGE switch and confirm with the METER switch in the plate voltage position, Ep, that the HV is  $2150 \pm 200$  VDC. Because the plate voltage is increased by 50%, this permits operating the TITAN at inputs of approximately 2 to 2.5 times the tune-up level with only very minor changes in tuning. Switch the exciter to the ssb mode and slowly advance the drive until the rf output peak meter shows 1500W peaks. This must occur without showing more than 30 mA grid current peaks, 0.5 A plate current peaks or flashing the OVERDRIVE.

THE LAST LED OF THE PEAK OUTPUT POWER BARGRAPH DISPLAY HAS BEEN CALIBRATED TO LIGHT WHEN THE 1500 WATT LEGAL LIMIT IS EXCEEDED.

Occasionally check the SWR while operating to make sure it remains below 2:1. Also, monitoring reflected power is useful in that any sudden change provides warning of antenna problems such as bad connections, antenna coupler faults, transmission line flaws, or trap or balun failure. Particularly in the case of flashover (arcing) problems, the reflected power indication may flicker sharply upward only on high power voice peaks.

#### ALC

When the TITAN's negative-going ALC is used (usually with tube output types of exciters and transceivers), adjustment of the ALC threshold is accomplished using the ALC ADJ control located on the back panel of the amplifier. If the exciter manufacturer does not provide instructions for adjustment of the ALC with a linear amplifier, then the following procedure should be satisfactory:

Set the TITAN's ALC control to yield the desired amplifier PLATE CURRENT swings on voice crests, while alternately adjusting the exciter microphone gain (or its rf output control, if it has such a control independent of the mike gain) to provide the desired degree of exciter ALC action. With exciter/transceivers having no means to monitor internal ALC action, follow the manufacturer's instructions for achieving "normal" exciter/transceiver operation. It is desirable in such a case to have a friend listen to your signal "on the air" to confirm that excessive ALC "pumping" does not result. If it does, the solution is to reduce the microphone gain until the "pumping" is barely noticeable. CAUTION: Be sure that your listener does not confuse "pumping" in his receiver's AGC with ALC action - receiver AGC should be turned off during such a listening test.

### OPERATING NOTES

TUBES. The 3CX800A7's ceramic/metal triodes are very rugged and normally operate with a large margin of safety in the TITAN amplifier. They will deliver outstanding service for many years if not damaged by abuse — especially excessive grid current (which leads to excessive grid dissipation) or blockage of the cooling airflow leading to anode heating and possible seal failure. KEEP THE AIR INTAKE AND EXHAUST VENT AREAS COMPLETELY CLEAR!

WARNING! DO NOT ALLOW the PLATE CURRENT indication to ever exceed 1.2 Amperes for more than 5 seconds.  
DO NOT ALLOW the GRID CURRENT ever to exceed 150 mA (full scale in the METER Ig position); normal operation requires only 20 - 80 mA.

INTERLOCKS. The TITAN is equipped with interlock switches intended to shut off the power and to short out the high voltage power supply when either cabinet cover is not securely fastened in place. These protective interlocks are provided to protect you against a POTENTIALLY FATAL ELECTRIC SHOCK resulting from accidental contact with lethal voltages inside the amplifier and power supply. HOWEVER, you should never depend on the interlock switches alone to protect you by removing dangerous voltages: ALWAYS DISCONNECT THE AC LINE CABLE TO THE TITAN POWER SUPPLY BEFORE REMOVING THE COVERS.

WARNING!! The amplifier SHOULD NEVER BE ENERGIZED WITH THE COVERS REMOVED except by thoroughly knowledgeable service personnel!

FUSES. Except in rare instances of component failure, blowing one or both primary line fuses indicates that the maximum safe average power capability of the amplifier has been substantially exceeded.

## SECTION IV

MAINTENANCE AND TROUBLESHOOTING

Most problems and apparent failures with TEN-TEC amplifiers result from the operator's failure to read and thoroughly understand the contents of the instruction manual ... as well as basic linear amplifier principles ... rather than from actual equipment defects. Should some problem arise, the troubleshooting hints in TABLE 2 will help isolate the nature of the problem.

The amplifier compartment, particularly areas around high voltage components and rf compartment, should be cleaned frequently enough (using a soft bristle brush and vacuum cleaner) to prevent visible accumulation of dust. DO NOT blow air directly into the fan blades; you can over-rev the fan and damage the bearings. If extremely dusty conditions prevail, it may be advisable to secure a thin plastic foam air filter, of the type commonly used in window air conditioners, and tape it across the air intake perforations on the sides of the cabinet. Make certain that the filter material does not restrict the air flow into the amplifier.

TABLE 2 . TROUBLESHOOTING HINTS

<u>SYMPTOM</u>	<u>POSSIBLE CAUSE/CURE</u>
1. Will not turn on; nothing happens when the ON switch is pressed.	a) Fuse missing or open. b) Interlock open, cover not tight. c) House wiring incorrect or breaker open. d) Power cable to amplifier missing.
2. K1 (and possibly K2) closes but no high voltage at turn-on.	a) R2 or R3 in power supply open. b) HV short to ground. c) Shorted tube.
3. K1 closes at turn-on, but line fuse(s) blow immediately.	a) HV shorted at crowbar or elsewhere b) Shorted tube. c) Malfunction in 28V supply.
4. Relays close, fan starts, HV normal, but WAIT LED does not go out; T/R relays stay in RCV.	a) Defective time delay component on Relay pc board 81218.
5. Relays close, fan starts, HV meter deflects downscale, fuse(s) may blow.	a) Interelectrode short in tube. b) Shorted or deformed HV electrolytic filter capacitor.

6. Amplifier won't drive, zero grid and plate current, high input SWR.
7. Amplifier drives easily, but grid meter pins at low drive.
8. Amplifier difficult to drive, grid current low, high input SWR.
9. Amplifier drives easily, grid current low, little or no output (may be accompanied by "frying sound").
10. Plate current flows in RCV or standby condition.
11. Amplifier drives normally, PLATE CURRENT very high.
12. T/R relays remain in transmit even in SBY condition.
13. Low output, exciter drive seems lower than normal.
14. Flashover in rf compartment, usually between TUNE or LOAD capacitor plates.
- a) Defective cable from driver to amplifier input.  
b) Input reed relay not closing (K3).  
c) Damage to input network.
- a) Grid current metering resistor R19 open or damaged by severe overdrive or insufficient loading of amplifier.
- a) BAND switch in wrong position.  
b) Defective input coax cable.  
c) Contacts of K3 not closing.  
d) Zener diode D2 open or defective.  
e) Damaged input network.  
f) Interelectrode short in tube.
- a) Arc-over of component in rf tank.  
b) Defective output vacuum T/R relay.  
c) Amplifier bandswitch in wrong position.  
d) Excessively high load SWR.
- a) Q1 or D1 on Bias Switch shorted.  
b) D13 in power supply shorted.
- a) Plate meter shunt resistors R15-R17 damaged.
- a) Rf drive power is present from exciter.  
b) Q2 on Bias switch bd shorted.
- a) Amplifier ALC sensitivity set too high (excessive ALC voltage).
- a) Excessive load SWR - wrong ant.  
b) Defective rf output cables.  
c) Improper tune-up procedure and/or excessive drive from exciter.  
d) Dirt or other foreign matter between capacitor plates.  
e) BAND switch in wrong position.  
f) Defective output T/R relay K4.

15. Distorted ssb output signal, possibly with severe TVI.
- a) Excessive load SWR.
  - b) Defective rf cables, connectors.
  - c) Improper tune-up - especially excessive drive from exciter.
  - d) Antenna trap, balun, or feedline arc-over on voice peaks.
  - e) RF feedback from antenna or feedline into exciter/microphone.
16. No indication on multi-meter.
- a) Meter damaged or open.
17. No indication of FWD or REV power on METER or PEAK meter.
- a) Diodes on SWR bridge open.
  - b) Null capacitor shorted.
18. Wattmeter highly inaccurate.
- a) Very high SWR.
  - b) SWR null capacitor misadjusted.
  - c) Multi-meter damaged.
19. Amplifier will not key to transmit condition using conventional PTT or VOX control hookup for cw or ssb (stays in SBY mode).
- a) RF appears at RF input jack before T/R line closure from exciter. See Section III.
  - b) Defective Q2 on Bias board.
  - c) Defective output T/R relay K4.
20. In QSK, exciter keys immediately when amplifier OPR switch is pressed.
- a) K6 contacts welded due to damage.
  - b) Q3 on RELAY board shorted.
21. With QSK hookup, exciter is not fully keyed, or will not key by the amplifier KEY OUT line.
- a) Resistance of contact protection resistor R1 too large to permit full exciter keying. Use a smaller value.

**SECTION V**

## THEORY OF OPERATION

RF AMPLIFIER SECTION.

TUBES. Ceramic/metal triodes V1 and V2 are parallel-connected in a class AB-2 grounded grid configuration. Cut-off bias of +28 volts is applied to the cathodes through L8 during non-transmit periods. The bias is reduced to about +8 volts whenever the T/R relays are actuated. RF drive is applied to the cathodes through the Input Matching network board 81223. These are switched by the BAND switch to insure the proper load for the exciter, reduce distortion and improve efficiency at lower frequencies.

Pi-L Network. The full pi-L plate output network is switched by three sections (S1A-S1C) of the bandswitch. This connects the TUNE and LOAD capacitors, C14 and C21 respectively, to the appropriate taps on the pi and L inductors. The resulting pi-L network has excellent harmonic rejection, > 50 dB.

Internal RF Wattmeter. An rf directional wattmeter consisting of T1 and associated components on the SWR board 81217, senses forward and reflected power in the rf output line. Trimmer capacitor C27 permits the SWR bridge to be nulled when the output is terminated in a 50 ohm nonreactive load. Trimpot R13 provides calibration of the FWD meter scale, and trimpot R14 provides calibration of the REV meter scale.

**WARNING!** POTENTIALLY LETHAL VOLTAGES, both rf and dc exist very near the SWR pc board. If adjustment of the NULL or calibration trimpots should ever become necessary, it should only be performed by experienced and knowledgeable personnel!

ALC Detector. ALC detector and filter circuit, C1, C2, D11, and associated circuitry on the Bias switch pc board 81219, develops a negative-going ALC voltage whenever the present rf input voltage exceeds the threshold level set by the ALC ADJ control on the rear panel of the amplifier. The threshold is adjusted to suit the exciter in use.

POWER SUPPLY.

Transformer. The TITAN power transformer (T1) is a 1.8 KVA CCS, Hipersil® core unit which supplies all of the required operating voltages in the amplifier. No wiring changes are required for operation from either the U.S. standard 117-N-117 V, or from typical over-seas 234 V (nominal) two-wire systems with or without a "central" neutral wire. In any case, the third power cable wire (green) must always be connected only to ground, for safety purposes.

Supply Voltages. The high voltage supply for the tubes is provided by a full-wave bridge rectifier, D5-D12, and is filtered by a composite 50  $\mu$ F, 3.6KV capacitor bank consisting of 8 computer-grade electrolytic capacitors, C10-C17. Resistors R7-R23 provide both bleeder and voltage equalization for the capacitor bank.

Relay K2 selects high or low voltage taps on the high voltage secondary winding of the power transformer, and is controlled by the VOLTAGE HI/LO switch on the amplifier front panel. Interlock switch S1 prevents activation of the primary power relay K1 unless the power supply cover is in place. Additional operator protection is provided by the safety "crowbar" which shorts out the high voltage supply and discharges the filter capacitors when the cover is opened.

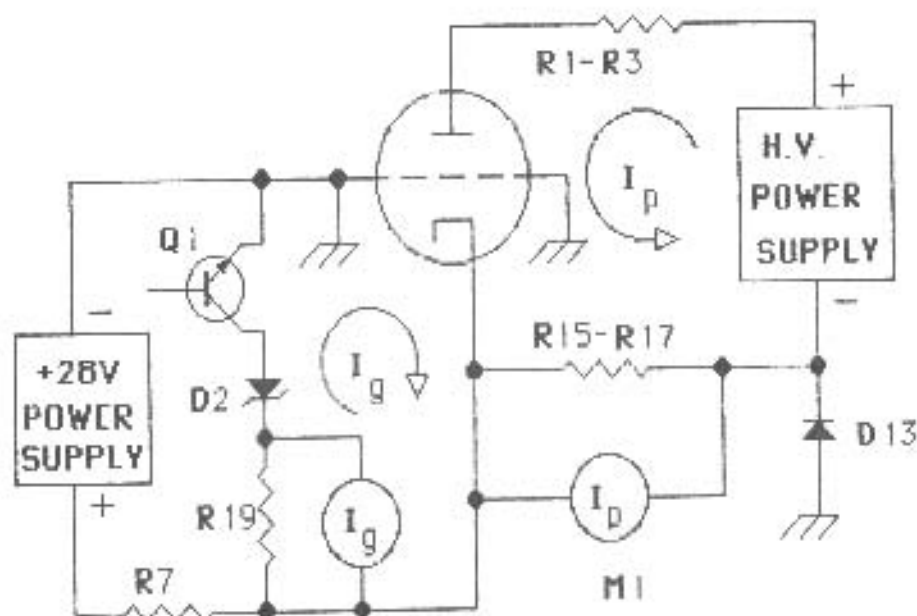
D1-D4 and C4 provide the +28VDC for the various bias and control circuits, including the time delay and T/R functions.

### CONTROL AND METERING

Power ON/OFF. The power switch on the front panel of the amplifier is connected in series with both of the cover interlock switches for operator protection. If all of the covers are on when the ON switch is pressed, line voltage is applied to power control relay K1 in the power supply. Resistors R2 and R3 limit the inrush current surge and also provide a continuing protection from line voltage transients which might otherwise damage the high voltage rectifiers. R1 is a dropping resistor which permits operation of relay K1 from a 240 V line.

Time Delay. The 3CX800A7 tubes are protected from cathode current flow during their MANDATORY heater warmup time (3 minutes nominal) by the time delay circuit located on the Relay pc board 81218. The unijunction transistor Q5 fires SCR Q6 after a gate charging time determined by R10/C8. SCR Q6 activates relay K5 which enables the amplifier T/R circuitry. When K5 closes, the WAIT LED goes out and the OPERATE or STANDBY LED will come on, depending on the position of the SBY/OPR mode switch.

**Metering and Bias.** The circuits used for metering and biasing can be most easily understood by referring to the simplified schematic shown below.



The plate current meter (M1, 0-1.5 ADC) is in series with the negative return of the high voltage power supply, and it indicates plate current only (not cathode current, grid plus plate). Grid current is monitored separately by sensing the voltage drop ( $I_g \times R19$ ) across resistor R19 on the Bias pc board. (This voltage drop is too small by itself to drive the meter directly so it is amplified by op amp U1A on the meter switch pc board.)

When the TITAN is in SBY or receive, the bias switching transistor Q1 is off, resulting in cathode-to-grid voltage of +28 V which biases the tubes past cut-off. When Q1 is turned on by keying the amplifier T/R relay line (KEY IN), bias voltage is switched to the operating level of approximately + 8.5 VDC.

High voltage fault current limiting is provided by R1 in the amplifier chassis, and by R2, R3, and D13 in the power supply. Should the positive high voltage line be accidentally grounded, the resistors limit the fault current to a safe level and D13 provides a return fault current return path to the power supply.



### CW BREAK-IN (QSK) SYSTEM

Simply stated, the QSK system combines a very fast relay T/R switching function with a system which prevents these relays from being switched while rf energy is present, (hot switching). The amplifier will not key on if there is drive present BEFORE key down, and will not unkey if there is drive present AFTER the key is up. In most other respects, it performs much like conventional linear amplifier T/R systems.

The operation of the QSK system is best understood by following through the sequence of events that occur when the KEY IN line is first closed, and then opened. Placing the mode switch in the DPR position closes the T/R enable relay K5, on the Relay pc board, activating the T/R system.

- 1] Immediately upon closure of the KEY IN line, Q4 turns off because its base is pulled to ground through R4. Q3 on the Bias pc board also turns off causing Q1 and Q2 to turn on by the base current provided through R7, R14, and R18.
- 2] Q4 on the Bias pc board is normally turned on by the current through R8, R12, and D3 whenever the KEY IN line is open, provided no rf drive power is present at the amplifier RF INPUT jack. If the "pre-K3 rf detector" does provide a negative voltage as a result of the presence of rf drive, then Q4 will be turned off thus preventing the completion of the sequence in 1] above. NOTE that once Q4 is turned on, Q5 must always be off since Q4 clamps the base of Q5 to ground. Thus Q4/Q5 serves only to prevent the closing of the T/R relay in the event that rf power is present at the amplifier input before the KEY IN line is closed.
- 3] Assume that no rf was present at the input initially, so that Q1 and Q2 on the Bias board are turned on. Then the collector of Q2 will go to near ground, activating both K3 and K4 (via plug #80), and the collector of Q1 will pull the cathode voltage down to the level established by the voltage drops across R15/R17, R19, and zener diode D2. Thus, Q1 and Q2 switch the amplifier into its "transmit" condition.
- 4] Q4 on the Relay pc board can be turned on by two sources - via R4 and D4 as explained above, and via R3 and D2. The first source goes to zero when the amplifier is keyed. The second source goes to zero when the output T/R relay K4's normally open contacts close. This latter path to ground is via plug #91 through L9, L10, the N.O contacts of K4, L11 and L12. NOTE: The forward drop across diodes D1-D3 on the output relay pc board is sufficient to maintain a low impedance dc path to ground as a safety measure - to prevent high voltage dc from appearing on the output coax line in the event of a blocking capacitor failure.

- 5) Once Q4 has turned off after the closure of K4, Q3 immediately turns on and energizes the coil of K6, the KEY OUT exciter keying relay.
- 6) When the KEY IN jack opens, Q4 turns on instantly, which turns off Q3 and opens the KEY OUT contacts of K6. HOWEVER, if the "post K3 rf detector" (R2, D8, D9 and associated components) sense the continuing presence of rf drive after the key opens, the resulting negative voltage at the base of Q3 on the bias pc board prevents Q3 from turning on (and thus prevents Q1 or Q2 from releasing the T/R relays and cutoff bias) until the rf drive from the exciter drops below about 75 mW. Thus, once the rf from the driver nears zero, Q3 turns on, Q1 and Q2 turn off and the amplifier returns to the receive or key-up condition.

No arbitrary or unnecessary time delays are introduced by the QSK system, since "break" or return to "receive" after the key line is opened is also delayed only the minimum time required for the exciter output to drop to zero after the exciter key contacts open. Keying speed is limited only by the closing time of K4 (about 2 mS) and of K6 (about 0.5 mS), and by the "break" shaping of the exciter keying characteristic. Even so, proper sequencing of keying functions is assured and it is virtually impossible to "hot switch" the T/R relays. Full break-in keying is possible to speeds well in excess of 50 WPM -- provided that the exciter has equivalent capability, which all TEN-TEC transceivers do.

**IMPORTANT NOTICE:** The contacts of the exciter keying relay K6 are protected against damage by an R-C network consisting of R1, R2, and C3. On rare occasions an exciter may be encountered which will not key properly (to full output) with 100 ohms in series with the key line. In such a case, the Relay pc board may be removed and R1 changed to a smaller resistance. Use the largest value which permits normal exciter keying, and not less than 47 ohms unless absolutely necessary.

Finally, when the TITAN is OFF or in SBY, the KEY IN jack is connected directly through to the KEY OUT jack (via relay K5). This permits keying the exciter without changing the interconnecting cables when the amplifier is not on.

It is essential that the Titan be keyed on before the exciter and keyed off after the exciter. If this sequence is not assured the vacuum relay in the Titan can be destroyed. It is also possible to drive the Titan without a proper load connected to the output which can cause the band switch to arc over and be destroyed. The series hook-up of the PTT or Control line shown below will assure the proper turn-on sequence. The RF sensing circuit in the Titan will prevent turn-off if RF is present at the input of the Titan.

In most cases, the cw key and PTT line can be connected in parallel to simplify station inter-connections. If your exciter will not operate with these lines in parallel, it will be necessary to install a line select switch or change control cable hook-up when you change modes.

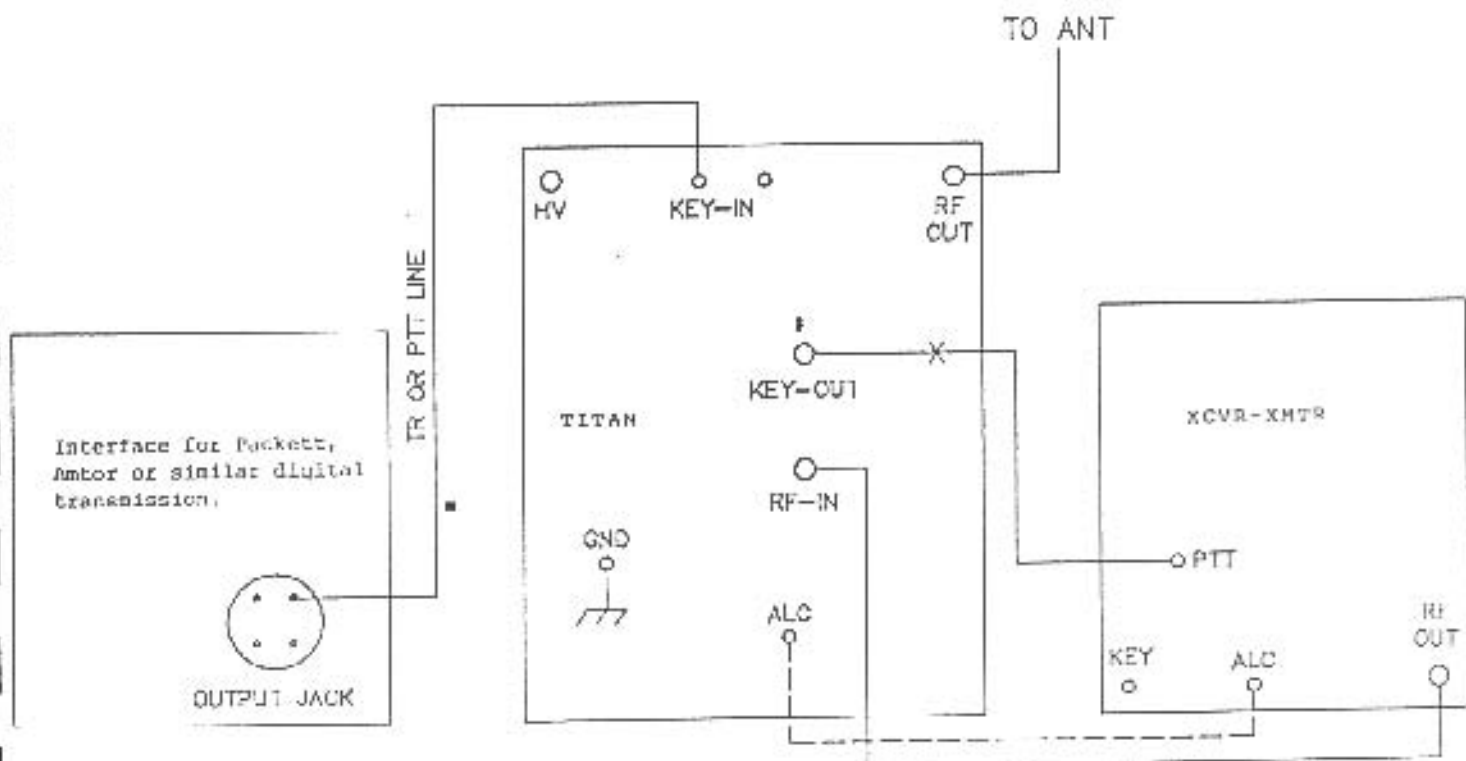
Notes to schematic:

-ALC hook-up is not required with TEN-TEC Transceivers.

\*This control line may be called PTT, T/R control, amplifier control, key-line and other designators. It is the normally open relay contacts that close when the station is switched to the transmit mode.

#If the cw key and the PTT line are connected in parallel, this can be easily done using a RCA phono "Y" adaptor.

XSome transceivers may require a switch to select between cw key and PTT functions.



TITAN, alternate tuning method.

The critical parameter is the grid current of the power amplifier tubes. Excess grid current even for a relatively short period of time can and will destroy the tubes. On the other side of the coin, if grid current limits are not exceeded, the Eimac 3CX800 tubes will deliver many years of trouble free service. We suggest that the following procedures be used.

1. Always monitor "grid current" using the multi-meter. Consider the "overdrive" warning LED on the front panel as a "back-up" system only. Use the peak reading wattmeter LED display to monitor forward power.
2. For tune up, simply monitor power out with the LED bargraph display and grid current with the multi-meter. Drive the amplifier with reduced power and tune for maximum power out and minimum grid current. You will find that these values are not always synchronized. Always chose the lower grid current adjustment even if the power output is slightly less.
3. Many operators prefer to "rag chew" at reduced power levels (500 watts, or so, output) but want the option to abruptly increase power to 1500 watts (new country mode) without re-tuning. To do this you must first tune the Titan for 1500 watts output. You can then reduce power to the desired level by reducing the drive from your exciter. The grid current will go down as you reduce drive and that is OK. The amplifier will not be quite as efficient at reduced power levels using this method but the 3CX800 tubes will not be damaged. The efficiency (drive required for 500 watts output) can of course be restored by re-tuning the amplifier for operation at the 500 watt level but remember, if you then increase the drive you must re-tune the amplifier.

BLOWER HI/LO SPEED. You may always use LO speed when operating SSB. Normal CW duty cycles at 1000 watts or less, output, can also use LO speed. CW at 1500 watts should have the benefit of HI speed blower operation. "Key down" modes, such as RTTY should always use HI speed blower position.

TRANSFORMER RATINGS. The transformer used in the Titan is a tape wound Hypersil that we manufacture in-house. It is rated at 2.5 KVA CCS (continuous commercial service). It weighs 41 lbs. The weight of a transformer is directly proportional to the capacity of that transformer. A 35 pound transformer of the same type may be rated higher by another manufacturer but only if different standards are applied, such as heat rise. Just for comparison, if our transformer were rated for IVS (intermittent voice service) or SSB operation only, it would be 9 KVA. In summary, your power supply is adequate.