

TEN-TEC MODELS 227 & 228 ANTENNA TUNERS

GENERAL

Models 227 and 228 Antenna Tuners are inductive/capacitive networks used for matching unbalanced 50-75 ohm output impedances of transmitters and transceivers to a variety of loads, both balanced and unbalanced. They operate over a frequency range of 1.8 to 30 MHz. Both have a built-in antenna select switch which permits bypassing the tuner or selection of three different antennas. Model 228 has, in addition to the tuner components, a built-in SWR bridge and meter.

SPECIFICATIONS

Circuit: T network.
Rf Power: 200 watts, intermittent; 100 watts, continuous.
Capacitor Voltage Rating: 1 kV.
Inductor: 47 taps; 18 gauge silver-plated wire on 2" diameter core.
Input Impedance: 50-75 ohms, unbalanced.
Output: Matches most loads, balanced and unbalanced. Maximum balanced load 1.8 to 4.0 MHz is 500 ohms.
Frequency Range: 1.8 to 30 MHz.
Finish: Painted front and rear panel; black textured sides and top.

Model 227 Only:

Size: HWD 3-3/8" x 8-1/4" x 7".
Weight: 3-1/2 lbs.

Model 228 Only:

Size: HWD 3-3/8" x 10-1/2" x 7".
Weight: 3-1/2 lbs.

INSTALLATION

1. Connect coaxial output of transmitter to coaxial input of tuner with short length of RG-8 or RG-58 cable. Connectors are PL-259 types.
Notice: To reduce possibility of rf from getting into transmitter, position tuner as far away from transmitter as is practical.
2. Connect station ground buss to terminal on tuner marked GND with heavy metallic braid or wire. This lead should go directly to the earth ground system with as short a lead as possible.
3. Connect antenna transmission line(s) to appropriate terminals on the tuner as follows:
 - A. For coax-fed antennas (unbalanced transmission lines), use either ANT 1, ANT 2, or ANT 3.
 - B. For single wire antenna, connect to SINGLE WIRE terminal.
 - C. For balanced line feed systems, first install a jumper from SINGLE WIRE to one BALANCED LINE terminal with a short wire. Then, connect feed line to the two BALANCED LINE terminals.

In both single wire and balanced line systems, take special care to route transmission line as far away from station equipment as possible. Never drape lines over transmitter. These lines may have a high voltage point inside the shack which presents high rf fields.

4. In the Model 228, the SWR bridge-meter is in the circuit at all times. If you have the Model 227 and no bridge is incorporated in your transmitter, insert an SWR bridge between the transmitter and the tuner input. Do not place the bridge in the antenna line. An SWR bridge is necessary for proper tuner adjustment.

OPERATION

TUNER

1. Always make tuner adjustments with the minimum transmitter power necessary to operate the SWR bridge. To do this, set the SENSITIVITY control of the 228 to full CW, switch to REV.
2. Set TRANSMITTER and LOAD MATCH controls to mid-position (5 position).
3. Apply enough transmitter drive for a half-scale meter reading.
4. Attempt to find a null as the INDUCTANCE control is rotated from the full CW position. The null may not be very deep at this point.
5. With INDUCTANCE set for best null, deepen the null by adjusting both the LOAD and TRANSMITTER MATCH controls.
6. If either MATCH control reaches the end of its travel (0 or 10 position) before a 1 to 1 null is obtained, step the INDUCTANCE control CCW by one position and continue.
7. To determine if the SWR is sufficiently low, set the switch to FWD and adjust the SENSITIVITY to the FWD index at full scale. Switch back to REV. and read SWR on the meter scale. A reading below 2 is usually acceptable.
8. It is good procedure to leave the switch in the REV. position to monitor SWR while operating. If you change frequency too far from resonance, it will show on the meter and you can retune for best match.
9. It is convenient to record the control settings for each band or antenna. Tune-up on a new band will be simplified by having the starting points already established.

ANTENNA SELECT SWITCH

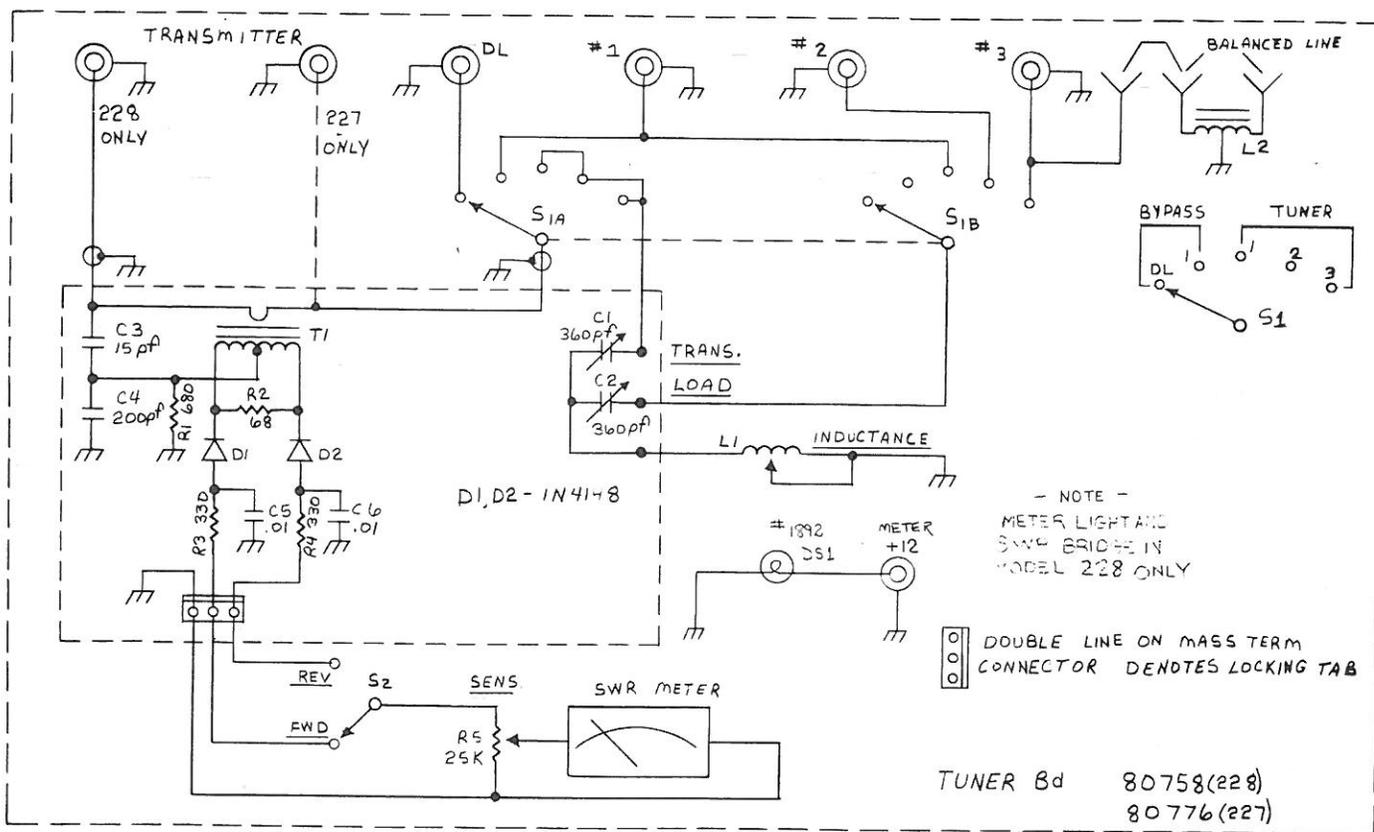
The configuration of this switch is unique to the 227/228 antenna tuners and permits maximum flexibility in your station. The function of each position is as follows:

1. DL BYPASS. A direct connection from the transmitter input to the DL (dummy load) output. Used for tune-up and testing of the transmitter without putting a signal on the air. It is especially suited for use with the Model 209 Dummy Load. Alternatively, it may be used as a bypass to an antenna which requires no matching.
2. 1 BYPASS. Provides a direct connection from the input to the ANT 1 output.
3. 1 TUNER. Feeds ANT 1 through the antenna tuner circuit. Coax antennas only.
4. 2 TUNER. Feeds ANT 2 through the antenna tuner circuit. Coax antennas only.
5. 3 TUNER. Feeds ANT 3, SINGLE WIRE or, with jumper installed, BALANCED LINE through the antenna tuner circuit. Only one antenna, coax, single wire or balanced line feed, may be attached at one time to these outputs; otherwise, the antennas will be fed in parallel and the lowest impedance antenna will receive the most power. When using either ANT 3 (coax) or the SINGLE WIRE terminal, do not connect the jumper between SINGLE WIRE and one BALANCED LINE terminal as damage to the balun may result.

SEVERAL OPERATING HINTS

If it is noticed that placing your hand on the top of the tuner causes a shift in SWR, it is an indication of excessive "rf in the shack." Improve the ground system or change the length of the feedline slightly. This is especially noticeable when using wire-fed antennas.

When using BALANCED LINE, if the SWR rises during a long transmission, it is an indication that a significant portion of the transmitter power is being lost in the balun. This will be the case when the antenna impedance is greater than 500 ohms. Changing the length of the antenna and/or feedline will usually cure this problem.



ANTENNA SYSTEMS MATCHING THEORY

Most transmitters are designed to work into a 50-75 ohm resistive load, and they are not able to effectively supply rf power to loads that depart far from these values. However, many antenna systems, which include the antenna and the transmission line, have complex impedances that make it difficult if not impossible to load the transmitter properly. These impedances are a function of the operating frequency, type of antenna, type and length of transmission line, height of antenna and its proximity to other objects.

Models 227/228 provide a coupling method to convert the resistive/reactive load to a pure resistance of 50 ohms that will accept maximum power from the transmitter. This is not to say that any and all antennas, when converted to a 50 ohm resistive impedance by means of a tuner, will give identical performance. To best understand the tuner adjustments required, it is necessary to have a fundamental knowledge of how antenna systems function. To this end, a short technical discussion follows. It is recommended that additional reading on the subject be done by those interested in obtaining maximum performance from their antenna systems. The ARRL Antenna Handbook, ARRL Amateur's Radio Handbook (antenna and transmission line sections) and other antenna books published by the publishers of Amateur Radio magazines are excellent sources of information.

THE ANTENNA - Any conductor that has rf currents flowing in it can be looked on as an antenna or radiator. The extent to which power leaves the conductor and radiates into the surrounding medium depends on many factors -- length, frequency, amount of current, configuration, etc. Since the antenna absorbs power from the device feeding it, it can be replaced with a resistance whose value is such that the power delivered to this resistance is the same as that delivered to the antenna. The value of this resistance is now a measure of the radiating effectiveness of the antenna and is termed "radiation resistance." For a given value of antenna current, the higher this resistance, the more power that is radiated. ($P=I^2R$)

Due to the facts that an antenna has physical length, that currents travel at a velocity less than instantaneous and that the conductor possesses a certain amount of self-inductance and capacitance, the current at the feed point may not be in phase with the voltage at this point. As a result, the impedance at this point may not look like the pure resistance first suspected, but as an impedance consisting of resistance and either inductive or capacitive reactance. This added reactance will limit the amount of current supplied to the antenna for a given voltage, and therefore reduce the amount of radiated power. The reactance does not absorb power in itself -- only a resistance can do that -- but its presence reduces the overall radiated power and antenna current.

There are two ways to restore the power to its non-reactive value. The first, which is not the preferred way because it does not maximize power transfer, is to raise the feed point voltage enough so that the current returns to its original value. The second, and preferred method, is to add a reactance in series, equal in value but opposite in type (sign) to the reactance value of the antenna. For example, if the antenna at the operating frequency presents an inductive reactance of 100 ohms (+j100) along with a resistance of 50 ohms, inserting a capacitor whose reactance is also 100 ohms (-j100) in series has the effect of cancelling out the reactance of the antenna, leaving only the 50 ohms resistive. This can be looked on as a series R,L,C circuit that is in resonance, whose total impedance is only that of the resistance. Another term for this approach to maximize power transfer is "conjugate impedance matching."

In the above example, we used a value of 50 ohms for the radiation resistance. If this value were not 50 but 150 ohms, the impedance after cancelling the reactance out would be 150 ohms. Connecting this load to the transmitter designed to operate with 50 ohms load would not result in optimum power transfer. It would, however, be better than leaving the inductive reactance in, since the antenna current is maximized for the conditions that do exist. To obtain design performance, it is necessary to transform the 150 ohms to 50. This can be done with a transformer with a turns ratio of 1.73 to 1. (Impedance transformation is equal to the square of the turns ratio.) It is also possible to accomplish this transformation with a parallel tuned circuit with primary and secondary taps properly located on the inductor, or using two or more capacitors in series with taps taken from the series string. Under these conditions, the transceiver will deliver rated power to the antenna.

One last observation before we go on. The antenna impedance in the above example was stated as that at the feed point. If we now feed the antenna at a different location along the conductor, the impedance will be different, both resistive and reactive components. There are an infinite number of impedance choices available, depending on where the tap is made. This factor is helpful in designing and matching antennas. The factors that determine this impedance are the current and voltage values at this point, and the phase between them.

THE TRANSMISSION LINE - In the above example, we assumed that the transmitter output was connected directly to the feed point. This is hardly practical. So that the transmitter can be located at a distance from the antenna, we use a transmission line to deliver the power. Unless we have a perfectly matched system, i.e. antenna, line and transmitter output impedances all the same value without reactive components, the addition of the transmission line completely changes the picture. The transmitter will not see the antenna impedance of 50 ohms resistive and 100 ohms inductive reactance, but some other combination. It will depend on the electrical length of the line, its characteristic impedance and frequency. The impedance at the transmitter end is what we are interested in, and the inductive component may even be changed to capacitance. (Only when the electrical length of the line is an exact multiple of the half wavelength will the impedance at the transmitter be the same as the antenna impedance.)

Briefly, the line characteristic impedance is determined by the physical dimensions of the line -- wire diameter and spacing -- and the dielectric of the material in between. The wire also possesses a resistive component which will dissipate power when current flows through it to the antenna. This shows up as heat loss and dictates use of low loss cable. Formulas for coax and open wire line impedances are given in the handbooks.

Since rf currents flow in the transmission line, one may ask if it then becomes an antenna. In the case of coax type lines, the current should flow on the inside surface of the outer conductor and outer surface of the inner conductor. The electric and magnetic fields caused by the current flow are confined between the two, so none can escape and be radiated. If a system configuration results in some rf current flowing on the outer surface of the outer conductor, such as when a dipole is fed with coax without a balun or other means of changing the feed line from an unbalanced to balanced configuration, it will radiate power. In the case of parallel lines, the current in one conductor at a given location should be flowing in the opposite direction to the current in the adjacent conductor, and if the system is well balanced, the amplitudes of the two will be equal. Under these conditions, the two sets of fields exactly cancel each other and very little radiation will result. If the two currents are not equal or not in exact opposite phase, there will be radiation. Also, if the spacing between lines is a considerable portion of the wavelength, radiation will occur. This is not a factor below VHF.

One final characteristic of transmission lines should be mentioned. The rf current flowing in the line travels at a speed less than that of radiated power in a vacuum, or the speed of light, both 186,000 miles per second. This slowing is caused by the dielectric property of the medium through which the field traverses. In coax cables it is polyethelene between inner and outer conductors, and in parallel lines, it may be the plastic between the conductors in the case of twin-lead type line, or the air and plastic spacers in open wire types. The ratio of the speed in the line to the speed in a vacuum (air is almost the same) is called the velocity factor of the cable. It is always less than unity. Because of this slowing, the physical length of a transmission line is not the same as the electrical length. For example, the wavelength in free space of a 30 MHz signal is exactly 10 meters. A transmission line 10 meters long will be one full wavelength only if the dielectric between the conductors is air. In the case of coax cable with polyethelene dielectric, the velocity factor runs about 0.67. The same 10 meter length of cable will now appear electrically as an open wire or air dielectric cable 15 meters long (10 divided by 0.67). This is equivalent to one and one half wavelengths. A polyethelene type cable would only have to be 6.7 meters long to be one wavelength.

EFFECT OF TRANSMISSION LINE ON ANTENNA IMPEDANCE - As a result of all of the above, in situations where we do not have a matched system throughout, and this is most of the time, the impedance presented to the transmission line by the antenna sets up standing waves on the line. These standing waves will alter the antenna impedance all along the line toward the transmitter. What we really want to accomplish with the antenna tuner is to take whatever impedance that is established at the transmitter end of the line and alter it to a 50 ohm resistance. Then the transmitter will be happy, at least. The tuner will not affect the mismatch of antenna to line -- only constructing the antenna differently will do that -- nor eliminate a standing wave on the transmission line. It will eliminate a standing wave on the line between transmitter and tuner input, but not on the output side of the tuner. A good antenna is still needed to "get out." If the antenna has a low resistance, the tuner will transform it, along with the cable loss resistance, to 50 ohms. The full power will enter the system, but it will be divided between radiation and cable heat loss. It is not uncommon that more than half of the available power is wasted in cable losses, even with low loss cable. It just gets a bit hotter. The split depends entirely on the ratio of radiation resistance to loss resistance.

What is the impedance established at the transmitter end of the line? It depends first on the antenna impedance, which is then transformed by the line. This transformation is dependent on frequency, electrical length of the line and the loss in the line. In an Amateur setup where many different frequencies are used with the same antenna, there will be a multitude of impedances presented to the tuner, so adjustment of the matching network will be required as frequency is changed.

STANDING WAVE RATIO - A measure of how badly a system is mismatched is given by the standing wave ratio (SWR) on the line. SWR is the ratio of the maximum voltage encountered along a transmission line greater than one half wavelength long to the minimum voltage. It is also the ratio of maximum to minimum current. The more nearly uniform the voltage distribution along the line, the closer matched it is, and the ultimate is when the voltage is constant down the length of a lossless line, or drops slowly and uniformly along a line with losses. This is the matched condition, represented by a 1 to 1 SWR. The impedance at the load end of such a line is the same as that at the generator end. When adjusting a matching network properly, the way to do it is to observe the SWR and tune for as low a ratio as possible.

The SWR is also an indication of the value of resistance at the load end. The ratio is the same as the ratio of load resistance to line characteristic impedance. This ratio can mean that the load is either greater than or less than the line's impedance. For example, if the SWR on a length of 50 ohm line is 3 to 1, the load resistance is either 150 ohms or 16.7 ohms (3 times 50 or one-third of 50). This is only accurate with pure resistive loads.

It can be shown mathematically that a 2 to 1 SWR in a system which has the transmitter output impedance equal to the line impedance delivers 89% of the power to the load that it would if perfectly matched. This relates to a power loss of half a decibel -- hardly noticeable in signal strength. At a 3 to 1 ratio, the loss becomes appreciable with 25% of the power lost. So in adjusting antenna tuners, it is a nice feeling if you achieve a 1 to 1 match, but in reality, anything below 2 to 1 is satisfactory. Line losses do increase a bit also with increasing SWR, but it is still a small fraction of a dB at 2:1.

OVERALL SUMMARY

1. Any antenna can be represented as an equivalent resistive/reactive impedance whose resistive component, termed radiation resistance, is a measure of the power radiated. Reactance can be either inductive or capacitive.
2. Antenna impedance is a function of frequency, configuration, selection of feed point location, height above ground and nearness to surrounding objects.

3. The reactive portion of the impedance does not absorb power but limits the amount of power radiated by the resistive component. It is best to eliminate the reactive component, by inserting an equal value reactance in series, but of the opposite type.
4. Best system performance is attained when antenna impedance is purely resistive with value equal to transmission line impedance, which in turn equals transmitter output impedance.
5. Since antennas seldom present matched impedances to line over a band of frequencies and from band to band, a partial solution to using these mismatched systems is to convert the impedances at the transmitter end of the line to what the transmitter is designed for, with an antenna tuner.
6. The transmission line will change the antenna impedance in both resistive and reactive values at the transmitter end, depending on the line's electrical length, frequency and characteristic impedance.
7. Due to slowing down of the current flow in the transmission line from that in free space, the electrical length of a line will be longer than the physical length.
8. One special situation where the line does not alter the impedance is when its length is an exact multiple of the electrical half wavelength.
9. An antenna tuner will not affect the antenna impedance nor the standing wave condition on the transmission line. It will correct the SWR on that portion of the line between transmitter output and tuner input, so that the transmitter will supply rated power to the system.
10. Standing wave ratio, SWR, is a measure of the mis-match of the system and is used as the indicator when making tuner adjustments. SWR is direct ratio of load resistance to line's characteristic impedance.
11. SWR other than 1 to 1 indicates two possible impedances, one greater and one less than characteristic impedance.
12. Any SWR value less than 2 to 1 is considered a good match.
13. Transmatch tuner circuit can provide a number of different control settings, all of which produce a match. Difference is in L to C ratio of the tuned circuit.
14. The lowest L/C ratio will provide greatest bandwidth for a given SWR limit. If adjusted for maximum bandwidth, retuning across the band will only be necessary on 160 and 80 meters, and possibly on extremes of 40 meter band.

ALIGNMENT

In the unlikely event SWR bridge adjustment becomes necessary, proceed as follows:

1. Connect a 50 ohm dummy load to the DL jack.
2. Place the ANTENNA SELECT switch in the DL position.
3. METER switch in REV. and SENSITIVITY at max.
4. Apply power from the transmitter and adjust the trimmer, C3, in the SWR bridge for a null.

TEN-TEC, INC.
Sevierville, TN 37862

REPAIR DEPARTMENT TELEPHONE
615-428-0364

LIMITED WARRANTY AND SERVICE POLICY

GENERAL

TEN-TEC, Inc. warrants all products to be free from defects in material and workmanship for a period of one year after date of purchase, under these conditions:

- 1.) Registration: The warranty card must be returned promptly to establish the warranty period unless otherwise stated on the card. Our card file also serves as a check on stolen equipment which may be sent in for repair. Please notify us immediately if your TEN-TEC equipment is stolen.
- 2.) Original Purchaser: This warranty applies only to the original purchaser. Your warranty card listing from whom purchased establishes you as the original purchaser.
- 3.) Communication with the Factory: If trouble develops, contact the TEN-TEC dealer from whom you purchased the unit. He is obligated to try to correct the malfunction or return the unit to us. If he is unable to correct the fault, you or the dealer should contact the factory by mail or by telephone (615-428-0364), giving serial number if assigned, symptoms of fault and conditions under which they appear. You will be advised whether to return the unit to us or to try a replacement plug-in assembly that will be sent to you. To facilitate service calls, please use our direct Repair Department telephone number, 615-428-0364. (NO COLLECT CALLS, PLEASE.)
- 4.) In-Warranty Field Repairs: To expedite repairs TEN-TEC will send replacement assemblies prior to receiving the suspected defective one from you. The replacement will be billed on a 30 day memo, and credit will be issued when the defective unit is returned to us. No remittance or deposit is required. If the defective assembly is not returned within 30 days, you will be billed. Unit will be shipped to you, transportation paid by TEN-TEC. Shipping charges to the factory are to be borne by you.
- 5.) Return to Non-Selling Dealer: If you return the in-warranty unit to an authorized TEN-TEC dealer who did not sell the unit to you, he may, at his option, repair the unit or handle the return to the factory. Under these conditions TEN-TEC will repair or replace all defective components without charge, but reasonable labor charges may be levied by the servicing dealer. TEN-TEC is not liable for labor charges under these conditions.
- 6.) Proper Delivery: If the unit is returned to the factory, it must be adequately packed. A note should be included outlining the problem, conditions under which it appears, and attempted remedies. The more specific you are, the better the possibility of a complete fix. Shipping charges to the factory are to be borne by you. Unit will be returned transportation paid by TEN-TEC.
- 7.) Exclusions: This warranty does not apply to damage caused by mishandling, lightning, voltages in excess of rating, reverse polarity of DC supply, or changes in circuits. Claims for damage in transit should be filed with the carrier. This warranty, however, is NOT voided for attempted repairs of defective units or for incorporation of additional components such as switches, etc. when there is no change in the basic circuit. Under no circumstances is TEN-TEC liable for consequential damage to person or property by use of this unit.
- 8.) TEN-TEC reserves the right to make any improvements to its products which it may deem desirable without obligating itself to install such improvements in its previously manufactured products.
- 9.) This warranty is given in lieu of any other warranty, expressed or implied.

SERVICE OUTSIDE OF U.S.A.

- 1.) Service Centers: The policies listed in this warranty do not necessarily apply outside the U.S.A. Many overseas TEN-TEC dealers are qualified service centers. Contact the dealer nearest you for warranty service information.
- 2.) Transportation: In the event that you deal directly with TEN-TEC, Inc., all shipping charges to and from the factory are to be borne by you.

TRANSCEIVERS

- 1.) Extended Pro-Rata Warranty on Models 546/560 Output Transistors: The output transistors on these models are unconditionally guaranteed against damage for a period of one year after date of purchase, under any load condition or mode of operation, except for static discharge on the antenna or direct lightning strike. If they fail after the warranty period, the following replacement schedule will apply, provided that our service department makes the repair. (Prices listed are maximum and subject to reduction, depending on current transistor prices at time of repair.)

1 to 2 Years

2 to 3 Years

3 to 5 Years

\$12.00 each

\$15.00 each

\$18.00 each

(Two transistors per transceiver. Labor not included.)

- 2.) Warranty on Models 515/525 Output Transistors: The output transistors on these models are unconditionally guaranteed against damage for a period of one year after date of purchase, under any load condition or mode of operation, except for static discharge on the antenna or direct lightning strike.

LINEAR AMPLIFIERS

- 1.) Model 444 Warranty Exceptions: The Amplifier and Power Supply units are both covered under the GENERAL conditions stated above, with the following exceptions:
- A.) The warranty is void if the amplifier is powered by any source other than an approved TEN-TEC power supply.
 - B.) The warranty is void if any of the factory sealed internal adjustments are altered.
 - C.) The warranty is void if any of the protective circuits are disabled.
 - D.) If used with other than a TEN-TEC transceiver the warranty may not apply. A list of approved transceivers is included with the amplifier. If your transceiver is not listed, contact the factory.
- 2.) Extended Pro-Rata Warranty on Model 444 Output Transistors: The output transistors on this model are unconditionally guaranteed against damage for a period of one year after date of purchase, under any load condition or mode of operation, except for static discharge on the antenna or direct lightning strike. If they fail after the warranty period, the following replacement schedule will apply, provided that our service department makes the repair. (Prices listed are maximum and subject to reduction, depending on current transistor prices at time of repair.)

1 to 2 Years

2 to 3 Years

3 to 5 Years

\$30.00 each

\$35.00 each

\$40.00 each

(Four transistors per amplifier. Labor not included.)

- 3.) Proper Delivery: If the unit is returned to the factory it must be adequately packed. If the power supply section is to be returned, remove the power transformer. The transformer may be retained or returned separately as indicated.

OUT-OF-WARRANTY REPAIRS

- 1.) Field Repairs: New circuit boards or discrete components can often be supplied to eliminate the cost and bother of shipping the complete unit to us. A nominal charge will be made for the material sent. Certain assemblies integral with the main chassis, such as VFO assemblies and rack tuning mechanisms, are not field replaceable.
- 2.) Returned Units: Along with the unit, please submit a complete report on the nature of the malfunction and the conditions under which it occurs. This will enable our service department to pay special attention to your problem area and reduce overall labor costs. No matter what the malfunction is, every unit will be given a complete alignment and operational check before being returned.
- 3.) Quotations: Quotations on repair work will be given on request, after examination of the unit. The amount quoted will be firm for the specific work outlined in the quotation. Should additional material or labor requirements come to light after the repair is initiated, you will be contacted for approval before this phase of the repair is started.
- 4.) Repair Charge Payment: Charges below the \$25.00 level will be billed to you after completion of the work and at the time of re-shipment. A report of all work done and parts used will accompany the bill. For charges greater than \$25.00, prepayment will be required before the unit is returned. One of three methods of payment may be selected. 1.) Upon completion of the work the billing will be made but the unit will be held here. Upon receipt of the payment, the unit will be shipped. 2.) The unit will be returned to you on a COD basis, with COD charges borne by you. 3.) The repair charges may be paid by either MasterCard or VISA. Approval for COD or charge card options can be given either at the time the unit is submitted to us (in the accompanying letter) or when contacted upon completion of the repair. Please submit all raised information on your charge card when paying by this means.
- 5.) Transportation Charges: Units should be returned, transportation and insurance charges prepaid. Return transportation and insurance charges will be billed to you with other costs.