TRANS WORLD COMMUNICATIONS, INC.

TW1000A
LINEAR AMPLIFIER

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TW1000A MANUAL CHANGES

1. Page 21, Table 3. Parts List, Amplifier Module.

   ECN # 008:
   Change the part number of R2 from 160500 to 160250; description is correct.

2. Page 28, Table 4. Parts List, Linear Amplifier.

   ECN # 034:
   Change C113 from 241226 to 241100, a 10 microfarad, tantalum capacitor.

MAY 19, 1988

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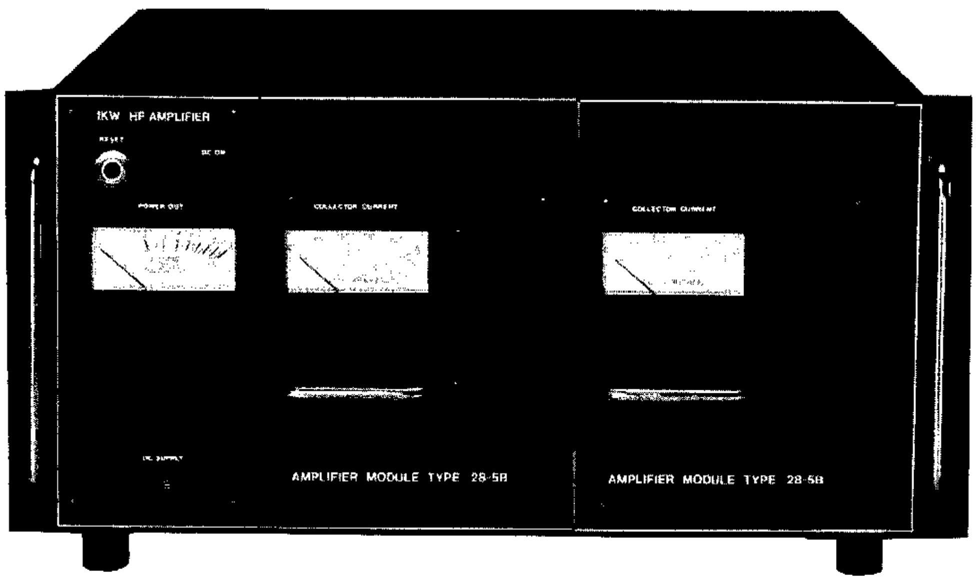


FIGURE 1. Linear Amplifier.

SECTION 1
INTRODUCTION

1.1 GENERAL INFORMATION

The TW1000A Linear Amplifier is designed for use with the TW100 series of synthesized HF transceiver to form a high power 2-30MHz communication system. The power output is 1000W and with the correct choice of power source, the amplifier is rated for continuous service in all operational modes. The amplifier has a power gain of 10-12dB and can be used with any transmitter or transceiver with a power output of 100W. The amplifier is used to increase the signal strength, range and reliability of the HF communication system. With the correct choice of antennas and operating frequencies, the systems will provide worldwide coverage.

1.2 GENERAL DESCRIPTION

The amplifier is entirely solid state and operates from a high current 28Vdc supply source. The amplifier uses two 500W plug-in amplifier modules. Each module uses two push-pull 250W amplifiers combined for an output of 500W. The amplifiers are completely broadband in design and cover the frequency range 2-30MHz without adjustment. The amplifier is constructed in a compact aluminum case designed for mounting in a standard 19-inch rack.

1.3 APPLICATIONS

The amplifier has been designed for continuous duty commercial requirements where high performance and reliability are essential. The amplifier will normally be mounted in a 19-inch rack with the companion exciter and receiver or transceiver together with the FSK modem and any other ancillary equipment. The amplifier will normally be operated with the PS500 or PS1000 power supplies running on the 115 or 230V, 50 or 60Hz AC power mains. The amplifier does operate from a high current 28Vdc supply source for shipboard or emergency applications.

1.4 MODES

The amplifier operates in linear service and is normally operated in single sideband or FSK service. The amplifier is suitable for almost any relatively narrow band mode including CW, AM and NBFM. The peak or average power output should not exceed 1000W.

1.5 DUTY CYCLE

The amplifier is rated for continuous operation at a maximum power output of 1000W (AVG). The power supply must be capable of continuous operation at the rated supply current which will be approximately 70A for FSK service and 30A for SSB service.

1.6 MODULES

The amplifier uses two 500W modules. These modules are provided with individual metering and cooling fans. The modules plug in to the front panel and may be changed by removing four screws and withdrawing the module. If a module should fail, the amplifier will continue working at reduced efficiency. The plug-in modules are a great advantage for simplicity of service and maintenance.

1.7 COOLING SYSTEM

Each module is provided with a 28Vdc (Hall Effect) cooling fan mounted directly on the heatsinks. The fan blows air through the fins in the center of the module and provides efficient cooling. The fans are controlled by 60 degree centigrade thermostats mounted on the heatsinks and will only operate when the heatsink temperature reaches 60 degrees centigrade. In typical SSB service, the fans will seldom operate and will switch off soon after the amplifier FSK transmit cycle is ended. A second thermostat on each module switches the amplifier to the straight through mode, if heatsink temperature exceeds 85 degrees centigrade.

1.8 BYPASS MODE

Switching the DC power off switches the exciter through to the antenna. This feature is useful for providing lower power operation or as a failsafe method of providing communications in the event of an amplifier fault condition.

1.9 HARMONIC FILTERS

The amplifier uses six seven-pole elliptic function filters covering the frequency range in six bands. The filters provide excellent suppression of all harmonics. The filters are normally selected automatically by the exciter or transceiver. An optional manual switch for filter selection is available. When this manual switch is used, a VSWR bridge is used between the amplifier and the filters. This bridge detects selection of the wrong filter and prevents damage to the amplifier by switching it off.

1.10 METERING

The collector current to each amplifier module is measured separately. The collector current in both modules should be approximately equal. Fault

1.10 METERING

The collector current to each amplifier module is measured separately. The collector current in both modules should be approximately equal. Fault conditions are immediately indicated by unbalances in the collector currents between modules. A third meter is used to measure the power output.

1.11 FUSES

Current limiting is provided by a 100A magnetic circuit breaker that is also used as the amplifier ON/OFF switch. The circuit breaker is reset from the front panel.

1.12 ALC ANTENNA MISMATCH PROTECTION

A VSWR bridge is used to provide the ALC control voltage. The reverse arm of the bridge is used to reduce the power output as the VSWR rises and protects the amplifier against all conditions of mismatch.

1.13 INTERFACING WITH EXCITER

The amplifier is designed for simple interfacing with the TW100 series of transmitters and receivers. Plugging in the control cable between the amplifier and the transceiver provides automatic selection of the harmonic filters, control of the drive level, and operation through the microphone PTT switch. The control circuiting is simple and interfacing with other types of equipment is usually not difficult.

1.14 HIGH SPEED SWITCHING

The amplifier uses a high speed switching circuit for applications such as ARQ (SITOR). Provision is made to control an external high speed vacuum relay for antenna switching.

1.15 POWER SUPPLIES

The amplifier may be operated on SSB from a 28V 50A (peak) supply source. This same supply may be used for FSK operation at 500W output. For operation at 1000W (AVG) in FSK service or similar modes, the power supply source should be rated at 28V 70A (min.) continuous.

The PS500 is a heavy duty 40A (50A peak) power supply that will power both the transceiver and the amplifier for continuous SSB operation at 1000W PEP and for FSK operation at 500W (50% transmit/receive duty cycle).

The PS1000 is a heavy duty 80A power supply rated for continuous operation. With this power supply, both the transceiver and amplifier may be operated continuously in any mode at 1000W output.

Both power supplies use CVT's (constant voltage transformers) to provide good regulation without electronic circuitry. The reliability of the CVT is outstanding and they provide almost complete protection against line transients. The supplies are also short circuit proof. Internal connections are provided to operate from 115V/230V 50/60Hz.

SECTION 2
TECHNICAL SPECIFICATIONS

2.1 TECHNICAL SPECIFICATIONS
The technical specifications for the Linear Amplifier are defined in Table 1.

2.2 SEMICONDUCTORS
The semiconductors are defined in Table 2.

TABLE 1. Technical Specifications.

POWER OUTPUT: 1000W PEP or Avg ± 1dB.

FREQUENCY RANGE: 2-30MHz (1.6-2MHz at reduced harmonic specification).

INTERMODULATION DISTORTION*: 2-24MHz 30dB 3rd Order
36dB 5th Order
24-30MHz 26dB 3rd Order
30dB 5th Order

Measured relative to PEP output.

SPURIOUS PRODUCTS: -60dB.

HARMONIC FILTERS: 7-Pole Elliptic Function.
Ranges - 2-3MHz 8-13MHz
3-5MHz 13-20MHz
5-8MHz 20-30MHz

The filters are selected by grounding each filter control line.

DUTY CYCLE: Rated for continuous services all modes.

DRIVE LEVEL: 100W nominal.

INPUT IMPEDANCE: 50 ohm VSWR less than 1.5:1.

OUTPUT IMPEDANCE: 50 ohm.

POWER REQUIREMENTS: 28Vdc negative ground.
SSB 30A avg. voice.
FSK 70A typical.

COOLING: Dual fans controlled by 60°C thermostats.
(Over temperature shutoff at 85°C).

CIRCUIT BREAKER: 100A magnetic.

SIZE: 22.2 X 48.3 X 38.9 cm.

WEIGHT: 23.6 Kg.

CONTROLS: Amplifier ON/OFF.

METERING: Module collector current 50A (2x).
Power output 0 - 1500W.

TABLE 1. Technical Specifications, Continued.

CONNECTORS:	RF input UHF RF output UHF Control 10 pin Aux 28V 2 pin DC Power 4 pin

*The intermodulation distortion and spurious products are also a function of the excitation source. The distortion products and spurious output are measured using two high power RF signal generators as the two-tone test source. The generators are coupled through a combiner adjusted for maximum isolation between input ports. The output is coupled to the amplifier through low pass harmonic filters. To ensure compliance with the published specifications, the excitation sources should have a minimum distortion figure at least 3dB greater than the amplifier at the required drive level, the spurious products should not exceed -60dB and the harmonic level should not exceed -40dB. Spurious products in the exciter, below the cutoff frequency of the TW1000A amplifier low pass filter, will be amplified without attenuation. Spurious products and harmonics above the amplifier filter cutoff frequency will be attenuated by the amplifier, however, excessive harmonic or spurious output from the exciter may increase the distortion products.

TABLE 2. Semiconductors.

Designator	Function	Description
MAINFRAME:		
Q1	ALC Control Amp.	2N5306
Q2	Meter Amp.	2N5306
Q3	PTT Control Amp.	2N5306
Q4	Relay Driver	TIP120
Q5	Relay Driver	TIP120
Q6	Stop Switch	EC103Y
U2	Voltage Regulator	UA7812KC
AMP MODULES:		
Q1A, Q2A, Q1B, Q2B	150W RF Amp	D310050
Q3, Q3B	Bias Driver	TIP33B
Q4, Q4B	Bias Compensation	TIP29A

SECTION 3
INSTALLATION

3.1 UNPACKING
Remove the amplifier from the shipping carton. Inspect carefully for any shipping damage. If the amplifier has been damaged, a claim should immediately be lodged with the shipping company. Retain the shipping carton and the packing material in case the amplifier has to be reshipped.

3.2 MOUNTING
The amplifier should be mounted in the 19-inch rack using the mounting screws on each side of the panel. It is important to ensure the back panel of the amplifier is completely unobstructed to ensure free airflow to the amplifier. We recommend installing the power supply at the bottom of the rack and the amplifier above. If there is spare rack space available, the blank panels may be inserted between the power supply and the amplifier so that the meters and controls are at a convenient height.

CAUTION

The amplifier should never be installed in a closed rack unless forced air circulation is provided through the cabinet.

3.3 GROUND CONNECTIONS
It is important to make a good ground connection to the amplifier. Without a good ground connection, circulating currents may cause feedback in the amplifier and transceiver. The entire equipment may be at a high RF potential causing RF burns when touched. The ground is particularly important when an antenna tuner or unbalanced antenna is used. Use a heavy gauge copper strap for the ground connection and keep the ground strap as short as possible.

3.4 INTERCONNECTIONS
Figure 1 shows the interconnections between the amplifier and the transceiver. If the equipment is ordered as a system, all interconnecting cables will be supplied and assembled and it is simply a matter of connecting the RF control and power cables between the amplifier and the transceiver.

For transceivers other than those manufactured by this company, it will be necessary to arrange that the appropriate filter is enabled by the transceiver itself. To achieve this, the transceiver must ground the control line of the correct filter selection relay pair. As mentioned elsewhere, the filter ranges are as follows: 2-3MHz, 3-5MHz, 5-8MHz, 8-13MHz, 13-20MHz, and 20-30MHz. In some cases it may be necessary to interface with synthesizer arithmetic logic to enable the entire action to take place automatically.

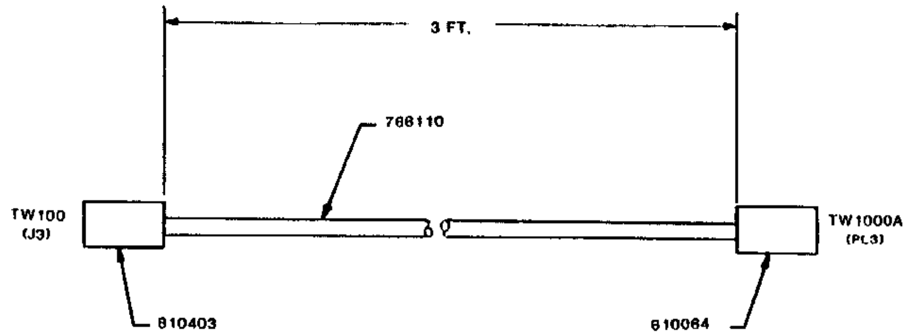
Where absolutely necessary, a version of the amplifier with a manual front panel switch for filter selection can be supplied, but in view of the danger of amplifier damage due to wrong filter selection, this is not a recommended technique.

3.5 POWER CONNECTIONS
The amplifier and transceiver may draw peak currents as high as 100A. This means that low resistance connections are essential. The power supply connection uses two contacts each for the positive and negative leads. A 4-wire 8 AWG cable must be used for the power cable. The maximum length of the power cable must not exceed 1.25 meters (4 feet). If the power source is located some distance from the amplifier, terminate the power cable at a heavy duty junction box as close as possible to the transceiver. The junction box is then connected to the power source using heavy duty cable capable of carrying the heavy duty cable with negligible loss. Heavy duty starter cable is ideal. Remember, a cable resistance of 0.1 ohm would cause a voltage drop of 10V.

3.6 ANTENNA CONNECTION
The output impedance of the amplifier is 50 ohms. Use a heavy duty coaxial cable of the RG8/U type for the connection to the antenna or the antenna tuner. Only use heavy duty coaxial cable and make sure the connections are securely soldered and tightened as the peak RF currents exceed 5A.

3.7 ANTENNA MATCHING
For best efficiency, the amplifier must operate into a correctly matched antenna system. If the VSWR exceeds 1.5:1, the automatic protection circuits will progressively reduce the power output and the performance of the system will be reduced. Use a Bird Model 43 with a 1000H element. The reflected power should not exceed 30% of the forward power.

3.8 ANTENNAS
The antenna system should have a minimum power capability of 1 kilowatt. The antenna will normally be fed with 50 ohm coaxial line, and the antenna matching should be adjusted for the lowest



CONNECTOR WIRING TABLE

TO	PIN	FUNCTIONS	PIN	FROM
TW100 J3	4	2-3 MHZ	A	TW1000A (PL3)
TW100 J3	5	3-5 MHZ	B	TW1000A (PL3)
TW100 J3	6	5-8 MHZ	C	TW1000A (PL3)
TW100 J3	7	8-13 MHZ	D	TW1000A (PL3)
TW100 J3	8	13-20 MHZ	E	TW1000A (PL3)
TW100 J3	9	20-30 MHZ	F	TW1000A (PL3)
TW100 J3	2	AMP ALC	I	TW1000A (PL3)
TW100 J3	1	GROUND	J	TW1000A (PL3)
	3	PTT	H	

FIGURE 2. Interface Cable Diagram.

VSWR (preferably less than 1.5:1). The choice of antenna(s) will depend on the frequencies and the distances to be covered. If the amplifier is to be used on specific bands or channels, resonant dipoles or multiple dipoles are an excellent choice. The amplifier will provide continuous coverage from 2-30MHz and when used with exciters covering this range, it is necessary to use an antenna tuner or a broadband antenna system. Best results will be obtained with the broadband antenna systems such as the discone type of construction of the log periodic beams. Many excellent proprietary brands of broadband antenna covering every frequency range in both omni-directional and directional forms are available. When there is insufficient space for a broadband antenna, an antenna tuner may be used with a tower or long wire antenna. Tuners are available for manual adjustment, or for maximum flexibility, the automatic tuner, with motor driven elements that tune for minimum VSWR is used.

3.9 ADJUSTMENTS

The amplifier is fully broadband and requires no tuning or adjustment for operation at any frequency. If the equipment is ordered as a system, the ALC system will have been set for the correct power output. The following adjustment procedure should be followed if the power output level is not correct.

3.9.1 POWER OUTPUT ADJUSTMENT

Two separate controls provide a control voltage which is proportional to either the peak or average value of the power output.

NOTE

It is necessary to adjust BOTH of these controls only if operation will be in more than one mode, involving a large change in peak to average power ratio, and if either of these conditions will result in amplifier or power supply overload. For example, if the PS1000 power supply is in use, the "PEAK" control would provide the correct power level for all modes, whereas if the smaller PS500 were in use, it would be necessary to restrict the average power level to 600 watts or so.

Initially, the "AVERAGE" control should be advanced to the maximum power setting, (fully clockwise). After the "PEAK" control has been set, the "AVERAGE" control may then be set to restrict power levels if a mode change will result in overload. It should be noted that there may be some small interaction between controls and also that it is not, of course, possible for either control circuit to increase the power level if the other is already the controlling circuit. It will be necessary to provide test signals in both modes to correctly set both controls. If only one control is in use, this OTHER must be advanced to it's fully clockwise (Max Pwr) position.

3.10 POWER SUPPLIES

Refer to the separate instruction manual for the power supply. It is very important to ensure the power supply has been connected for the correct mains supply voltage and frequency.

3.11 OPERATION WITH OTHER EXCITERS

If the amplifier is to be used with other types of exciters or transceivers, refer to Section 3.4 for interfacing information.

SECTION 4
OPERATION

4.1 GENERAL
The amplifier requires no tuning adjustments. If the antenna is correctly matched at the operating frequency, the amplifier will deliver full output power.

4.2 CONTROLS - ON/OFF
When the amplifier is used with exciters providing automatic filter selection, there is only one operating control - the ON/OFF switch. In the OFF position, the amplifier is bypassed and the exciter delivers the normal power output direct to the antenna. Turning the switch on brings the amplifier on line and no further adjustments are required. The ON/OFF switch can also be considered the high-low power switch. The switch is a magnetic circuit breaker and will trip if there is a fault in the amplifier causing excessive current drain.

4.3 OPTIONAL CONTROLS - FILTER SELECTION
These controls are only required when the exciter does not have provision for automatic selection of the output filters. The switch should be turned to the filter range corresponding with the operating frequency.

CAUTION

Do not switch filters when the amplifier is operating.

4.4 METERING

4.4.1 POWER OUTPUT
This meter measures the power output to the antenna. On FSK or CW transmissions, the meter should give a steady reading at approximately 1000W. On SSB voice transmissions, the meter will kick up on voice peaks towards the 1000W mark. If the meter does not indicate normal power output, the antenna is probably not correctly matched. The protective circuitry automatically reduces the output power when the antenna does not provide a correct match.

4.4.2 COLLECTOR CURRENT
Each module is provided with a meter to measure the collector current. Monitoring the collector currents to each module provides a very good indication of correct operation. The collector current to each module should be approximately equal. Any large imbalance in collector current indicates a fault in one of the modules.

4.5 COOLING FANS
The operation of the cooling fans is automatic. They are controlled by individual thermostats on the modules. When the heatsink temperature reaches 60 degrees centigrade, the cooling fan will come on. It is normal for the fans in each module to switch on and off at slightly different times due to small variations in the thermostat operating temperatures. The fans will not switch on for short voice transmissions unless the ambient temperature is very high.

SECTION 5
TECHNICAL DESCRIPTION

5.1 GENERAL

The amplifier consists of two 500W plug-in modules with input and output impedances of 50 ohms. The two modules are combined using 2:1 combining transformers at the input and output. See Figure 3, Plug Module Assembly. The input is fed through a gain leveling network providing a 50 ohm input and substantial level gain throughout the frequency range. The output of the amplifier is coupled to the antenna through a series of six low pass filters. Each amplifier module uses two 250W push-pull amplifiers with 100 ohm inputs and outputs. These amplifiers are combined to give 50 ohm input and output.

5.2 250W AMPLIFIERS

The 250W amplifiers are a push-pull design using modern high power 28V, broadband rated linear RF power transistors. These transistors use emitter ballasted chief design to control impedance and gain over a bandwidth of more than a decade.

The schematic diagram shows the transistors Q1 and Q2 connected in a conventional transformer coupled push-pull circuit. In order to provide uniform performance over nearly four octaves, it is essential to use high performance input and output transformers. The output transformer T2 must not only be capable of providing the correct impedance transformation over the 2-30MHz range, it must also operate at high efficiency at the high current levels and at a power level of 250W. The specially designed transformers use ferrite loaded brass tubes as the base and collector windings with teflon insulated wires wound inside the tubes to form the 100 ohm input and output windings. The center taps of the transformers operate at RF ground potential. Extensive bypassing provides a very low impedance at audio frequencies and up through the RF operating range.

Negative feedback is essential to prevent spurious operations and to reduce the gain variations through the range. Resistive feedback is used directly from the collector to the base. The DC blocking capacitor provides a low impedance down into the audio range. While it is necessary to dissipate substantial power in the feedback resistor, this system ensures feedback independent of the characteristics of the input and output transformers.

For maximum efficiency and good linearity, the amplifiers are operated in class AB. It is essential to provide a stable low impedance bias source for the bases of the transistors. The emitters of the transistors are grounded and the base impedance changes as the transistors heat, leading to a potentially unstable bias condition. This means that apart from providing a low impedance bias source, it is essential to provide thermal compensation with temperature sensing closely coupled to the high power RF transistors.

The bias circuit uses the two transistors Q3 and Q4. The bias voltage at the center tap of the transformer is equal to the sum of the voltage across the adjustable resistor R3, and the emitter base voltage of Q4. This means that the emitter base voltage of Q4 must be lower than the voltage required to produce the forward bias current for Q1 and Q2. R3 may then be adjusted to provide the correct bias current. Q3 is an emitter follower with the base of Q4 connected to the emitter of Q3. The circuit provides the low impedance bias source required by the high power RF transistors. The diode D1 effectively shunts the bases of Q1 and Q2 and provides back up to the primary bias circuit. In the event of any defect in the bias circuit, D1 prevents catastrophic damage to the RF transistor. Q4 is mounted on the copper heatsink immediately adjacent to the RF power transistors. The tight thermal coupling ensures that Q4 will compensate the 2mV/°C emitter base voltage change of the output transistors. The circuit provides excellent thermal tracking with the desirable attribute of a small negative temperature characteristic. This means a small reduction of the amplifier quiescent current at elevated temperatures.

Each of the four amplifiers uses identical circuitry. Individual bias regulator for each amplifier ensure uniform control of the quiescent current even if there are variations between the transistors used in each amplifier.

5.3 500W MODULES

Each 500W module uses two amplifiers mounted on individual heatsinks. The heatsinks are mounted so that the fins face in forming a tunnel with a 28Vdc Hall Effect brushless fan mounted at the end of the heatsinks. This ensures an excellent flow of cooling air through the module while retaining very good accessibility to the amplifiers. A 60 degree centigrade thermostat is mounted on one heatsink. This activates the fan when the heating temperature rises above 60 degrees. A second, 85 degree centigrade thermostat, mounted on the other heatsink, switches the amplifier to the bypass mode if, for any reason the cooling system fails.

The modules contain plugs on the rear frame for the RF input and output connections and the 28Vdc supply. A tapered guide pin ensures correct alignment of the connectors. Each module is provided with a 50A panel meter. The modules are held in the amplifier frame using four retaining screws on the front panel.

The input and output impedance of each amplifier is 100 ohms. The connections to each amplifier are made through 100 ohm coaxial cables cut to exactly the same lengths to maintain phase symmetry. The outputs and inputs are combined to provide the module with 50 ohm inputs and outputs.

The 100 ohm inputs and outputs are each combined in separate hybrids to provide a nominal impedance of 50 ohms in each case. The input impedance of the transistor pairs varies considerably with frequency, as does the gain. Compensation of these effects is provided in the amplifier mainframe.

5.4 INPUT CIRCUIT

The input circuits of the two modules are combined in the input combiner T1. The transformer is a 2:1 "Christmas Tree" design which combines the two 50 ohm inputs to the modules to provide a 50 ohm impedance to the amplifier.

The gain leveling network uses capacitive, resistive and inductive elements to compensate for the lower gain of the amplifiers at the upper end of the frequency range. The network has been designed to maintain a constant input impedance with a VSWR of less than 1.5:1 over the entire frequency range.

5.5 OUTPUT CIRCUIT

The outputs of the two modules are 50 ohms. They are combined in the output combiner T2 which uses a 2:1 "Christmas Tree" design to provide an output impedance of 50 ohms with good port to port isolation. When the two modules are in balance, the voltages are equal at both ends of the primary winding of the combiner and no power is dissipated in the resistors R25 and R26. In the event of unbalance or failure of either module, power is dissipated in R25 and R26. In the case of complete failure of one module, 50% of the remaining power is dissipated in the resistors but the amplifier will continue to operate. R25 and R26 are high wattage non-inductive designs that use the chassis as a heatsink.

5.6 OUTPUT FILTERS

A broadband transistor amplifier has a high level of harmonic output. As the amplifier operates in push pull, the even order harmonics tend to cancel but there is less suppression of odd order harmonics. On the lower channel frequencies the second harmonic level is typically -30dB, while the third harmonic may be as much as -15dB. This means that the filters must have an ultimate attenuation of at least 50dB to meet the amplifier design specification. The filter design selected is a seven-pole elliptic function with reflection co-efficient of 5%. A low reflection co-efficient is essential to prevent excessive VSWR between the amplifier and the filter.

The frequency range has been divided into six bands. The cut-off frequency of each filter is just above the highest frequency in each band. The characteristics of the filter ensure a minimum attenuation of -50dB at the third harmonics of the signal frequency when operating at the lowest frequency in the band. For example, the attenuation of the 2-4MHz filter is a minimum of -50dB at 6MHz. This is the third harmonic of 2MHz. Designing for this "worst case" situation ensures high harmonic attenuation throughout the operational range.

The filters are selected by the relays K3 to K14. Separate relays are used at the input and output of each filter. The unused filters are shorted at the inputs and outputs.

The design of satisfactory filters, capable of operating at continuous power levels of 1000W, does pose a considerable design problem. Transmitting grade mica capacitors are bulky, prohibitively expensive and exhibit excessive inductance for satisfactory operation on the higher frequencies. The final solution was the use of multiple high voltage ceramic disc capacitors. Each capacitor in the filter is made up from two or three disc capacitors selected so that the current is distributed between the individual capacitors.

In order to keep the filters compact, toroidal inductors were selected for the five lower frequency filters. These inductors have the further advantage of a restricted external field and eliminate the

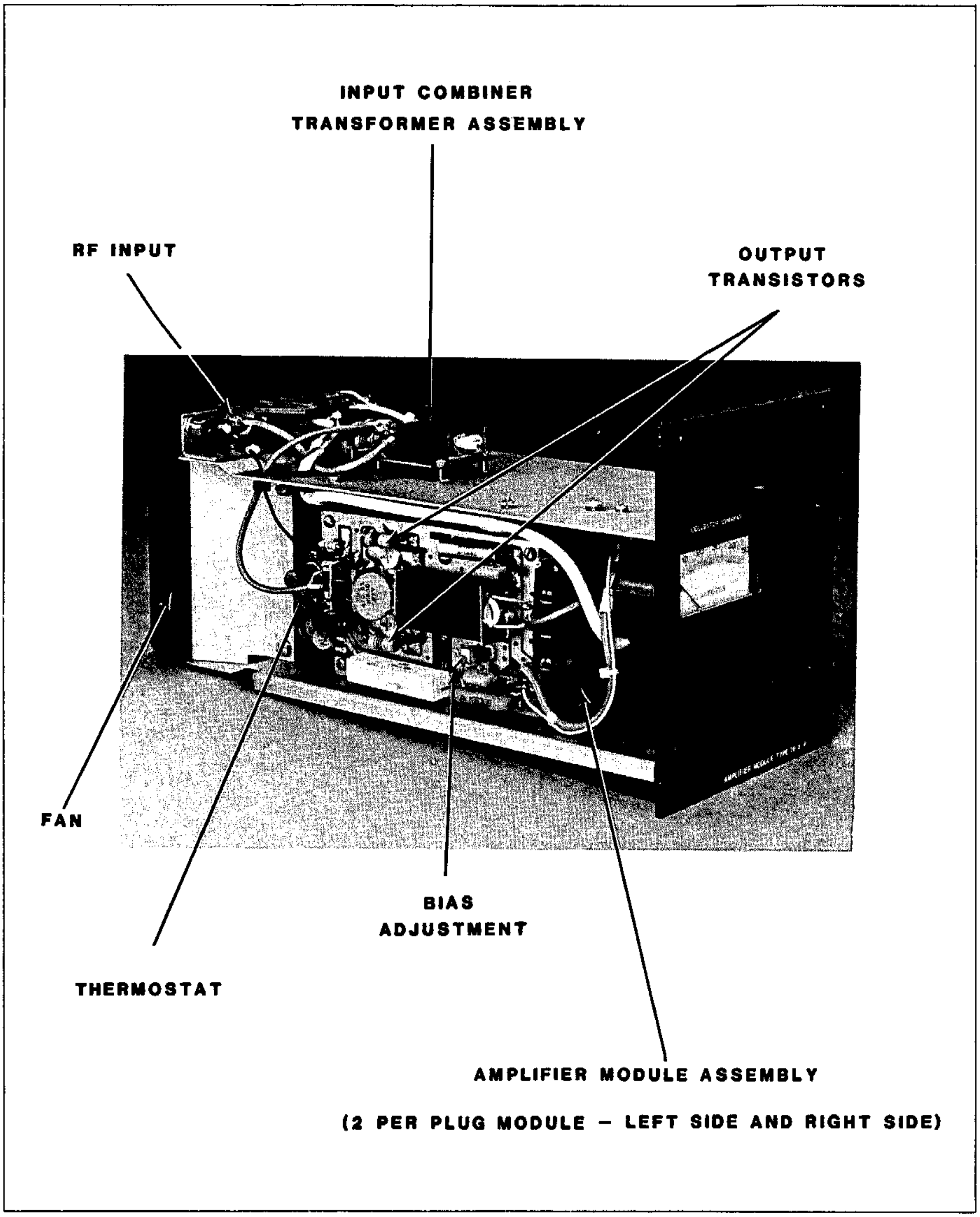


FIGURE 3. Plug Module Assembly.

necessity to assemble the filters in individually shielded compartments. In examining the physical construction of the filter, the liberal use of ferrite sleeves, extensive bypassing of the DC control wiring, and the careful selection of ground points, will be noted. It is important not to change any of the wiring or grounds, as unwanted loops will frequently bypass the filter causing a major reduction in the harmonic attenuation.

The filters are selected by grounding the control wire to each pair of relays. Diode isolation from the control switching in the transceiver is provided by D1-D6. If manual switching is provided, the filter select switch grounds the relays for each filter in turn.

5.7 DIRECTIONAL COUPLER

The directional coupler is used to measure the forward power, to provide the ALC control voltage, and to reduce the amplifier power when the VSWR increases.

T4 is a toroidal pickup transformer which senses the magnitude and phase of the current. The inner conductor of the output coaxial cable passes through the center of the toroid to form a single turn primary winding. L3 provides a DC center tap to the secondary of T4. C90 and C91 form a capacitive divider providing a sample of the voltage on the coaxial line. When the amplifier is terminated in a 50 ohm load the bridge balances and there is no output from the reverse arm of the bridge.

The forward arm of the bridge is rectified by D10 and D12. R30 and C98 provide a filter network giving output corresponding to the average power output from the amplifier. C97 connects directly to D12 and provides a peak reading circuit. The potentiometer R31 sets the peak power output. The average and peak power control voltages are combined with the output from the reverse arm of the bridge. Diodes D11, D13 and D14 provide isolation of the three outputs.

5.8 ALC CONTROL

The three outputs from the directional coupler are applied to the base of the Darlington Transistor Q1. In the TRANSWORLD transceivers, the gain is controlled by reducing the voltage on the high impedance control line. The collector of Q1 is connected to the control line and as the forward bias increases on Q1, the collector voltage is reduced until the system gain reaches the preset level.

The peak and average reading outputs from the bridge are adjusted to give the correct output in the SSB and FSK or CW modes. There is no output from the reverse arm of the bridge when the amplifier is operating into a correctly matched load. This output increases as the VSWR rises and progressively reduces the power output. This protects the RF transistors in the amplifier against mismatches.

As mentioned above, two separate ALC controls are provided. They are labelled "Average" and "Peak". In general it is intended that the Peak control only should be used with full 1KW average systems using the 80A supply and that the Average control should only be used with the smaller system using the 40A supply. In either case the control not in use should be rotated clockwise to its maximum power position.

5.9 POWER OUTPUT METER

The output power is measured at the peak detector D12. The Darlington Transistor Q2 drives the meter. R11 is the calibration control. (See Figure 4.)

5.10 ON/OFF SWITCHING - HIGH SPEED

In line with the requirements of modern ARQ teletype systems, the modular amplifiers have special circuitry enabling them to cycle from receive to transmit and back in much shorter times than was customary in older equipment. Typically switch times are of the order of 10 milliseconds or less.

The PTT line is a low current drain, (typically less than 1mA) circuit, which enables it to be switched by almost any normal transceiver PTT line or any logic system, without interfering with the system operation. It is internally diode isolated so that voltage differences will be ignored. To switch to the transmit condition, pin "H" of the interface socket must be pulled down to around .6V or less, from its normal level of approximately 3.6V.

The circuit action is as follows. Q3, a low power Darlington transistor, is normally held in conduction by the divider chain composed of R9, R13, and R8. The collector of Q3 is directly connected to the base Q4, which in turn drives the output relay, K2. Although the output relay is nominally a 12V device, it is supplied from the 28V supply via R15. R15 limits the current flowing in K2 to its normal value. This has the effect of supplying the relay from a substantially constant current source, and hastens the relay closure. The current flowing in the coil of K2 is sensed by R10, in the emitter of Q4. When

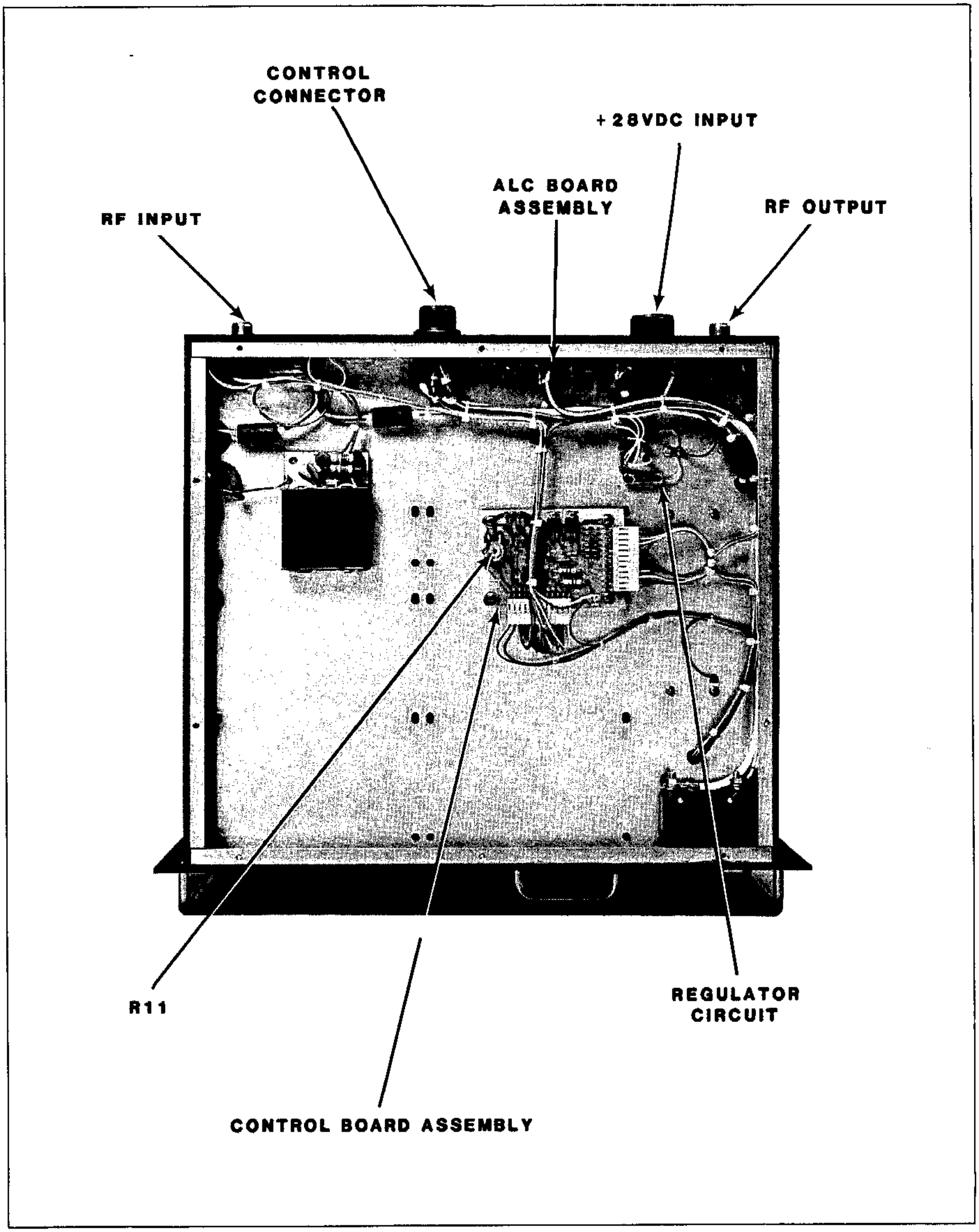


FIGURE 4. Amplifier, Bottom View.

the current has built up to a value sufficient to close K2, Q5 is switched on via R12, which in turn closes K1, the input relay. K1 uses the same supply system as K2, via R16. The overall effect of this circuitry, on PTT closure, is to ensure that the input relay closes AFTER the output relay, so that the amplifier can not be driven until the load is applied. When the PTT line is opened the reverse must take place. The sequence is as follows: When the PTT line is allowed to rise in voltage, Q3 again conducts, switching off Q4. The current in K2 is prevented from collapsing instantly by D7 and R14, and consequently K2 does not open immediately. Q5 however switches off without delay and opens the input relay. Thus the output relay always switches on first when going from receive to transmit, and always switches off last when switching in the opposite direction. The protection circuitry is also incorporated in the PTT circuitry, and is described under that heading.

5.11 PROTECTIVE CIRCUITRY

The protective circuits described below refer only to the HIGH SWR circuitry. The amplifier does have the inherent protection provided by the ferro-resonant power supply discussed under that section.

Although no protective system can provide ABSOLUTE immunity to incorrect operation, particularly the conditions which occur when an amplifier is heavily driven while in a totally unloaded or shorted condition, it is possible to build in a reasonable tolerance to the circumstances likely to be encountered in the field. The approach taken in this case is to provide a dual response system based on the measurement of SWR at the output terminal.

IT MUST BE EMPHASIZED THAT NO PROTECTION AGAINST WRONG FILTER SELECTION IS PROVIDED.

The two control systems activated by excess SWR are:

1. The transceiver ALC system. (High SWR provides an open collector ground, via a 2.2K resistor, R4 at pin I of the control socket). This control will normally keep the transceiver from supplying normal drive to the amplifier, and is not subject to adjustment by either of the amplifier ALC controls.

NOTE

If a transceiver not made by this company is used, it may be necessary to provide a different ALC interface.

2. An internal "Trip" system, which disables the PTT line, causing the Amplifier to switch to the receive or bypass condition. This system automatically resets when the PTT line is returned to the "high" state, by the external control. Some versions of the amplifier will have a "Reset" button on the front panel to reset the system without having to drop the PTT line. In any case, repeated tripping of this protective system should be taken as a signal that a problem may exist.

Also included under the heading of "Protective Circuitry," is an unbalance detector system, which detects the unbalance which occurs when for any reason a module shuts down or fails. A sensor which is located on the rear of the main output combiner detects this condition and trips the amplifier into the "straight through" condition. If this precaution was not taken, the transceiver, when it senses lower output from the amplifier, would attempt to increase it's output to compensate, resulting in heavy peak flattening and distortion.

NOTE

The trip circuitry resets every time the PTT line returns to the receive condition.

SECTION 6
SERVICE AND MAINTENANCE

6.1 INTRODUCTION
The amplifier requires no routine maintenance. The power transistors are rated for an extended service life and need replacement only in the extent of a failure. It is important to ensure that the ALC is adjusted correctly. If the ALC is set for too high a power output, interference will be caused on adjacent channels and there is a possibility of damage to the amplifiers.

6.2 CLEANING
If the amplifier is operated in a dusty atmosphere, it is desirable to clean the interior of the amplifier regularly. Use a soft brush and compressed air to clean the interior. Take particular care to see that all air passages and the cooling fins are clean.

6.3 AMPLIFIER MODULES

6.3.1 CHANGING MODULES
The amplifier uses field replaceable modules. To remove a module, unscrew the four retaining screws on the front panel and withdraw the module from the amplifier. To replace the module, make sure that it is in the plastic guide rails, slide it back until the connectors engage and replace the four retaining screws.

6.3.2 FAULT DETECTION
The collector current in each module is monitored independently by the front panel meters. A fault in a module is nearly always indicated by an imbalance in the collector current between the two modules and a decrease in the power output. It is normal for there to be small differences in the collector currents between the different transistors and variations up to 10% are acceptable.

Check the quiescent current in each module. The bias has been set for a quiescent collector current of 200-300mA for the module. The panel meter reads 50A full scale and it will not be possible to measure the quiescent current accurately. Check that there is a small deflection of the meter when the amplifier is keyed. No meter movement or a substantial meter movement in one module indicates a fault in the bias circuit.

The operation of each module may be checked by removing the suspect module and operating the amplifier with only one module in place. The power output will be approximately 25% of normal as 50% of the power is dissipated in the balance resistors in the combining of both modules deliver equal power when operated alone, the fault is not in the modules.

The best possible check for correct operation is to check the modules by replacement with a known good module.

6.3.3 MODULE REPAIR
The most probable fault in a module is the failure of an RF power transistor. A defective transistor is located by the following procedure.

If it is suspected that a power transistor is at fault, as evidenced by a markedly lower collector current for the module, combined with a substantial drop in maximum output power for the entire amplifier, remove the module and perform the following checks.

Terminate the output connector of the module (R.H. connector viewed from the front of the module), in a 50 ohm 500W dummy load or high power attenuator. Connect a suitable source of 28-30Vdc to the power connector of the module, and jumper this voltage to the bias supply connector which is immediately adjacent to the output coaxial connector. Ensure that the negative lead of the power source is firmly grounded to the DC power source.

Bias Check
Measure the DC voltage between the base of the power transistors and ground on each amplifier block. It should be in the range +0.6V to +0.7V. If it is not, a thorough check of the bias circuitry should be made. (See Section 5.2 for a description of this circuitry.)

Functional Check
Connect a source of two tone RF power at about 15MHz (maximum power 10-15W) to the input coaxial connector. Adjust the power level until a collector current of 3-5A is indicated, and with an oscilloscope observe the amplitude of the RF envelope at the output terminal of each amplifier block. If either block shows a markedly low output, further examine the particular transistor pair as follows:

Remove the RF drive source and disconnect the DC power. Carefully remove the solder from the base and collector leads of each transistor with a "solder sucker" or other solder removing means. With a suitable metal probe or other tool, applying further heat if necessary, GENTLY pry up the base and collector leads of both transistors so as to isolate them from the printed circuitry. With a conventional multimeter set on a low resistance measuring scale (1000 ohms full scale or so), perform the following test: Connect the multimeter positive terminal (check which terminal actually has a positive voltage relative to the other) to the base of the transistor under test and leave it there for the following tests. Connect the other multimeter lead to the PC board ground. The meter should read a typical "diode drop" value (10-20 ohms). A similar reading should be obtained on connecting the test lead to the collector lead. If any doubt exists as to what the ohmmeter should read, a test performed on any general purpose silicon diode will establish a normal reading. If either test results in other than a normal reading, the transistor involved should be replaced. Although this test is a very basic one, the nature of high power transistor failure is such that almost all failed parts will be detected by this procedure.

6.3.4 RF TRANSISTOR REPLACEMENT

Remove the two mounting screws from the transistor mounting flange. Unsolder the four transistor leads. This operation will require some dexterity and an assistant with a second soldering iron may prove very helpful. Remove as much solder as possible with a desoldering tool or one of the proprietary solder removal tapes. It will then be possible to unsolder each lead in turn. Remove the defective transistor. Coat the mounting flange of the replacement transistor with heatsink compound and inspect the mounting area for dirt, etc. Check to ensure that the leads are correctly aligned and mount the transistor on the heatsink. The screws should be tightened securely but not over tightened, as this will distort the mounting flange. Do not solder the leads until the mounting screws are tightened. Use a large capacity soldering iron to solder the leads in place. Complete the joint as quickly as possible so that the leads are soldered in place before the heat has time to be conducted through to the transistor chip.

6.4 POWER SUPPLY

Measure the power source both at no load and full load. The voltage should not exceed 32V without load and should be 28V at full power output. The amplifier will continue to operate at lower supply voltages but will not deliver the rated power output.

6.5 FILTER SERVICE

A filter defect is usually only apparent on one filter range. If the defect is present on more than one range, check the filter wiring and check for contacts sticking in the ON position in one of the relays. If the fault is confined to one filter, check the relays for DC continuity through the filter. If a capacitor in the filter fails, the capacitor will probably have a burned appearance and can be visually identified. The inductors are unlikely to give any problems unless the toroidal cores are broken. A special procedure is used in the factory for filter alignment, and a sweep generator is essential. Fortunately, the replacement of a single capacitor, or even an inductor, will not cause sufficient change to require realignment. If the filters suffer substantial damage (only likely if there is severe physical damage to the amplifier), a replacement filter assembly should be installed, or the original filter should be returned to the factory for service.

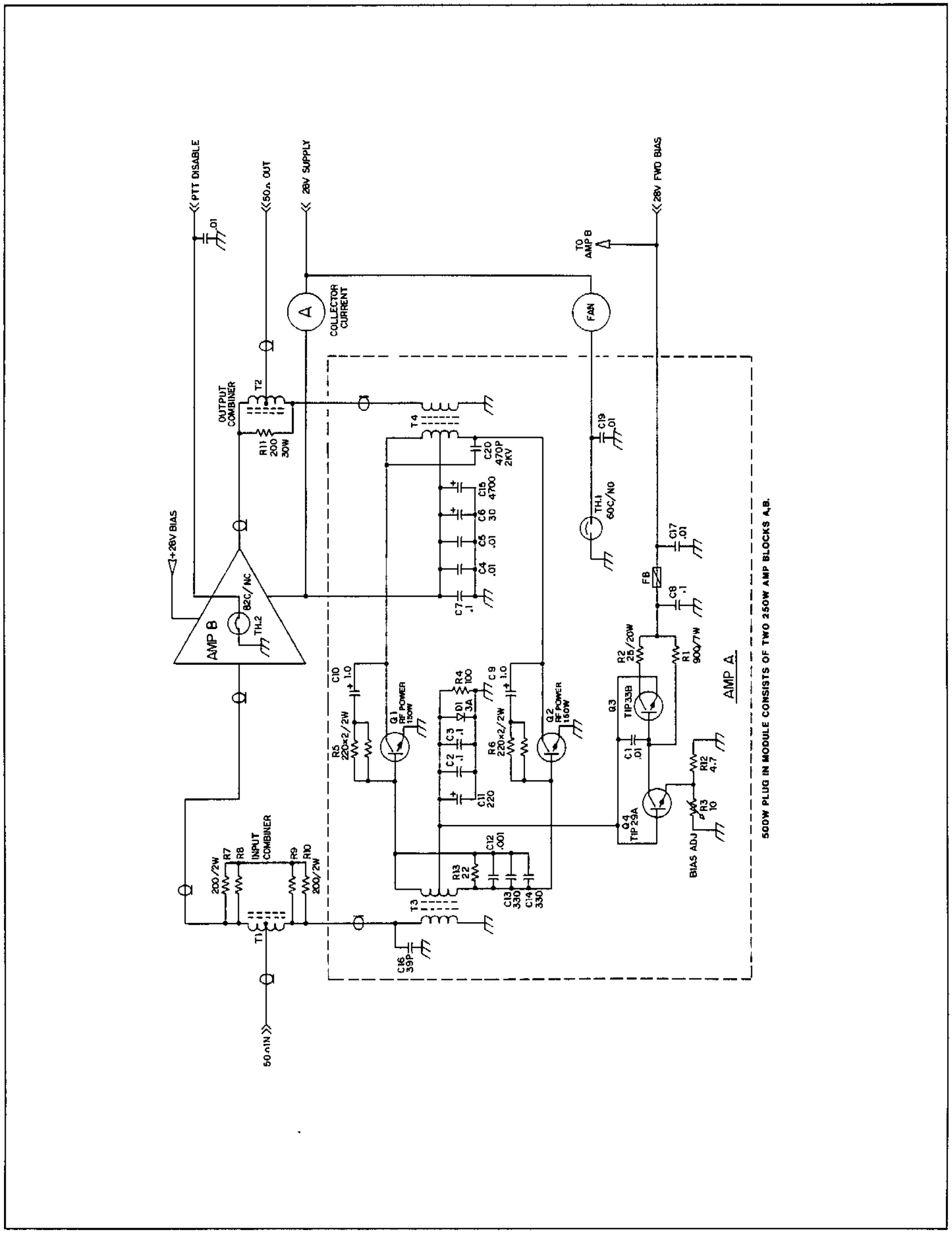


FIGURE 5. Schematic Diagram, Amplifier Module.

TABLE 3. Parts List, Amplifier Module.
(4 PER UNIT)

C1	211103	Capacitor, Disc 500V .01
C2	210104	Capacitor, Disc 25V .1
C3	210104	Capacitor, Disc 25V .1
C4	211103	Capacitor, Disc 500V .01
C5	211103	Capacitor, Disc 500V .01
C6	230300	Capacitor, 100V 30
C7	254104	Capacitor, Mylar 100V .1
C8	254104	Capacitor, Mylar 100V .1
C9	240010	Capacitor, Tantalum 75V 1
C10	240010	Capacitor, Tantalum 75V 1
C11	230201	Capacitor, Electrolytic 16V 200
C12	215102	Capacitor, Chip 100V .001
C13	224331	Capacitor, Mica DM19 330pF
C14	224331	Capacitor, Mica DM19 330pF
C15	230502	Capacitor, Electrolytic 35V 4700
C16	220390	Capacitor, Mica DM15 39pF
C17*	211103	Capacitor, Disc .01
C18*	211103	Capacitor, Disc .01
C19*	211103	Capacitor, Disc .01
C20	212471	Capacitor, Disc 2kV 470pF
D1	320103	Diode, Silicon 3 Amp 50V
FAN*	770003	Fan, 28Vdc
FB	490201	Bead, Ferrite
Q1	310050	Transistor, Power RF 28V
Q2	310050	Transistor, Power RF 28V
Q3	310025	Transistor, MJE3055K
Q4	310024	Transistor, MJE29A
R1	160901	Resistor, WW 7W 900
R2	160250	Resistor, WW 20W 25
R3	170212	Resistor, Trimmer 10
R4	144101	Resistor, Carbon 1W 100
R5	153221, 153221	Resistor, Flameproof 2W 5% 220
R6	153221, 153221	Resistor, Flameproof 2W 5% 220
R7*	153201	Resistor, Flameproof 2W 5% 200
R8*	153201	Resistor, Flameproof 2W 5% 200
R9*	153201	Resistor, Flameproof 2W 5% 200
R10*	153201	Resistor, Flameproof 2W 5% 200
R11*	164201	Resistor, Film 10% 30W 200
R12	124047	Resistor, Film 1/4W 5% 4.7
R13	153220	Resistor, Film 2W 5% 22
TH1*	560002	Thermostat 60^{o}C N.O.
TH2*	560004	Thermostat 82^{o}C N.O.

*Part is located on Plug Module (2 per unit).

NOTE: Unless otherwise specified, capacitance is in microfarads and resistance is in ohms.

TABLE 4. Parts List, Linear Amplifier.

Designator	Part Number	Location	Description
C1	210102	Control Board	Capacitor, Disc .001
C2	210102	Control Board	Capacitor, Disc .001
C3	210102	Control Board	Capacitor, Disc .001
C4	210103	Control Board	Capacitor, Disc .01
C5	210103	Control Board	Capacitor, Disc .01
C6	210103	Control Board	Capacitor, Disc .01
C7	241010	Control Board	Capacitor, Tantalum 1
C8	230201	Chassis	Capacitor, Electrolytic 16V 200
C9	230300	Output Combiner	Capacitor, Disc 5kV 39pF
C10	212560	Output Combiner	Capacitor, Disc 3kV 56pF
C11	212560	Output Combiner	Capacitor, Disc 3kV 56pF
C12	212391	Chassis	Capacitor, Disc 2kV 390pF
C13	212751	Chassis	Capacitor, Disc 2kV 750pF
C14	212751	Chassis	Capacitor, Disc 2kV 750pF
C15	212470	Input Combiner	Capacitor, Disc 5kV 47pF
C16	212470	Input Combiner	Capacitor, Disc 5kV 47pF
C17	212560	Input Combiner	Capacitor, Disc 3kV 56pF
C18	212560	Input Combiner	Capacitor, Disc 3kV 56pF
C19	241010	Control Board	Capacitor, Tantalum 1
C20	211103	Input Relay	Capacitor, Disc 500V .01
C21	211103	Input Relay	Capacitor, Disc 500V .01
C22	211103	Filter Block	Capacitor, Disc 500V .01
C23	211103	Filter Block	Capacitor, Disc 500V .01
C24	211103	Filter Block	Capacitor, Disc 500V .01
C25	211103	Filter Block	Capacitor, Disc 500V .01
C26	211103	Filter Block	Capacitor, Disc 500V .01
C27	211103	Filter Block	Capacitor, Disc 500V .01
C28	211103	Filter Block	Capacitor, Disc 500V .01
C29	211103	Filter Block	Capacitor, Disc 500V .01
C30	211103	Filter Block	Capacitor, Disc 500V .01
C31	211103	Filter Block	Capacitor, Disc 500V .01
C32	211103	Filter Block	Capacitor, Disc 500V .01
C33	211103	Filter Block	Capacitor, Disc 500V .01
C34	211103	Filter Block	Capacitor, Disc 500V .01
C35	211103	Filter Block	Capacitor, Disc 500V .01
C36	211103	Filter Block	Capacitor, Disc 500V .01
C37	211103	Filter Block	Capacitor, Disc 500V .01
C38	211103	Filter Block	Capacitor, Disc 500V .01
C39	211103	Filter Block	Capacitor, Disc 500V .01
C40	211103	Filter Block	Capacitor, Disc 500V .01
C41	211103	Filter Block	Capacitor, Disc 500V .01
C42	211103	Filter Block	Capacitor, Disc 500V .01
C43	211103	Filter Block	Capacitor, Disc 500V .01
C44	211103	Filter Block	Capacitor, Disc 500V .01
C45	211103	Filter Block	Capacitor, Disc 500V .01
C46	211103	Output Relay	Capacitor, Disc 500V .01
C47	211103	Output Relay	Capacitor, Disc 500V .01
C48	212560	Filter Block	Capacitor, Disc 3kV 56pF
C49	212470	Filter Block	Capacitor, Disc 5kV 47pF
C50A	212560	Filter Block	Capacitor, Disc 3kV 56pF
C50B	212680	Filter Block	Capacitor, Disc 5kV 68pF

TABLE 4. Parts List, Linear Amplifier, Continued.

C51	212680	Filter Block	Capacitor, Disc 5kV 68pF
C52A	212560	Filter Block	Capacitor, Disc 3kV 56pF
C52B	212820	Filter Block	Capacitor, Disc 5kV 82pF
C53	212120	Filter Block	Capacitor, Disc 3kV 12pF
C54A	212390	Filter Block	Capacitor, Disc 5kV 39pF
C54B	212390	Filter Block	Capacitor, Disc 5kV 39pF
C55A	212101	Filter Block	Capacitor, Disc 3kV 100pF
C55B	212271	Filter Block	Capacitor, Disc 2kV 270pF
C55C	212391	Filter Block	Capacitor, Disc 2kV 390pF
C56A	212470	Filter Block	Capacitor, Disc 5kV 47pF
C56B	212470	Filter Block	Capacitor, Disc 5kV 47pF
C56C	212390	Filter Block	Capacitor, Disc 5kV 39pF
C57A	212471	Filter Block	Capacitor, Disc 2kV 470pF
C57B	212471	Filter Block	Capacitor, Disc 2kV 470pF
C57C	212471	Filter Block	Capacitor, Disc 2kV 470pF
C58A	212271	Filter Block	Capacitor, Disc 2kV 270pF
C58B	212271	Filter Block	Capacitor, Disc 2kV 270pF
C59A	212121	Filter Block	Capacitor, Disc 3kV 12pF
C59B	212471	Filter Block	Capacitor, Disc 2kV 470pF
C60A	212391	Filter Block	Capacitor, Disc 2kV 390pF
C60B	212101	Filter Block	Capacitor, Disc 3kV 100pF
C61A	212391	Filter Block	Capacitor, Disc 2kV 390pF
C61B	212101	Filter Block	Capacitor, Disc 3kV 100pF
C62A	212151	Filter Block	Capacitor, Disc 4kV 150pF
C62B	212151	Filter Block	Capacitor, Disc 4kV 150pF
C62C	212151	Filter Block	Capacitor, Disc 4kV 150pF
C63A	212390	Filter Block	Capacitor, Disc 5kV 39pF
C63B	212390	Filter Block	Capacitor, Disc 5kV 39pF
C64A	212391	Filter Block	Capacitor, Disc 2kV 390pF
C64B	212391	Filter Block	Capacitor, Disc 2kV 390pF
C64C	212680	Filter Block	Capacitor, Disc 5kV 68pF
C65A	212271	Filter Block	Capacitor, Disc 2kV 270pF
C65B	212101	Filter Block	Capacitor, Disc 3kV 100pF
C66A	212391	Filter Block	Capacitor, Disc 2kV 390pF
C66B	212271	Filter Block	Capacitor, Disc 2kV 270pF
C66C	212101	Filter Block	Capacitor, Disc 3kV 100pF
C67A	212560	Filter Block	Capacitor, Disc 3kV 56pF
C67B	212121	Filter Block	Capacitor, Disc 3kV 120pF
C67C	212121	Filter Block	Capacitor, Disc 3kV 120pF
C68A	212560	Filter Block	Capacitor, Disc 3kV 56pF
C68B	212121	Filter Block	Capacitor, Disc 3kV 120pF
C68C	212121	Filter Block	Capacitor, Disc 3kV 120pF
C69A	212101	Filter Block	Capacitor, Disc 3kV 100pF
C69B	212101	Filter Block	Capacitor, Disc 3kV 100pF
C69C	212820	Filter Block	Capacitor, Disc 5kV 82pF
70	212470	Filter Block	Capacitor, Disc 5kV 47pF
1A	212271	Filter Block	Capacitor, Disc 2kV 270pF
B	212201	Filter Block	Capacitor, Disc 3kV 200pF
	212560	Filter Block	Capacitor, Disc 3kV 56pF
	212121	Filter Block	Capacitor, Disc 4kV 120pF
	212121	Filter Block	Capacitor, Disc 5kV 120pF
	212271	Filter Block	Capacitor, Disc 2kV 270pF
	212201	Filter Block	Capacitor, Disc 3kV 200pF

TABLE 4. Parts List, Linear Amplifier, Continued.

C74A	212560	Filter Block	Capacitor, Disc 3kV
C74B	212560	Filter Block	Capacitor, Disc 3kV 56pF
C74C	212680	Filter Block	Capacitor, Disc 5kV
C75A	212560	Filter Block	Capacitor, Disc 3kV 56pF
C75B	212560	Filter Block	Capacitor, Disc 3kV 56pF
C75C	212580	Filter Block	Capacitor, Disc 5kV 68pf
C76			Not Used.
C77	210102	ALC Board	Capacitor, Disc .001
C78A	212101	Filter Block	Capacitor, Disc 3kV 100pF
C78B	212820	Filter Block	Capacitor, Disc 5kV 82pF
C78C	212820	Filter Block	Capacitor, Disc 5kV 82pF
C79A	212390	Filter Block	Capacitor, Disc 5kV 39pF
C79B	212470	Filter Block	Capacitor, Disc 5kV 47pF
C80A	212121	Filter Block	Capacitor, Disc 3kV 120pF
C80B	212121	Filter Block	Capacitor, Disc 3kV 120pF
C80C	212560	Filter Block	Capacitor, Disc 3kV 56pF
C81	212470	Filter Block	Capacitor, Disc 5kV 47pF
C82A	212470	Filter Block	Capacitor, Disc 5kV 47pF
C82B	212470	Filter Block	Capacitor, Disc 5kV 47pF
C82C	212390	Filter Block	Capacitor, Disc 5kV 39pF
C83A	212390	Filter Block	Capacitor, Disc 5kV 39pF
C83B	212390	Filter Block	Capacitor, Disc 5kV 39pF
C83C	212390	Filter Block	Capacitor, Disc 5kV 39pF
C84A	212100	Filter Block	Capacitor, Disc 3kV 10pF
C84B	212100	Filter Block	Capacitor, Disc 3kV 10pF
C85A	212820	Filter Block	Capacitor, Disc 5kV 82pF
C85B	212820	Filter Block	Capacitor, Disc 5kV 82pF
C85C	212470	Filter Block	Capacitor, Disc 5kV 47pF
C86A	212470	Filter Block	Capacitor, Disc 5kV 47pF
C86B	212470	Filter Block	Capacitor, Disc 5kV 47pF
C87A	212680	Filter Block	Capacitor, Disc 5kV 68pF
C87B	212680	Filter Block	Capacitor, Disc 5kV 68pF
C87C	212560	Filter Block	Capacitor, Disc 3kV 56pF
C88A	212390	Filter Block	Capacitor, Disc 5kV 39pF
C88B	212390	Filter Block	Capacitor, Disc 5kV 39pF
C89A	220150	ALC Board	Capacitor, Mica DM15 15pF
C89B	220150	ALC Board	Capacitor, Mica DM15 15pF
C90A	212390	Filter Block	Capacitor, Disc 5kV 39pF
C90B	212390	Filter Block	Capacitor, Disc 5kV 39pF
C91	220431	ALC Board	Capacitor, Mica DM15 430pF
C92	210103	ALC Board	Capacitor, Disc .01
C93	210103	ALC Board	Capacitor, Disc .01
C94	210103	ALC Board	Capacitor, Disc .01
C95	210103	ALC Board	Capacitor, Disc .01
C96	210103	ALC Board	Capacitor, Disc .01
C97	241001	ALC Board	Capacitor, Tantalum .1
C98	241020	ALC Board	Capacitor, Tantalum 2.2
C99	211103	Rear Panel	Capacitor, Disc 500V .01
C100	211103	Rear Panel	Capacitor, Disc 500V .01
C101	211103	Rear Panel	Capacitor, Disc 500V .01
C102	211103	Rear Panel	Capacitor, Disc 500V .01
C103	211103	Rear Panel	Capacitor, Disc 500V .01
C104	211103	Rear Panel	Capacitor, Disc 500V .01

TABLE 4. Parts List, Linear Amplifier, Continued.

C105	211103	Rear Panel	Capacitor, Disc 500V .01
C106	211103	Rear Panel	Capacitor, Disc 500V .01
C107	210103	ALC Board	Capacitor, Disc .01
C108	210103	Output Combiner	Capacitor, Disc .01
C109	211103	Chassis	Capacitor, Disc 500V .01
C110	211103	Chassis	Capacitor, Disc 500V .01
C111	220270	ALC Board	Capacitor, Mica DM15 27pF
C112	210102	Control Board	Capacitor, Disc .001
C113	241226	Control Board	Capacitor, Tantalum 22
D1	320101	Control Board	Diode, 1N4005
D2	320101	Control Board	Diode, 1N4005
D3	320101	Control Board	Diode, 1N4005
D4	320101	Control Board	Diode, 1N4005
D5	320101	Control Board	Diode, 1N4005
D6	320101	Control Board	Diode, 1N4005
D7	320101	Control Board	Diode, 1N4005
D8	320101	Control Board	Diode, 1N4005
D9	320002	Control Board	Diode, 1N4148
D10	320002	ALC Board	Diode, 1N4148
D11	320002	ALC Board	Diode, 1N4148
D12	320002	ALC Board	Diode, 1N4148
D13	320002	ALC Board	Diode, 1N4148
D14	320002	ALC Board	Diode, 1N4148
D15	320002	ALC Board	Diode, 1N4148
D16	320002	Output Combiner	Diode, 1N4148
FB	490502	Various	Bead, Ferrite
FB	490302	Rear Panel	Bead, Ferrite Balun
K1	540008	Input Relay	Relay DPDT 12V
K2	540013	Output Relay	Relay SPDT 12Vdc 10A
K3	540013	Filter Block	Relay SPDT 12Vdc 10A
K4	540013	Filter Block	Relay SPDT 12Vdc 10A
K5	540013	Filter Block	Relay SPDT 12Vdc 10A
K6	540013	Filter Block	Relay SPDT 12Vdc 10A
K7	540013	Filter Block	Relay SPDT 12Vdc 10A
K8	540013	Filter Block	Relay SPDT 12Vdc 10A
K9	540013	Filter Block	Relay SPDT 12Vdc 10A
K10	540013	Filter Block	Relay SPDT 12Vdc 10A
K11	540013	Filter Block	Relay SPDT 12Vdc 10A
K12	540013	Filter Block	Relay SPDT 12Vdc 10A
K13	540013	Filter Block	Relay SPDT 12Vdc 10A
K14	540013	Filter Block	Relay SPDT 12Vdc 10A
L1	490008	Chassis	Inductor, Toroidal
L2			Not Used.
L3	490202	ALC Board	Inductor, Bead
L4			Not Used.
L5	450411	Filter Block	Inductor, Air 20-30MHz
L6	450411	Filter Block	Inductor, Air 20-30MHz
L7	450412	Filter Block	Inductor, Air 20-30MHz
L8	450501	Filter Block	Inductor, Toroidal 2-5MHz
L9	450502	Filter Block	Inductor, Toroidal 2-5MHz

TABLE 4. Parts List, Linear Amplifier, Continued.

L10	450502	Filter Block	Inductor, Toroidal 2-3MHz
L11	450503	Filter Block	Inductor, Toroidal 3-5MHz
L12	450504	Filter Block	Inductor, Toroidal 3-5MHz
L13	450504	Filter Block	Inductor, Toroidal 3-5MHz
L14	450505	Filter Block	Inductor, Toroidal 5-8MHz
L15	450506	Filter Block	Inductor, Toroidal 5-8MHz
L16	450506	Filter Block	Inductor, Toroidal 5-8MHz
L17	450508	Filter Block	Inductor, Toroidal 8-13MHz
L18	450507	Filter Block	Inductor, Toroidal 8-13MHz
L19	450509	Filter Block	Inductor, Toroidal 13-20MHz
L20	450412	Filter Block	Inductor, Toroidal 13-20MHz
L21	450510	Filter Block	Inductor, Toroidal 13-20MHz
L22	450507	Filter Block	Inductor, Toroidal 8-13MHz
M1	740010	Front Panel	Meter, RF Power
PL1	610060	Rear Panel	Plug, Chassis
PL2	613014	Rear Panel	Plug, Chassis Socket
PL3	610063	Rear Panel	Plug, Chassis
PL4	610147	Control Board	Plug, PC Mount 12 Pin Polar
PL5	610147	Control Board	Plug, PC Mount 12 Pin Polar
Q1	310027	Control Board	Transistor, 2N5306
Q2	310027	Control Board	Transistor, 2N5306
Q3	310027	Control Board	Transistor, 2N5306
Q4	310053	Control Board	Transistor, NPN Darlington Tip 120
Q5	310053	Control Board	Transistor, NPN Darlington Tip 120
Q6	320602	Control Board	Transistor, SCR EC103Y
R1			Not Used.
R2	124272	Control Board	Resistor, Film 1/4W 5% 2.7K
R3	124102	Control Board	Resistor, Film 1/4W 5% 1K
R4	124222	Control Board	Resistor, Film 1/4W 5% 2.2K
R5	124104	Control Board	Resistor, Film 1/4W 5% 100K
R6	124223	Control Board	Resistor, Film 1/4W 5% 22K
R7	124221	Control Board	Resistor, Film 1/4W 5% 220
R8	124103	Control Board	Resistor, Film 1/4W 5% 10K
R9	124473	Control Board	Resistor, Film 1/4W 5% 47K
R10	124470	Control Board	Resistor, Film 1/4W 5% 47
R11	170103	Control Board	Resistor, Trimmer 5K
R12	124101	Control Board	Resistor, Film 1/4W 5% 100
R13	124153	Control Board	Resistor, Film 1/4W 5% 15K
R14	124222	Control Board	Resistor, Film 1/4W 5% 2.2K
R15			Not Used.
R16	144471	Control Board	Resistor, Film 1W 5% 470
R17	124472	Control Board	Resistor, Film 1/4W 5% 4.7K
R18	124104	Control Board	Resistor, Film 1/4W 5% 100K
R19	124472	Control Board	Resistor, Film 1/4W 5% 4.7K
R20	164500	Chassis	Resistor, Film 30W 50
R21	164500	Chassis	Resistor, Film 30W 50
R22	164500	Chassis	Resistor, Film 30W 50
R23	153201	Input Combiner	Resistor, 2W 5% 200
R24	153201	Input Combiner	Resistor, 2W 5% 200
R25	164201	Side Panel	Resistor, Film 30W 10% 200

TABLE 4. Parts List, Linear Amplifier, Continued.

R26	164201	Side Panel	Resistor, Film 30W 50
R27	124681	Control Board	Resistor, Film 1/4W 5% 680
R28			Not Used.
R29	134470	ALC Board	Resistor, Film 1/2W 5% 47
R30	124222	ALC Board	Resistor, Film 1/4W 5% 2.2K
R31	170106	ALC Board	Resistor, Trimmer 500K
R32	124102	ALC Board	Resistor, Film 1/4W 5% 1K
R33	124103	ALC Board	Resistor, Film 1/4W 5% 10K
R34	170101	ALC Board	Resistor, Variable 10K
R35	124221	Output Combiner	Resistor, Film 1/4W 5% 220
R36	124472	Output Combiner	Resistor, Film 1/4W 5% 4.7K
R37	124222	Output Combiner	Resistor, Film 1/4W 5% 2.2K
R38	124102	Output Combiner	Resistor, Film 1/4W 5% 1K
SW1	570005	Front Panel	Circuit Breaker, 100A
SW2			Not Used.
SW3	530001	Front Panel	Switch, Push Button
T4	490401	ALC Board	Transformer, Toroidal
U1			Not Used.
U2	330132	Chassis	IC, UA7812KC

NOTE: Unless otherwise specified, capacitance is in microfarads and resistance is in ohms.