TRANS WORLD COMMUNICATIONS, INC.

TW1000
LINEAR AMPLIFIER

Publication #D991007

JANUARY 1987

TABLE OF CONTENTS

SECTION 4 - TECHNICAL DESCRIPTION

SECTION 5 - SERVICE AND MAINTENANCE

TABLES

FIGURES

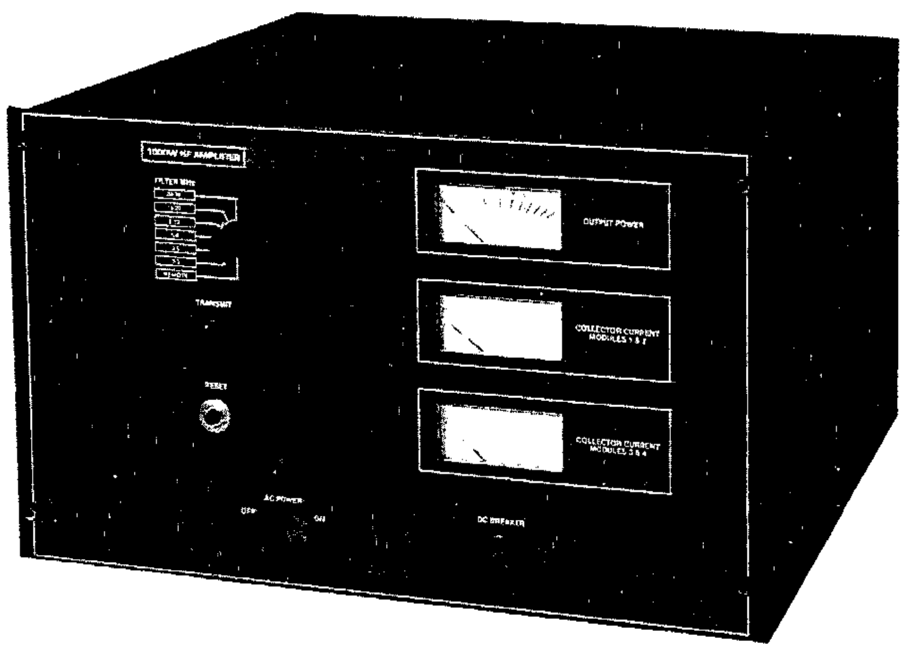


FIGURE 1. Linear Amplifier.

INTRODUCTION

Please note carefully the following important information about the Linear Amplifier.

1. The amplifier is broadband and has no tuning adjustments. This means that the amplifier will not operate correctly unless the antenna presents a 50 ohm non-inductive load to the amplifier. Do not expect the amplifier to operate correctly unless the VSWR is lower than 1.5:1. If it is not possible to obtain a good match, it is essential to use a simple antenna tuner.

Some users of the amplifier have expected results similar to those obtained with a tuned vacuum tube amplifier. This type of amplifier has an adjustable output network that enables the amplifier to be matched to incorrectly terminated lines.

The protective circuitry in the amplifier is set to operate if the VSWR exceeds 3:1, and on some frequencies the protect circuit may operate at even lower VSWR's. This limit has been set, as the amplifier will simply not provide satisfactory output unless the load is correctly matched. If the VSWR protective circuit operates, it will be necessary to improve the match to the antenna.

2. The amplifier uses a Constant Voltage Transformer in the power supply. The CVT uses a magnetic circuit to regulate the output voltage and the core operates at high flux densities. The following facts should be noted:

a. The power dissipation in the CVT is high under no-load conditions. The core losses will reduce as the load increases, and the power dissipation will remain substantially constant. This means that it is normal for the transformer temperature to rise under no-load conditions. The transformer is rated for operation at a maximum temperature of 130°C.

b. The high flux density in the core generates some lamination noise. This noise has been minimized in the amplifier by encapsulating the CVT in epoxy, however, some transformer "buzz" is normal.

c. The CVT will generate a considerable external magnetic field and the amplifier should not be operated close to any device subject to magnetic disturbance.

3. The standard amplifier is supplied for SSB service. This model should not be used for FSK service except on an intermittent basis (5 minutes transmit duty cycle maximum). The FSK model may be used for both SSB and FSK service. The peak output power in the SSB mode is slightly reduced. The SSB model can be modified for FSK operation. Conversion information is available at no charge from the factory.

SECTION 1

GENERAL

1.1 GENERAL INFORMATION

The Linear Amplifier is designed to amplify the output of 100W transmitters or transceivers operating in the frequency range 2-30MHz. The amplifier has a power gain of approximately 10dB and a power output of 1000W PEP. The amplifier is used to increase the signal strength, range and reliability of HF communication systems. With the correct choice of antennas and operating frequency the amplifier will give worldwide coverage.

1.2 THE AMPLIFIER

The Linear Amplifier is a professional grade amplifier designed for continuous commercial service in the SSB mode. The power output is 1000W PEP over the entire frequency range 2-30MHz. The design is all solid state using eight (8) transistors in four (4) 250W amplifier modules. This means a major step forward in reliability, service life, simplicity of adjustment and maintenance. The amplifier is completely broadband and requires no tuning or adjustment during service or installation. Unlike vacuum tube amplifiers there are no high voltages, and all circuitry operates at 28V DC or less giving components an extended service life. The amplifier incorporates high speed Transmit/Receive switching making it suitable for modern ARQ teletype systems. The switch time in both directions is typically of the order of 6 - 10 milliseconds. Additionally the PTT line has been made sensitive so that it may be switched by TTL level circuitry if this is necessary.

1.3 OPERATION

The amplifier has no tuning adjustments and can be used by unskilled operators. Unlike vacuum tube amplifiers the transistor amplifiers and combining networks use broadband transformers compensated for uniform output across the entire HF range. The frequency of the exciter can be changed without making any adjustments to the amplifier. Most exciters have provision for automatic switching of the low pass filters to the antenna. A manual mode for filter selection is provided in the desk-top model and the filters are selected by the front panel switch. Three front panel meters monitor PEP power output, and the combined collector of two of the four amplifier modules, respectively. Operation of the TW1000 is simply a matter of connecting the antenna and exciter and adjusting the drive level for the desired output power.

1.4 PERFORMANCE

The amplifier uses RF linear power transistors in carefully compensated circuits to ensure uniform performance and good linearity. Broadband transistor amplifiers generate substantial harmonic output and to ensure low spurious output, a series of relay selected low pass filters are used at the output of the amplifier. A 7-pole elliptic function design, with a .01dB ripple, is used for low loss and high harmonic attenuation. The filters are selected by the front panel switch, or in the remote mode are selected automatically by the exciter frequency controls.

1.5 PROTECTIVE CIRCUITRY

1. Input Power Source. The constant voltage transformer is designed to operate from poorly regulated mains supplies and will maintain constant voltage output over large supply voltage fluctuations.

2. Current Limiting. The power supply provides automatic current limiting and will not be damaged by a short circuit. High speed current limiting is provided by a 80A magnetic circuit breaker that is reset by a front panel switch. The breaker protects against excessive collector current and prevents operation at excessive power output.

3. Cooling. Dual cooling fans are used, although one fan will provide adequate cooling in most operational modes. If the heatsink temperature reaches 60°C, the fans automatically switch on. A second heatsink thermostat switches the amplifier off if the heatsink temperature reaches 75°C. The amplifier has excess cooling capability in all modes, and the second thermostat would normally operate only in the event of fan failure or obstruction of the cooling ducts.

4. Antenna Mismatch. There are two protective mechanisms against improper amplifier termination. The first, which is adjusted at the factory is intended to avoid amplifier damage due to wrong filter selection in manually selected filter versions. This version will simply switch abruptly to the "straight through" mode if an attempt is

made to operate with a potentially hazardous filter selection. A reset button is provided on the front panel to reset the protective circuit. All versions have a built-in directional coupler generating ALC control voltage for the driving transceiver. The output of this system is an open collector Darlington transistor which conducts more heavily as the amplifier power output increases. A fixed sample of the bridge output, proportional to the reflected component of the output port power is combined with the forward power control voltage to provide protection of the amplifier against excessively high SWR terminations. If the Amplifier-Tranceiver combination will not provide normal output power the load SWR should be checked to see if this is the cause.

5. Unbalanced Condition. A thermostat on the output combiner detects excessive unbalance in the amplifier and switches the amplifier off.

NOTE

In all fault modes the amplifier switches off and couples the exciter direct to the antenna permitting continued operation at lower power level.

1.6 FSK OPERATION

The amplifier is designed for continuous commercial service (CCS) in the SSB speech mode. A modified version, the TW1000 FSK, is designed for 600W CW or FSK on a 50% duty cycle basis, with a maximum continuous transmit cycle period of 4 hours. The TW1000 FSK uses modified RF output transformers in the power modules. The peak output in the SSB mode is slightly reduced. When the auxillary 28V DC outlet is used to power the exciter, the power output of the amplifier should be reduced to 500W.

1.7 POWER SUPPLY

The amplifier operates at a collector voltage of 28V. In the FSK model the supply must be capable of supplying a continuous 40-50A. A constant voltage transformer is used to give good efficiency and regulation at this high power level. The transformer maintains good voltage regulation with widely varying loads and with large supply voltage fluctuations. The constant voltage transformer has a square wave output, much reducing the filtering requirements. The heavy duty transformer is completely encapsulated and is tapped for operation at 115V or 230V and for 50Hz or 60Hz. The full wave rectifier system and filter uses 85A silicon diodes and computer grade electrolytic capacitors. It should be noted that it is normal for the transformers of the CVT design to produce lamination noise caused by core saturation. The noise has been minimized by complete encapsulation of the transformer, however, the residual noise level in the amplifier is normal. It should also be noted the transformer operates at elevated temperatures and is specified for safe operation to 135°C.

1.8 CONSTRUCTION

The amplifier is available in two models for either mounting in a standard 19-inch rack or for desktop operation and is completely self-contained. It is important to note that the rack mounted model must be supported on slides and not by the front panel. The amplifier case and frame is constructed of aluminum alloy. Each amplifier is mounted on a copper block which in turn is mounted on a large finned extruded aluminum heatsink. The four amplifier heatsinks are bolted together and stand vertically in the amplifier. The power supply and filters are mounted on a 32mm (.125") aluminum chassis. The frame of the amplifier is formed by the front and rear panels connected by 254mm X 95mm (1" X .375") aluminum bars. The covers are secured by eight bolts threaded directly into the side bars. The material is heavy aluminum alloy and together with the large side bars forms a design with extreme strength and rigidity. All aluminum surfaces are either anodized or gold irridited. The case and panel are finished in an attractive hardwearing black anodizing.

1.9 EXCITERS

The amplifier input is 50 Ohms with a maximum VSWR of 1.5:1 and provides an excellent match for exciters with a 50 Ohm output impedance. The power gain is approximately 10dB, and the maximum exciter power output required should not exceed 100W. Exciters in the 100W class will provide the required level of drive. The amplifier metering circuits are used to set the drive to the correct level. If possible, an external ALC loop from the amplifier output to the exciter ALC system should be used to control the drive level.

Types of Exciter

1. Terminal Type Exciter: The separate high performance transmitter used in terminal type installations provides an excellent drive source. The CCS rating, good linearity and low spurious output make the amplifier ideal for use in high grade SSB terminals.
2. Discrete Channel Transceivers: A crystal controlled transceiver is fully compatible with the amplifier. There are no restrictions on the

frequencies or number of channels. Most multi-channel transceivers have provision for antenna selection and this information is used for automatic selection of the amplifier filters.

3. Synthesized Transceivers: The amplifier is the ideal amplifier for the continuous coverage synthesized transceiver. Many transceivers provide external control switching from the "megahertz" switch and this information is used to select the amplifier filters. Operation of the amplifier is then completely automatic over the entire frequency range. Our own series of synthesized transceivers is provided with full interfacing with the amplifier and installation is only a matter of plugging in the interconnecting cables and adjusting the ALC for the correct output.

1.10 TECHNICAL SPECIFICATIONS

Table 1 defines the technical specifications of the Linear Amplifier.

1.11 SEMICONDUCTORS

Table 2 is a listing of the semiconductors used in the Linear Amplifier.

Table 1. Technical Specifications

POWER OUTPUT:	SSB Model 1000W PEP A3J. Rated for continuous commercial service. FSK Model 600W CW* CW, FSK, FM, etc. Rated for 50% duty cycle, 4 hour maximum. *500W when internal power supply is used to power the exciter.
FREQUENCY RANGE:	2-30MHz Broadband -- Continuous Coverage (1.6-2.0MHz at slightly reduced specifications). No tuning or adjustments required for any frequency in this range.
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: *	Greater than -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 remote control or by a front panel switch.
DRIVE LEVEL:	(Approximately 100W PEP) Input VSWR less than 1.5:1.
OUTPUT IMPEDANCE:	50 Ohms less than 2:1 VSWR Maximum.
POWER SUPPLY:	Internal 100/220V, 50/60Hz.
COOLING:	Dual fans thermostatically controlled.
SIZE:	45cm W X 28cm H X 43cm D. (17.6" X 11" X 17").
WEIGHT:	46 kilos (103 lbs.).
CONTROLS:	AC Power ON/OFF. DC Power ON/OFF (Resettable Circuit Breaker). Filter Range (not used in rack mount version). Filter Selection -- Remote/Local. VSWR Reset.

Table 1. Technical Specifications Continued

INDICATORS:	Transmit. DC Power On.
METERING:	Peak Power — 1.50kW Full Scale. (1) Collector Current — 50A Full Scale, Module 1 & 2. (2) Collector Current — 50A Full Scale, Module 3 & 4.
CONTROL CIRCUITRY:	12 Pin Connector on rear panel. Control voltage 12V. Actuation — all functions, ground control line. Functions — Transmit/Receive (sensitive). Filter Select (6 lines). ALC — Open collector, conducts more heavily with increased power.

Specifications subject to change without notice.

*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 2-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 TW1000 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	Location	Function	Description
D1	Chassis	Main Rectifier	85A 200 Piv Reverse Polarity Diode
D2	Chassis	Main Rectifier	85A 200 Piv Reverse Polarity Diode
D5	Swr. Brd.	Fwd. Power Peak Rect.	1N4148 Diode
D6	Swr. Brd.	Fwd. Power Avg. Rect.	1N4148 Diode
Q1	Chassis	Voltage Regulator	UA7812KC IC

Amplifier Module

Designator	Location	Function	Description
D1		Bias Clamp	3A Silicon Diode
Q1		Main Power Amp.	28V RF Power Transistor
Q2		Main Power Amp.	28V RF Power Transistor
Q3		Bias Regulator	MJE3055K Transistor
Q4		Bias Driver	MJE29A Transistor

Control Board

Designator	Function	Description
D1	Isolation Diode	1N4005 Diode
D2	Isolation Diode	1N4005 Diode
D3	Isolation Diode	1N4005 Diode
D4	Isolation Diode	1N4005 Diode
D5	Isolation Diode	1N4005 Diode
D6	Isolation Diode	1N4005 Diode
D7	Slugging Diode	1N4005 Diode
D8	PTT Isolator	1N4005 Diode
Q1	ALC Driver	2N5306 Transistor
Q2	Pwr. Meter Driver	2N5306 Transistor
Q3	Driver	2N5306 Transistor
Q4	Output Relay Driver	TIP120 NPN Transistor
Q5	Input Relay Driver	TIP120 NPN Transistor
Q6	Not Used	EC103Y SCR

SECTION 2

INSTALLATION

2.1 UNPACKING

The amplifier is shipped in a specially configured heavy walled multilayer package with specially shaped ethafoam corner packing pieces. The carton should be opened at the top and the amplifier carefully removed. Be sure to remove all connectors and interfacing parts. Check the equipment for damage and check the appropriate documentation. It is suggested that the main components of the shipping package be retained in case the amplifier needs to be shipped or transported.

2.2 POWER CONNECTIONS

The amplifier may be operated from 115V or 230V, 50Hz or 60Hz power mains. Check the local supply voltage and frequency. It is important to make the connections for the correct supply frequency, as the amplifier uses a CVT (Constant Voltage Transformer). This type of transformer uses a ferroresonant winding, and it is essential to make the correct frequency connections. If the transformer is correctly connected, the output will be substantially independent of mains supply variations. The connections are shown in the diagram, Figure 2. See also Figure 3, Amplifer With Bottom Cover Removed. Unless otherwise specified, the amplifier will be supplied connected for 115V 60Hz operation.

Fit the correct fuse in the holder located underneath the chassis to the rear. Use a type 3AB ceramic bodied fuse. Glass bodied fuses should not be used.

115V	Type 3AB30 A
230V	Type 3AB15 A

The power cable should be connected to a line connector in accordance with the requirements of the local power authority.

The power outlet should be capable of supplying the following peak load current:

115V	20A
230V	10A

2.3 LOCATION & MOUNTING

The amplifier is normally placed on the operators desk adjacent to the exciter. The cooling ducts are located on the rear panel, the base plate and the top of the case. Make sure that there are no obstructions to the airflow, particularly if the amplifier is to be operated in the FSK mode. The exciter may be mounted anywhere close to the amplifier. It is frequently convenient to mount the exciter on top of the amplifier, as the cooling ducts on the top case can be used to provide additional forced cooling for the exciter. Place the exciter so that the heatsink radiating fins or the cooling inlet ducts are immediately above the amplifier outlet ducts.

2.4 GROUND CONNECTIONS

A separate ground connection is advisable to prevent RF currents circulating in the wiring and cases of the amplifier and exciter. This ground connection is essential if the equipment is operated with an unbalanced antenna located close to the amplifier. Without a good ground the high RF circulating currents may induce feedback and distortion in the exciter and cause RF burns when the equipment is touched. Use a heavy gauge copper wire or strap for the connection. This lead should be as short and direct as possible. A good ground can be made by driving a 2 meter rod into moist soil.

2.5 FUSES

The amplifier uses a 80A magnetic circuit breaker mounted on the front panel. This breaker is also used as the DC ON/OFF switch. If the circuit breaker trips, the rocker switch turns to the OFF position. The circuit breaker is reset by turning the rocker switch to the ON position. The primary circuit is protected by a fuse located underneath the chassis. The bottom plate should be removed to replace the fuse. The primary fuse will normally blow only if there is an extreme power-line surge, a defect in the transformer or wiring, or the amplifier is connected to a supply of the incorrect voltage.

Always replace the fuse with the correct type and rating.

Primary Fuse — 115V Type 3AB 30A,
230V Type 3AB 15A.

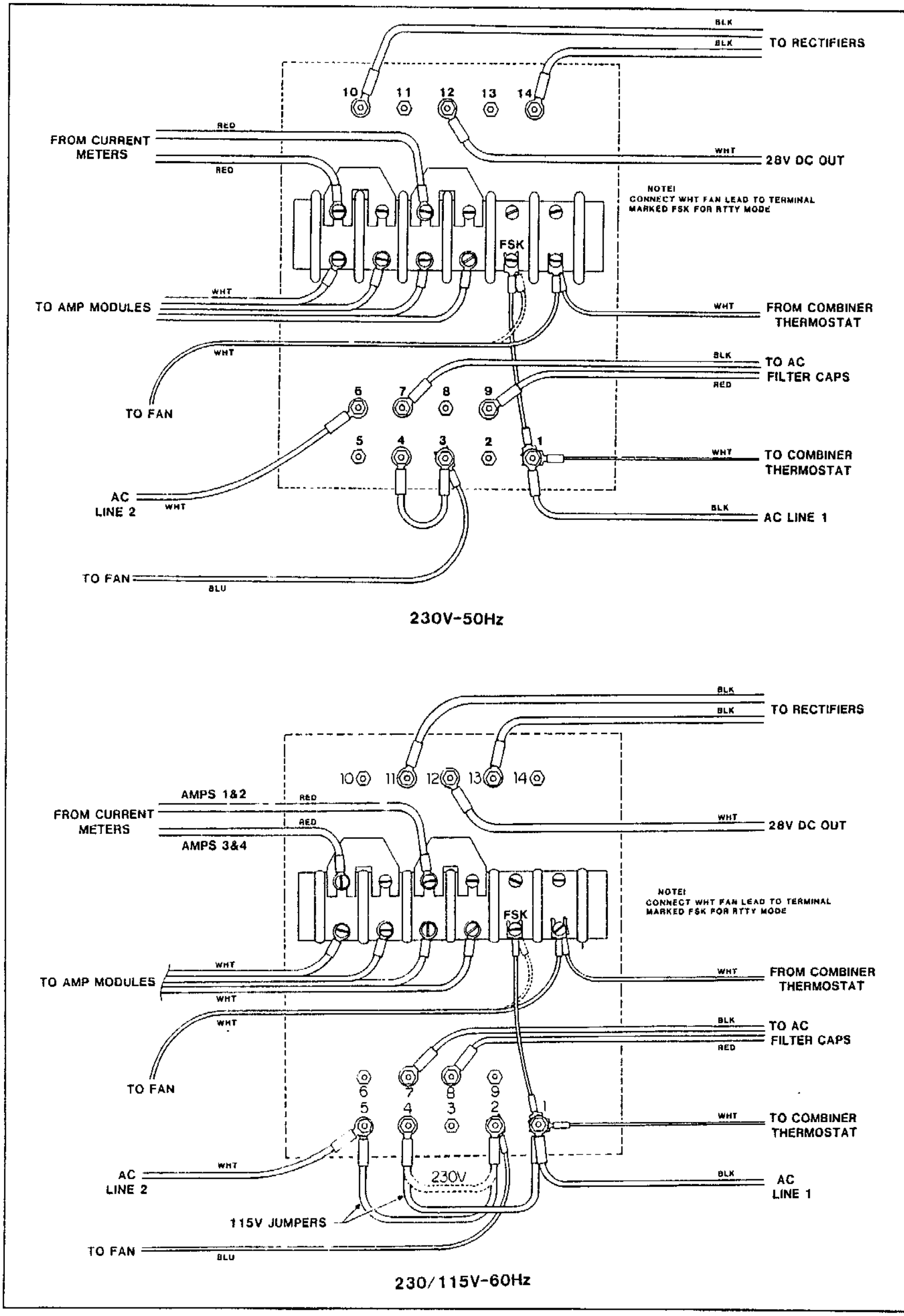


Figure 2. Transformer Connections.

2.6 ANTENNA CONNECTION

The amplifier output impedance is 50 Ohms, and a heavy duty coaxial cable of the RG8/U type should be used for the connection to the antenna or the antenna tuner. The cable is fitted to the PL259 UHF connector. Make sure the connections are securely soldered and tightened, as the peak RF currents will exceed 5A at full output.

2.7 ANTENNA MATCHING

For best efficiency, the amplifier should operate into a correctly matched antenna system. The automatic protect circuits will switch the amplifier off if the VSWR exceeds 2:1. For normal operation, the VSWR should not exceed 1.5:1 and for full output, the VSWR should be 1:1. It is best to check the VSWR using a VSWR indicator connected in the line to the antenna. It should be noted that the VSWR bridge is connected between the amplifiers and the low-pass filters. The filters have a maximum reflection co-efficient of 5%. This means that on some frequencies the meter will indicate a small residual reading even when the amplifier is correctly terminated. On the lower frequencies the amplifier harmonics may also cause a residual reflected power indication. The residual meter readings may be disregarded, and the antenna should simply be adjusted for the lowest possible reflected power indication.

2.8 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 possible 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 ABB series or log periodic beams. 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 that tunes for minimum VSWR is used.

2.9 FREQUENCY ADJUSTMENT

The amplifier is fully broadband and requires no adjustment or tuning for operation on any frequency.

2.10 FILTER SWITCHING

The filters are switched automatically in the TW1200 systems. If automatic filter switching is not available, the front panel pushbutton switch may be used to select the correct filter. The filter remote control circuits are wired through the 12 pin connector on the rear panel. Each filter is activated by grounding the appropriate control wire. The power is supplied by the amplifier, and the switching circuits should control approximately 12V at 200mA. The transceiver must select the filter appropriate for the frequency it is operating on, by grounding the control socket pin listed in Figure 4. Provided there is a bandswitch switching wafer available for external control, or some other equipment arrangement, it is usually possible to devise a suitable switching system. In some complex systems it may be necessary to use a diode control matrix to provide correct filter selection. Switching connections for specific exciters is available upon request. The TW100 series of transceivers include the interface circuitry for filter selection.

2.11 EXCITER INTERCONNECTIONS

The amplifier requires only two connections to the exciter. The input to the amplifier is connected through a 50 Ohm coaxial cable (RG58/U type) terminated in a PL259 UHF connector. The amplifier is switched on by grounding the control line. The control line may be switched by the exciter control relay or by the microphone press-to-talk switch. The operating voltage is approximately 12 volts, and the switching current is 10mA.

A separate short ground connection between the exciter and the amplifier should be provided. In all OFF conditions the exciter is connected to the antenna with only the 20 to 30MHz low pass filter in circuit. This means that the amplifier may be used with transceivers without any additional antenna switching requirements. To bypass the amplifier simply turn the AC power switch OFF. The suggested interconnecting wiring is shown in the diagram. This interface wiring is provided in the TW100 series of transceivers.

2.12 DRIVE LEVEL

The normal drive level for full output will not exceed 100W. The exciter ALC should be adjusted, so that the exciter does not overdrive the transmitter. A DC voltage, proportional to power output, is provided at pin 12 of the interconnection socket. The voltage may be used to control the exciter ALC system. The appropriate circuitry must be

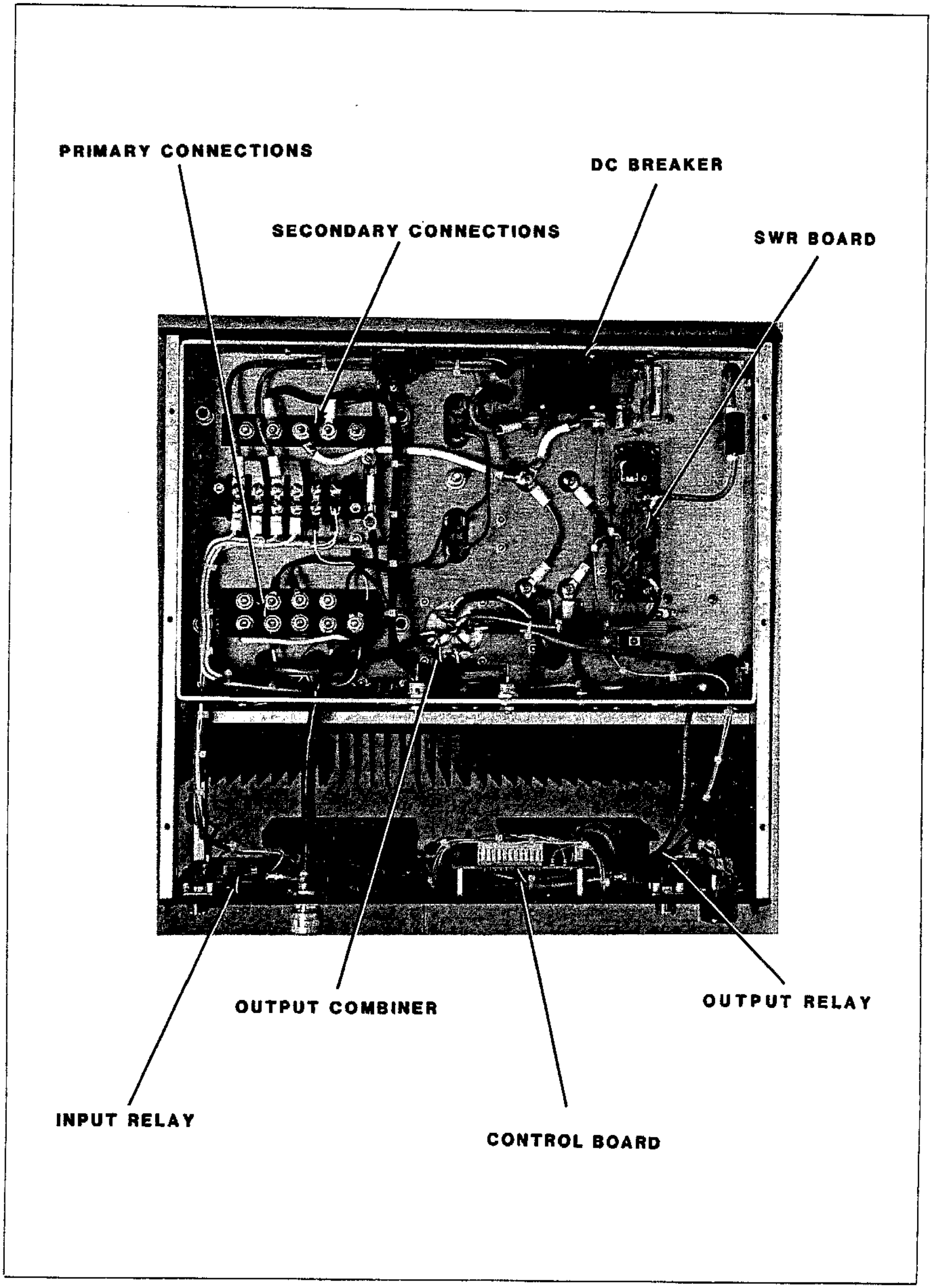


FIGURE 3. Amplifier - Bottom Cover Removed.

added to set the threshold level and to provide voltage level shifts required by the exciter ALC system. A separate SWR bridge is available for external attachment at the amplifier output terminal. Since it derives its output subsequent to the harmonic filtering and also senses reflected power, this unit should be employed whenever possible.

CAUTION
DO NOT OVERDRIVE

Drive levels in excess of 100W can destroy the expensive transistors in the final amplifier. If the exciter is capable of power outputs in excess of 100W, it is essential to modify the exciter final amplifier, so that excessive drive power cannot be employed.

2.13 CAUTION

The only high voltages in the TW1000 are at the primary and resonant windings of the power transformer. The usual lethal voltages used in a high power amplifier are not present, as the transistors operate at 28V. It is important to remember that RF voltages between 200-500V are present when the transmitter is operating at full power. These RF voltages can cause severe burns and extreme caution should be observed.

If the Linear Amplifier is to be used for teletype operation, the FSK model should be used and the fans should be connected for continuous full speed operation. The connections are shown in the diagram, Figure 2. It should be remembered that teletype operation makes much greater demand of the equipment than SSB or telegraphy. The transmitter must have a continuous CW power output compared with the lower duty cycle and much smaller average power requirements on SSB. The amplifiers in the Linear Amplifier have more than adequate cooling capacity, even at 1000W output on teletype operations and will cycle on and off. The limiting factor is the power supply and to prevent excessive size and weight, the teletype rating is reduced to 600W** output (CCS). Even at this level the power dissipation is high and to ensure maximum cooling, the fans should be reconnected as described. It is also recommended that the maximum transmit/receive duty cycle does not exceed 50% with a maximum continuous transmit time of 4 hours.

*The standard model TW1000 may be modified for FSK operation very simply. Send for information on the changes required if FSK operation is required.

**500W when the power supply is used for the exciter in the TW1200 systems.

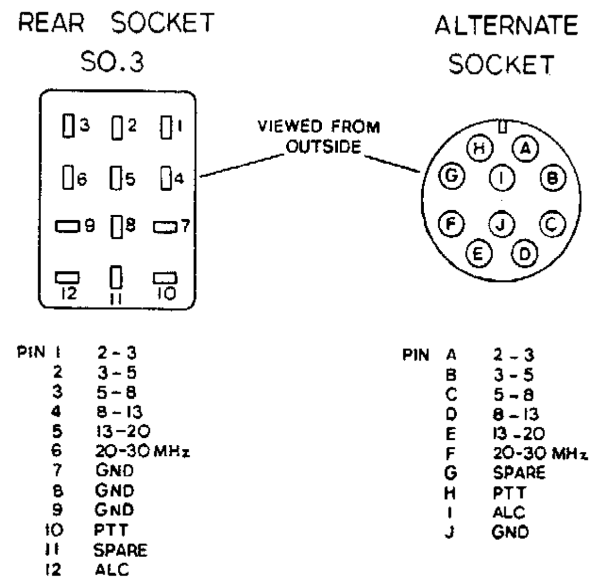
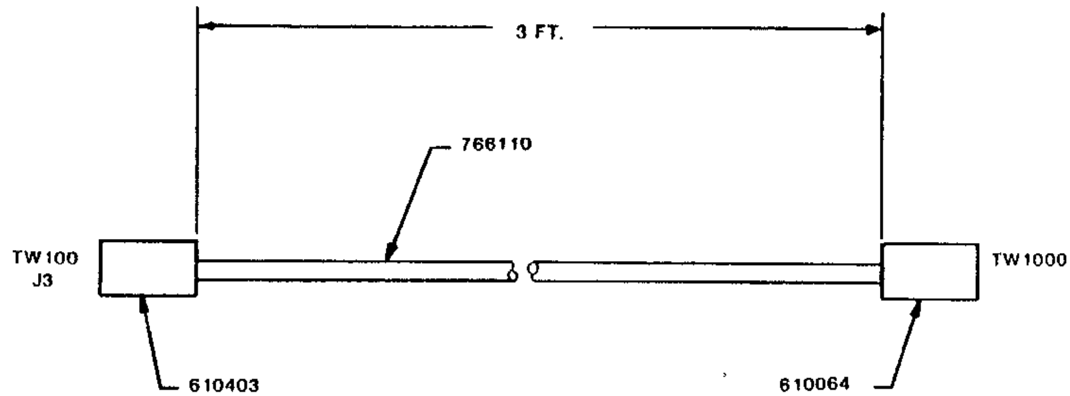


Figure 4. Wiring Connections, Filters.



AMPLIFIER/TRANSCEIVER INTERFACE CABLE DIAGRAM

CONNECTOR WIRING TABLE

TO		FUNCTIONS	FROM	
	PIN		PIN	
TW100 J3	4	2-3 MHZ	A	TW1000 J3
	5	3-5 MHZ	B	
	6	5-8 MHZ	C	
	7	8-13 MHZ	D	
	8	13-20 MHZ	E	
	9	20-30 MHZ	F	
	2	AMP ALC	I	
	1	GROUND	J	
	3	PTT	H	

Figure 5. Interconnect Wiring.

SECTION 3

OPERATION

3.1 GENERAL

The amplifier requires no tuning adjustments and provided the antenna is correctly terminated, the only operator attention required is checking the drive level and filter selection. If the ALC level has been set correctly and remote filter selection is used, the operation will be entirely automatic. The TW1200 system uses remote filter selection and ALC control of the drive for automatic operation.

3.2 CONTROLS

AC Line — ON/OFF

The rocker switch controls the primary power to the amplifier. In the OFF position the amplifier is completely switched off, and the exciter is connected directly to the antenna. The amplifier is all solid state and requires no warm up.

DC Power — ON/OFF

This switch is a 80A electro-magnetic circuit breaker in the main 28V DC supply line. The switch is normally left in the ON position and the amplifier power controlled by the AC line switch. If the current exceeds 80A, the circuit breaker will open and the switch will turn to the OFF position. The circuit breaker is reset by turning the switch back to the ON position. If the circuit breaker trips repeatedly, the drive level is excessive and should be reduced. The circuit breaker will also trip if there is a short or fault in the amplifier.

Filters — Local/Remote

(Not used in rack mount model)

The switch is turned to the REMOTE position only if the exciter has been programmed for automatic filter selection. The switch is turned to the Local position for manual filter selection.

Filter Switch

(Not used in rack mount model)

The 6-position switch controls the selection of the filter when the LOCAL/REMOTE switch is in the LOCAL position. If a filter with a cut-off frequency below the operating frequency is chosen, the amplifier switches off.

Reset Button

This momentary push switch resets the amplifier after a fault causing excess VSWR. If the amplifier switches off, check the filter selection and the antenna, then press the reset button.

3.3 INDICATORS

AC Power On

This indicator operates only if the AC power is switched ON. If the indicator does not light, check the mains supply and the primary fuse.

3.4 METERING

Three separate meters indicate PEP power output, the combined collector current of module 1 and 2 and the combined collector current of module 3 and 4 respectively. No meter switching is provided and all meters are operational at all times.

NOTE

Since the output power meter is Peak reading, it will respond to quite short "spikes" of RF energy, and this should be taken into account when interpreting meter readings. The two collector current meters should always read approximately the same current. Any major departure from this condition will indicate a departure from correct operation, and is the primary reason for the provision of two separate meters.

3.5 EXCITATION LEVEL

Apart from ensuring the antenna is correctly matched and selecting the correct filter range, the only operating adjustment is setting the drive to the correct level.

CW, FM, FSK Operation

IMPORTANT NOTE

Since the TW1000 is rated at 500 to 600 Watts for the above type operation only the AVERAGE control should be used unless special circumstances dictate otherwise.

Control of drive levels is best accomplished by controlling the transceiver ALC system from the amplifier power sensing bridge. Two controls are provided on the amplifier rear panel for this purpose. These controls are operational ONLY when they have been correctly interfaced with the transceiver ALC system. The two controls are identical in function EXCEPT for the fact that one has a very short time constant rectifier system (a millisecond or so - this is the AVERAGE control) and the other has a rectifier time constant of around half a second, (this is the PEAK control). In general only one control should be used at any one time, the nonoperational control should be advanced to its maximum power position (fully clockwise). (SEE NOTE ABOVE).

In general, an indicated collector current on each meter of 25 to 33A depending on the frequency range will be appropriate for operation in these modes.

SSB Operation
If operation will be in the voice SSB mode ONLY the preferred method of setting power levels would certainly be to observe a sample of the high power RF output on a broadband oscilloscope while increasing power level until a condition just below the onset of "peak flattening" is observed. The PEAK control will provide a closer control under speech conditions, so it is suggested that this control is used if ONLY SSB speech is to be used. Under these circumstances a perfectly satisfactory field level adjustment should be achieved if the power meter flicks occasionally above the 1kW level.

3.6 REDUCED POWER OPERATION

High power output is usually only required for long distance communications or under unfavorable conditions. Reduction of power to the minimum required for reliable communications will reduce interference to other users of the frequency. Remember, the Linear Amplifier is capable of worldwide coverage with good antenna systems. The amplifier will operate satisfactorily at reduced output power and by simply switching the amplifier off, the exciter will be coupled direct to the antenna.

3.7 AMPLIFIER SWITCH OFF

The amplifier is normally switched off by the AC Line switch. If the amplifier is switched off while operating, first switch the DC Power, then the AC Line. This prevents operating the exciter into an open circuit while the filter capacitors discharge.

CAUTION

Do not switch filters or AC power while amplifier is actually in the transmit condition.

(The above actions could result in momentary total unloading of the exciter or amplifier.)

NOTE

Some mechanical noise will be noticed from the constant voltage power transformer. This is mainly due to magnetostrictive effect and is quite normal. The transformer is rated for operation to 135°C and high case temperatures are normal.

SECTION 4

TECHNICAL DESCRIPTION

4.1 GENERAL

The amplifier consists of four 250W amplifier modules with input and output impedances of 200 ohms. The four amplifiers are paralleled through input and output combiners to give the composite amplifier a 50 ohm input and output impedance. The input from the exciter is fed through a matching network providing compensation and gain levelling through the frequency range. The output of the amplifier is coupled to the antenna through a series of six low pass filters. The internal regulated power supply is rated at 28V 80A peak.

4.2 250W AMPLIFIER MODULES

The 250W amplifiers are a simple push-pull design using two 150W broadband rated linear power transistors. These new generation transistors use a unique emitter ballasted chip 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 currents and at power levels of 250W. The transformers use ferrite loaded tubes as the base and collector windings. The input transformer T1 uses a matching network, common to all input transformers, at the 50 ohm input to the amplifier. The output transformer has excellent transfer characteristics and requires a minimal compensation to cancel the leakage characteristics. The center taps of the transformers T1 and T2 operate at RF ground potential. A very low impedance across the entire operating range and at audio frequencies is essential, and three paralleled capacitors are used at each of the transformer center taps.

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, causing 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 T1 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 used to adjust the bias current. Q3 is an emitter follower with the base of Q4 connected to the emitter of Q3. This circuit provides the low impedance bias source required for the high power RF transistors. The diode D1 effectively shunts the bases of Q1 and Q2 and provides back up to the primary bias circuitry. In the event of any defect in the bias circuit, D1 prevents catastrophic damage to the RF transistors.

Q4 is mounted on the copper heatsink immediately adjacent to Q1 and Q2. 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. Individual bias regulators for each of the four amplifiers ensure uniform comtrol of the quiescent current in each amplifier.

4.3 INPUT CIRCUIT

The matching of the four amplifier inputs over nearly four octaves frequency range presents a complex design problem. The base impedance of the RF transistors varies substantially over the frequency range and changes sign from -j to +j. The variation of the real part of the input impedance changes by a factor of almost 10, and the gain of the devices changes by approximately 8dB. The design objective was to attain a 50 ohm input with a 1.5:1 maximum VSWR and maintain the amplifier gain within 2dB.

The input to each amplifier is 200 ohms. If each amplifier was identical in all respects, it would be possible to simply parallel the four inputs for a combined input impedance of 50 ohms. In practice the mismatch between the amplifiers would prevent satisfactory operation. The solution is the use of the input combiner. The combiner is a company developed design using ferrite loading for compact size, low loss and effective port-to-port isolation. The amplifier inputs are effectively paralleled while each input is isolated from the other inputs. The unbalance components of the input are dissipated in non-inductive resistors incorporated in the combiner. Each amplifier is coupled to the combiner through a specially fabricated 200 ohm transmission line.

The excellent transfer characteristics of the input transformers and input combiner made it possible to use a single compensation network in the 50 ohm input instead of individual compensation at the bases of each of the four amplifiers. The complex computer designed input network uses a combination of inductors, resistors and capacitors to provide matching to the complex input impedance, and gain leveling across the 2-30MHz range. The elimination of individual input compensation networks for each transistor brings a substantial reduction in circuit complexity. The matching network fulfills the design requirements, and the amplifier has a low input VSWR with substantially level gain across the operating range.

4.4 OUTPUT CIRCUIT

The output of the four 250W amplifiers must be combined at an output impedance of 50 ohms. It is not possible to simply parallel the 200 ohm output, as this would result in interaction between the amplifiers with a resultant severe degradation of performance and increase in distortion. The output combiner provides good port-to-port isolation and effectively parallels the outputs with low combination losses. The unbalance components are dissipated in the non-inductive loads in the combiner. In the event of a defect in an amplifier module causing a severe unbalance in the combiners, the large unbalance components would cause excess dissipation in the loads and possible damage to the combiner. The thermostat TH2 is mounted on the combiner and will be activated if severe unbalance occurs, turning off the amplifier.

4.5 OUTPUT FILTER

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 7-pole elliptic function with a 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 and 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 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 ground loops will frequently bypass the filter causing a major reduction in the harmonic attenuation.

The relays are selected by grounding the control wire to each pair of relays. These wires are connected to both the remote control socket J3 and to the front panel switch. When the filter is selected by grounding the relay control line, by either the pushbutton switch or the remote control wiring, the ground return to the LED is complete, causing the indicator to light.

4.6 DIRECTIONAL COUPLER

There are two directional couplers incorporated in the TW1000. One is fitted between the combined amplifier outputs and the main filter block, the other is in the coaxial line between the filter output and the output relay. The first unit has a purely protective function, that of switching off the amplifier in the event of the selection of a filter which cuts off below the frequency of operation. (This is likely only in the event of mis-programming of transceiver filter selection, or of an incorrect manual filter selection in amplifiers so equipped). The output of this first coupler which is adjustable by R23 on the board located under the chassis, is set at the factory for a satisfactory protection level.

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.

4.7 ALC CONTROL

The three outputs from the directional coupler are applied to the base of the Darlington transistor Q1. In the TW100 series of 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," and are located on the rear panel. 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.

4.8 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 6).

4.9 POWER SUPPLY

The power supply uses a high grade epoxy encapsulated "Constant Voltage Transformer". The CVT is of conventional design using core saturation and the ferro resonance principle to maintain constant output voltage. C1 and C2 are the two capacitors used to resonate the winding at 50 or 60Hz.

The transformer has taps on the primary, the secondary and the resonant winding, so that it can be connected for 115 or 230V operation at a power line frequency of 50 or 60Hz. The CVT maintains constant output over a wide range of input voltages and under the varying secondary loads. This characteristic is particularly desirable in areas where the regulation of the

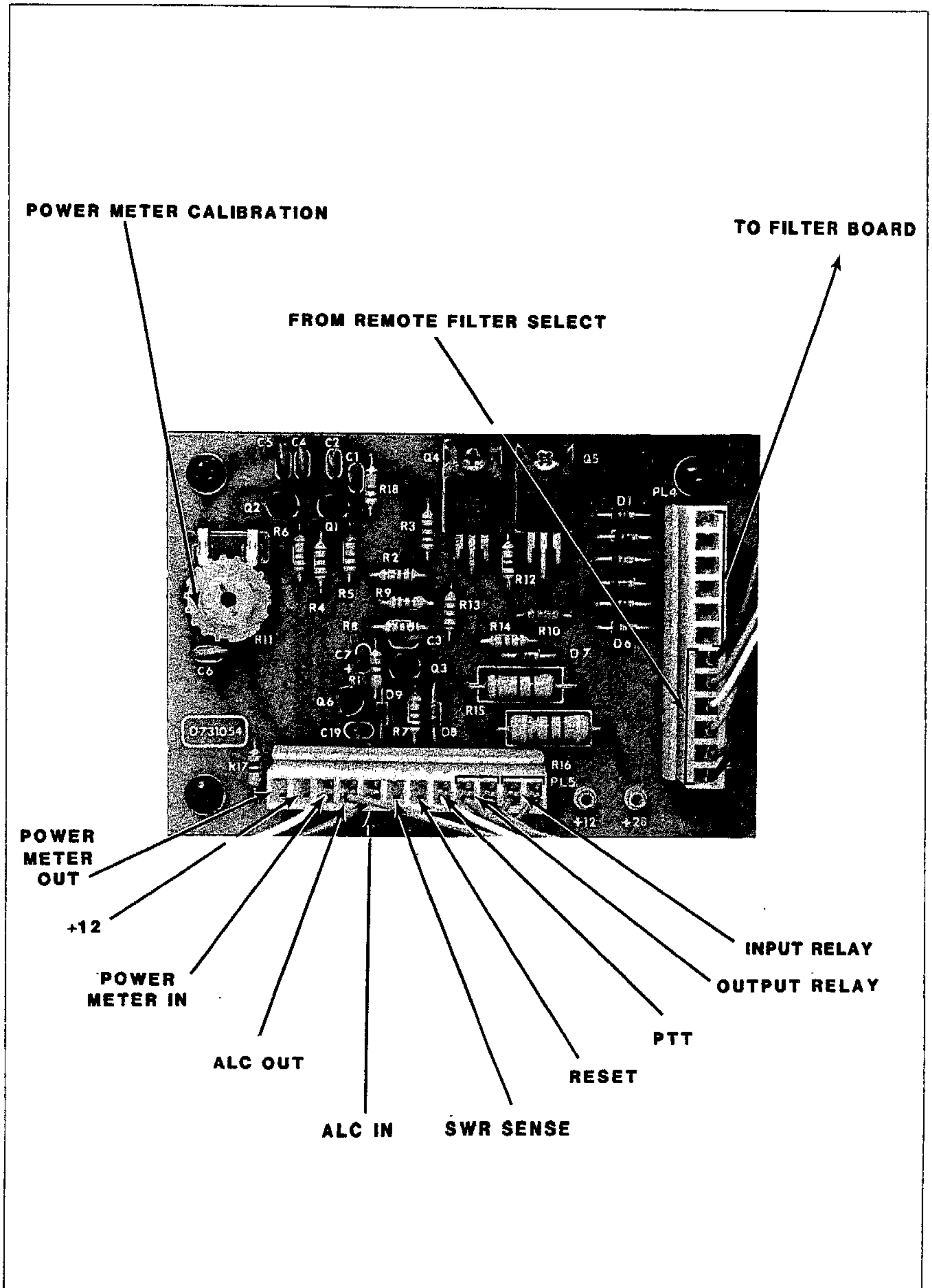


FIGURE 6. Control Board Detail.

supply mains is poor. The CVT also eliminates the problem of operation at 115V. With conventional transformers the mains voltage drop at high currents may limit peak output.

The output waveform from a CVT approaches a square wave. This substantially reduces the filtering requirements and the peak voltages. The rectifiers are two heavy duty 85A silicon power diodes D1 and D2 connected in a conventional full wave circuit. The anodes are grounded so that the diodes can be bolted direct to the chassis. The filter capacitors C7 and C8 are computer grade electrolytics.

A fuse is located in the primary supply. This fuse will normally only operate if there is a severe mains surge or a defect in the transformer. The CVT has been designed for short circuit protection and will automatically current limit at approximately 70A even if the supply is short circuited. The main supply protection is the fast acting 60A magnetic circuit breaker S2. The breaker prevents the amplifier from operating at excessive power output, and frequent tripping indicates an excessive drive level.

4.10 COOLING SYSTEM

Two fans are used in the cooling system. The fans are mounted on the rear panel and direct the main airflow at the heatsinks and exhaust through the ducts in the base plate and top cover. A secondary airflow is provided through to the front of the chassis to cool the interior of the amplifier. The air ducts are arranged to provide convection cooling of the heatsinks, and in the rare event of failure of both fans, the amplifier may be safely operated in the SSB mode without forced cooling.

The fans are wired across one of the 115V transformer windings. The transformer primary acts as an auto transformer when connected for 230V operation and eliminates the need for dual voltage fans. The thermostat TH3 is mounted on one of the amplifier heatsinks. If the heatsink temperature reaches 60°, the thermostat closes, shorting L3 so that the fans operate. A second 75° thermostat TH1 is mounted on the heatsinks. If the heatsink temperature reaches 75°, TH1 opens and switches the amplifier off. TH1 should never open under normal operating conditions, as the available cooling is more than adequate, even for teletype service.

4.11 12 VOLT REGULATED SUPPLY

A 12V regulated supply is provided by integrated circuit regulator Q7, located on the main chassis. This supply drives the relay for filter selection, and a portion of the circuitry located on the control board also located beneath the chassis.

4.12 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 10ms 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 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 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 AFTER the output relay, so that the amplifier cannot 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, Q4 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.

4.13 PROTECTIVE CIRCUITRY

The protective circuits described below refer only to the HIGH SWR circuitry. The amplifier does have the inherent protection provided by the ferroresonant 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.

NOTE

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 it 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.

SECTION 5

SERVICE AND MAINTENANCE

5.1 INTRODUCTION
The Linear Amplifier requires no routine maintenance. The power transistors are rated for an extended service life and only need to be replaced in the event of failure. The power transformer is encapsulated in epoxy and is rated for extreme reliability. The transistors operate at DC collector voltage of 40V and no high voltages are present in the amplifier. This makes a major contribution to low service requirements. The extensive protect circuitry makes it difficult to damage the amplifier through incorrect operation. The only real precaution required is to ensure that the exciter cannot supply a drive level much in excess of 100W.

5.2 AMPLIFIER ACCESS

5.2.1 CASE REMOVAL
The side and top panels are removed by unscrewing the six Philips-headed screws in each panel. Do not remove the screws at the front of the top plate.

5.2.2 BOTTOM PANEL
The bottom panel is removed by unscrewing the six binder head screws. The panel may then be lifted off.

5.2.3 REAR PANEL
Remove the four socket head screws located in the corners of the panel. Unscrew the cap on the power cord feed-through. This loosens the retaining grommet and permits the cable to slide through the feed-through. The panel can then be tilted back to give good access to all panel components.

5.2.4 FRONT PANEL
Remove the four socket head screws located in the corners of the panel. Remove the six oval head screws at the bottom of the panel. Note four of these screws retain the DC and AC switches in place. The panel can be tilted forward for access to all panel components.

5.2.5 AMPLIFIER MODULES
Remove the rear panel retaining screws and tilt the panel back. Remove the rear flat head screw located in both side bars at the bottom of the amplifier. This is the screw that screws into the heatsink. Leave the front flat head screw in place. Remove the two socket head screws from the top corners of the front panel. The entire amplifier assembly can then be tilted back to give access to amplifiers. (See Figure 7.)

5.2.6 VSWR CIRCUIT BOARD
To obtain access to the VSWR Circuit Board, unscrew the four retaining screws. Remove the heavy coaxial cable from the two terminals. The remaining leads have sufficient length to give access to the underneath of the board so that components may be replaced.

5.2.7 FILTERS
Remove the VSWR circuit board retaining screws. Push the circuit board to one side to give access to the four filter assembly retaining screws. These screws thread into the four brackets on the bottom of the filter assembly. When the retaining screws are removed, the filter assembly can be tilted clear of the amplifier for access to all components.

There is sufficient clearance to replace components located near the edge of the circuit board. The filter assembly may be taken apart to replace components located toward the center of the circuit boards. Remove the four screws from one of the circuit boards. These are the screws in four standoff posts joining the two circuit boards. Carefully unsolder one end of each of the two brass tubes joining the boards. Unsolder the center conductor inside of the tubes. The circuit boards may then be taken apart. Make sure that the two ferrite beads are replaced on each of the tubes when reassembling the filter boards.

5.2.8 INPUT MATCHING NETWORK
The input matching network is installed inside the top channel on the amplifier assembly. Remove the cover by unfastening the screw and hex nut at each end of the cover. The cover then lifts off to give access to input network and input combiner.

5.3 FUSE REPLACEMENT
The primary fuse holder is located inside the chassis. Remove the bottom panel to gain access. Always replace the fuse with the correct type. DO NOT use glass bodied fuses.

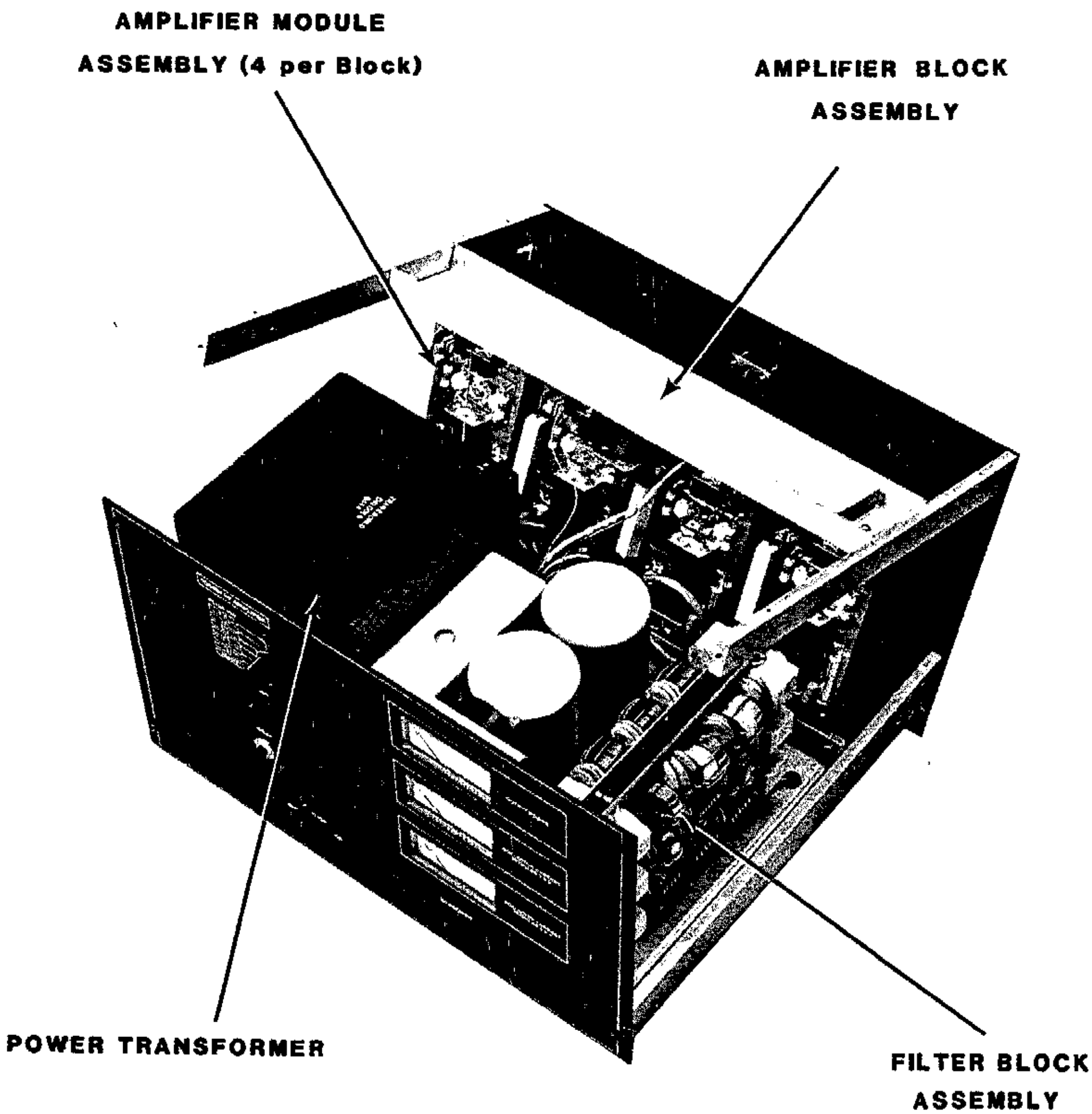


Figure 7. Interior View - Note Access to Amplifier Modules.

230V Operation — Fuse Type 3AB
15A rating

110V Operation — Fuse Type 3AB
30A rating

5.4 GENERAL FAULT FINDING TECHNIQUES

An examination of the schematic diagrams, Figures 8 and 9, indicates that the basic RF circuitry is simple. The high power levels usually mean that a defective component will suffer catastrophic failure and show external evidence of damage. If either transistor fails in one of the RF amplifiers, that amplifier will have negligible output. The most complex part of the amplifier is the control and protect circuitry. The operation of the circuitry is simple and most faults can be located by resistance and continuity checks using a simple VOM. Use the information in the preceding section to find the general area of the fault, then use a systematic analytical procedure to localize the specific fault if the initial visual examination does not pinpoint the problem. The following sections give detailed information on the different parts of the amplifier.

5.5 FAULT LOCATION

The front panel meter and indicators will provide information to locate the approximate area of the fault.

5.5.1 POWER SUPPLY

Check the supply voltage is approximately 32V without load. The voltage drop should not exceed 3-4V at 50A collector current. If the no load and full load voltages vary substantially, the power supply or AC mains regulation is faulty.

5.5.2 AMPLIFIER

If there is a defect in one of the amplifiers, the unbalance currents will cause heating in the output combiner. This actuates the thermostat TH2 and the fault indicator LD2 lights. As a first quick check, switch the amplifier off and feel the top of each transistor. The transistors in a non-operational amplifier will usually be much cooler than the transistors in the other amplifiers. For a more accurate check, measure the currents in the individual amplifiers. The amplifier currents may be measured by placing an ammeter (10A minimum) in the main supply lead to each amplifier. The supply leads are individually terminated on the large terminal block underneath the transformer as shown in the photograph and do not have to be unsoldered to make the current measurements. The defective amplifier will normally show a substantial variation in current drain compared with the other amplifiers. This measurement should be made at full output.

An alternate method of locating a defective amplifier module is to short the input of each amplifier to ground at the terminal at the top of the printed circuit board. The power output will drop substantially when the drive to each amplifier is shorted. No change in output or a smaller than normal change indicates a defective amplifier module.

5.5.3 INPUT CIRCUITS

Faults in the input matching circuits and combiner are indicated by low amplifier current at normal levels of drive. Check the exciter separately to ensure the drive level is adequate.

5.5.4 OUTPUT CIRCUITS & FILTER

Any defects in the output circuitry will cause the VSWR indicator LD2 to light. Check that the antenna matching is satisfactory by operating the amplifier into a 50 ohm dummy load or by using a separate VSWR indicator to the antenna. The dummy load must have an adequate power rating for the amplifier. If the antenna matching is satisfactory, the fault is in the amplifier output circuitry. Check the operation on each filter. If the defect is on only one frequency range, the fault is confined to that specific filter. If the fault is present on all filter positions, the fault will be in the switching or the wiring.

5.5.5 SWITCHING CIRCUITS

Check the relay supply voltage is approximately 12V. If the voltage is high, there is a defect in the relay voltage regulator Q1. Low voltage may also indicate a regulator defect, or more likely there is a short circuit or the protect circuitry is operating.

5.6 AMPLIFIER SERVICE

5.6.1 GENERAL

A. Check the current or short the drive to each amplifier (Sec. 5.5.2). This will usually indicate the defective module.

B. Check the RF voltage at the collectors of each amplifier using an oscilloscope or RF voltmeter. The defective amplifier will show a lower voltage than the operating amplifiers.

C. If the RF output level is very low, and the collector current increases as the drive is increased, one of the transistors has failed.

D. The defective transistor can be located by placing bypass capacitors (.1 microfarad) across each base and collector in turn. When the defective transistor is bypassed, the RF output of the amplifier will show a substantial increase.

5.6.2 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 the leads are correctly aligned and mount the transistor on the heatsink. The screws should be tightened securely but not overtightened, 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.

5.6.3 BIAS CIRCUIT

Check the quiescent collector current is set at 200-300mA. Measure the DC voltage at the center tap of the input transfomer. Under quiescent conditions, the voltage should be approximately .625V and should not decrease by more than around .01V at full drive. If the bias circuit does not appear to be operating correctly, check that the emitter base voltage differential of Q3 and Q4 is approximately .8V. Any substantial variation indicates the transistor is defective. The quiescent current collector should be reset to 200-300mA by adjusting R3 after replacing any transistor in the amplifier module.

5.6.4 PASSIVE COMPONENTS

The input and output transformers are unlikely to give any problems. Check for broken ferrite cores and for shorts between the brass tubes and the input and output windings. The resistor values should be checked with an ohmmeter after temporarily disconnecting one end of the resistor from the circuit. The capacitors in the amplifier are all used as bypasses. Short circuits at the input will be indicated by zero base voltage. Shorts at the output will operate the main circuit breaker.

5.7 INPUT CIRCUIT SERVICE

Check the operation of Relay K1. One set of contacts on K1 switches the 20V supply voltage to the individual bias regulators in each amplifier. Check that the 20V appears at the bias regulators in the "ON" condition. Faults in the input circuit are likely to be confined to the relay. The wiring should also be checked for continuity with an ohmmeter. Defects in the input matching network are only likely to happen as a result of excess drive which will be evidenced by over heating. It is recommended that the entire network is replaced in the event of damage. The input combiner is electrically virtually indestructable and should only require replacement in the event of physical damage.

5.8 OUTPUT COMBINER SERVICE

The output combiner is wound with teflon insulated 16 AWG wire and is extremely unlikely to fail. The termination resistors on the combiner dissipate any unbalance currents between the amplifiers. The thermostat TH2 switches off the amplifier if there is excess dissipation in the resistors. If there is any evidence of severe overheating or failure, check the operation of the thermostat.

5.9 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 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.

5.10 RELAY SUPPLY SERVICE

If either relay supply voltage is high, check the appropriate zener diode and pass transistor. If the transmit/receive relay supply is faulty, the active components are D11 and Q1. In the case of low output, first check that the protect circuitry is not operating, then for a shorted D11, and open Q1, or a short in the relay circuit itself. Check the bypass capacitors C46, C47, C10 and check R15. If the filter select relay supply is faulty, the active components are D14 and Q3. High output of this supply (which is not metered) will be caused by an open D14 or a shorted Q3. Low output will be caused by a shorted D14 or an open Q3. Also check for a shorted C95, and open R36, or a short anywhere in the filter assembly. Select a different filter to check for a possible short location.

5.11 POWER SUPPLY SERVICE

The power supply service is very simple. First, recheck the transformer connections are correct for both voltage and frequency. Check D1 and D2. A large voltage drop under load indicates a defective diode. Excessive power supply ripple indicates one or both of the electrolytic capacitors C7 and C8 are defective or have low capacity. If the rectifiers and filters appear normal, check the CVT transformer and resonating capacitors C1 and C2. Problems in the high grade encapsulated transformer are most unlikely, and faults are more likely to occur with the capacitors, diodes or extremely poor mains voltage regulation.

5.12 ADJUSTMENTS

The only adjustments to be made in the amplifier are setting the bias for the correct quiescent current in the final transistors, adjusting the VSWR bridge, and setting the excess VSWR trip point. These adjustments will only require resetting if there has been a component change in the related circuitry.

5.12.1 BIAS ADJUSTMENT

Open the collector supply lead to the amplifier requiring adjustment and insert an ammeter in series with the supply lead. The supply leads terminate at individual connections on the terminal block underneath the transformer. Make sure there is no drive power present and adjust the control R3 on the amplifier module for a quiescent current of 200-300mA.

5.12.2 VSWR ADJUSTMENT

Terminate the amplifier in a 50 ohm non-inductive load capable of handling the full amplifier output for at least one minute. Set the filters to the 20-30MHz range. Drive the amplifier to full power at a frequency of approximately 15MHz. Adjust C17 for minimum reflected power reading on the panel meter.

5.12.3 VSWR PROTECT CIRCUIT ADJUSTMENT

This adjustment has been factory set and the potentiometer (R20) sealed.

If for any reason it is necessary to reset this adjustment, the following procedure should be followed. Set R20 in the fully clockwise position. Terminate the amplifier in a 1kW 50 ohm load. Selecting the 13-20MHz filter range, drive the amplifier with a 15MHz CW signal and adjust the drive for a power output of 350W CW. Holding the reset button in, disconnect the load; release the button. The protect circuitry should operate immediately. Back off (anti-clockwise) R20 until the protect circuitry just operates, resetting with the reset button as necessary. When a satisfactory setting has been achieved, reconnect the load and seal the potentiometer rotor in place adjacent to the terminals.

5.13 DUMMY LOADS

It is desirable to use a 50 ohm non-inductive lead when servicing the amplifier. It is essential that the load has at least an intermittent rating of 1kW. Do not use the amplifier with low wattage loads, as they may be permanently damaged.

5.14 TEST MEASUREMENTS

Special care needs to be taken when making accurate measurements of spurious output and linearity. The high power levels mean that the test equipment is susceptible to ground loops and direct radiation. It is also important that the drive source be taken into consideration.

Tests are made using a Tektronix 7L13 spectrum analyzer for linearity and spurious measurements. The amplifier is operated into a precision 1 kilowatt attenuator.

Tests are made using a Singer SSB4 high resolution spectrum analyzer for linearity measurements and a Hewlett-Packard 85558B 0-1500MHz spectrum analyzer for spurious measurements. The amplifier is operated into precision 1 kilowatt load with a 40dB sampling attenuator inserted in the line to the load. This sampling attenuation introduces negligible mismatch, and the attenuation is level within 1dB from 0-200MHz.

NOTE

Probe type attenuators vary with frequency making them difficult to use for spurious measurements.

The drive source consists of two separate 100W broadband amplifiers excited by HP606A signal generators. The amplifier outputs are coupled to the amplifier through a combiner and harmonic filter. The measured output of the driver is - distortion 3rd order-50dB and harmonics is greater than -40dB. This system ensures that the driver is making negligible contribution to the performance of the amplifier.

To obtain accurate measurements it is essential to take extensive precautions. All connections are made through correctly terminated high quality coaxial cables. The connections between the amplifier and test equipment are extensively decoupled by using ferrite sleeves on all coaxial cables. The spectrum analyzer is physically separated from the other equipment by approximately 5 metres. Without these precautions, accurate measurements are impossible. Common mode currents and even the smallest level of RF feedback causes highly inaccurate readings.

In real life the amplifier will not be operated under the laboratory conditions, and practical test measurements should be made with the exciter that will be used in the system. It should be remembered that any exciter spurious products will not be attenuated by the amplifier unless they are above the cutoff frequency of the operational filter. Exciter harmonics will be attenuated by the amplifier low pass filters, however, there may be some degradation of harmonic suppression and an increase of distortion if the exciter harmonics are not suppressed 35-40dB. It is desirable that the intermodulation distortion in the exciter be as low as possible, although distortion levels 6dB below the amplifier distortion level will make a negligible contribution to the overall distortion level. In practice we have found that the linearity characteristics of modern solid state exciters are such that frequently there is no increase in distortion, even if the distortion levels of the exciter and amplifier are similar. In fact, in many instances the exciter and amplifier distortion characteristics are such that the overall linearity is improved.

It will be noted that there is a small increase in the distortion products at the high end of the frequency range. At the high frequency end of the range transistors are getting toward the limits of their frequency capability at full power. The distortion and harmonic measurements listed in the specifications represent the worst case conditions. Over most of the frequency range the performance will be substantially better than the published specification.

TABLE 3. Parts List
(Except Amplifier, Control and ALC Modules)

Ref.	Part Number	Location	Description
C1	280001	Chassis	Capacitor, Oil 66OV AC 8
C2	280001	Chassis	Capacitor, Oil 660V AC 8
C3	260800	Comp. Network	Capacitor, Comp. Trimmer 80pF
C4	212121	Comp. Network	Capacitor, Disc 120pF
C5	220431	Swr. Board	Capacitor, Mica DM15 430pF
C6	230300	Chassis	Capacitor, Electrolytic 100V 30
C7	230104	Chassis	Capacitor, Electrolytic 30V 100,000
C8	230104	Chassis	Capacitor, Electrolytic 30V 100,000
C9	211103		Not Used.
C10	220150	Swr. Board	Capacitor, Mica DM15 15pF
C11	220150	Swr. Board	Capacitor, Mica DM15 15pF
C12	241001	Swr. Board	Capacitor, Tantalum .1
C13	211103	Rear Panel	Capacitor, Disc 500V .01
C14	210103	Swr. Board	Capacitor, Disc 25V .01
C15	210103	Swr. Board	Capacitor, Disc 25V .01
C16	211103	Rear Panel	Capacitor, Disc 500V .01
C17			Not Used.
C18			Not Used.
C19			Not Used.
C20	211103	Input Relay	Capacitor, Disc 500V .01
C21	211103	Input Relay	Capacitor, Disc 500V .01
C22	211103	Filter Assy.	Capacitor, Disc 500V .01
C23	211103	Filter Assy.	Capacitor, Disc 500V .01
C24	211103	Filter Assy.	Capacitor, Disc 500V .01
C25	211103	Filter Assy.	Capacitor, Disc 500V .01
C26	211103	Filter Assy.	Capacitor, Disc 500V .01
C27	211103	Filter Assy.	Capacitor, Disc 500V .01
C28	211103	Filter Assy.	Capacitor, Disc 500V .01
C29	211103	Filter Assy.	Capacitor, Disc 500V .01
C30	211103	Filter Assy.	Capacitor, Disc 500V .01
C31	211103	Filter Assy.	Capacitor, Disc 500V .01
C32	211103	Filter Assy.	Capacitor, Disc 500V .01
C33	211103	Filter Assy.	Capacitor, Disc 500V .01
C34	211103	Filter Assy.	Capacitor, Disc 500V .01
C35	211103	Filter Assy.	Capacitor, Disc 500V .01
C36	211103	Filter Assy.	Capacitor, Disc 500V .01
C37	211103	Filter Assy.	Capacitor, Disc 500V .01
C38	211103	Filter Assy.	Capacitor, Disc 500V .01
C39	211103	Filter Assy.	Capacitor, Disc 500V .01
C40	211103	Filter Assy.	Capacitor, Disc 500V .01
C41	211103	Filter Assy.	Capacitor, Disc 500V .01
C42	211103	Filter Assy.	Capacitor, Disc 500V .01
C43	211103	Filter Assy.	Capacitor, Disc 500V .01
C44	211103	Filter Assy.	Capacitor, Disc 500V .01
C45	211103	Filter Assy.	Capacitor, Disc 500V .01
C46	211103	Rear Panel	Capacitor, Disc 500V .01
C47	211103	Rear Panel	Capacitor, Disc 500V .01
C48	212560	Filter Assy.	Capacitor, Disc 56pF 3kV
C49	212470	Filter Assy.	Capacitor, Disc 47pF 3kV

TABLE 3. Parts List
(Except Amplifier, Control and ALC Modules), Continued.

Ref.	Part Number	Location	Description
C50A	212560	Filter Assy.	Capacitor, Disc 56pF 3kV
C50B	212680	Filter Assy.	Capacitor, Disc 68pF 3kV
C51	212680	Filter Assy.	Capacitor, Disc 68pF 3kV
C52A	212560	Filter Assy.	Capacitor, Disc 56pF 3kV
C52B	212820	Filter Assy.	Capacitor, Disc 82pF 5kV
C53	212120	Filter Assy.	Capacitor, Disc 12pF 3kV
C54A	212390	Filter Assy.	Capacitor, Disc 39pF 3kV
C54B	212390	Filter Assy.	Capacitor, Disc 39pF 3kV
C55A	212101	Filter Assy.	Capacitor, Disc 100pF 3kV
C55B	212271	Filter Assy.	Capacitor, Disc 270pF 2kV
C55C	212391	Filter Assy.	Capacitor, Disc 390pF 2kV
C56A	212470	Filter Assy.	Capacitor, Disc 47pF 5kV
C56B	212470	Filter Assy.	Capacitor, Disc 47pF 5kV
C56C	212390	Filter Assy.	Capacitor, Disc 39pF 5kV
C57A	212471	Filter Assy.	Capacitor, Disc 470pF 2kV
C57B	212471	Filter Assy.	Capacitor, Disc 470pF 2kV
C57C	212471	Filter Assy.	Capacitor, Disc 470pF 2kV
C58A	212271	Filter Assy.	Capacitor, Disc 270pF 2kV
C58B	212271	Filter Assy.	Capacitor, Disc 270pF 2kV
C58C	212820	Filter Assy.	Capacitor, Disc 82pF 5kV
C59A	212121	Filter Assy.	Capacitor, Disc 120pF 3kV
C59B	212471	Filter Assy.	Capacitor, Disc 470pF 2kV
C59C	212681	Filter Assy.	Capacitor, Disc 680pF 2kV
C60A	212391	Filter Assy.	Capacitor, Disc 390pF 2kV
C60B	212101	Filter Assy.	Capacitor, Disc 100pF 3kV
C61A	212391	Filter Assy.	Capacitor, Disc 390pF 2kV
C61B	212101	Filter Assy.	Capacitor, Disc 100pF 3kV
C62A	212151	Filter Assy.	Capacitor, Disc 150pF 4kV
C62B	212151	Filter Assy.	Capacitor, Disc 150pF 4kV
C62C	212151	Filter Assy.	Capacitor, Disc 150pF 4kV
C63A	212390	Filter Assy.	Capacitor, Disc 39pF 5kV
C63B	212390	Filter Assy.	Capacitor, Disc 39pF 5kV
C64A	212391	Filter Assy.	Capacitor, Disc 390pF 2kV
C64B	212391	Filter Assy.	Capacitor, Disc 390pF 3kV
C64C	212680	Filter Assy.	Capacitor, Disc 68pF 5kV
C65A	212271	Filter Assy.	Capacitor, Disc 270pF 2kV
C65B	212101	Filter Assy.	Capacitor, Disc 100pF 3kV
C66A	212391	Filter Assy.	Capacitor, Disc 390pF 2kV
C66B	212271	Filter Assy.	Capacitor, Disc 270pF 2kV
C66C	212101	Filter Assy.	Capacitor, Disc 100pF 3kV
C67A	212560	Filter Assy.	Capacitor, Disc 56pF 3kV
C67B	212121	Filter Assy.	Capacitor, Disc 120pF 3kV
C67C	212121	Filter Assy.	Capacitor, Disc 120pF 3kV
C68A	212560	Filter Assy.	Capacitor, Disc 56pF 3kV
C68B	212121	Filter Assy.	Capacitor, Disc 120pF 3kV
C68C	212121	Filter Assy.	Capacitor, Disc 120pF 3kV
C69A	212101	Filter Assy.	Capacitor, Disc 100pF 3kV
C69B	212101	Filter Assy.	Capacitor, Disc 100pF 3kV
C69C	212820	Filter Assy.	Capacitor, Disc 82pF 5kV
C70	212470	Filter Assy.	Capacitor, Disc 47pF 3kV

TABLE 3. Parts List
(Except Amplifier, Control and ALC Modules), Continued.

Ref.	Part Number	Location	Description
C71A	212271	Filter Assy.	Capacitor, Disc 270pF 2kV
C71B	212201	Filter Assy.	Capacitor, Disc 200pF 3kV
C71C	212560	Filter Assy.	Capacitor, Disc 56pF 3kV
C72A	212151	Filter Assy.	Capacitor, Disc 150pF 4kV
C72B	212820	Filter Assy.	Capacitor, Disc 82pF 5kV
C73A	212271	Filter Assy.	Capacitor, Disc 270pF 2kV
C73B	212201	Filter Assy.	Capacitor, Disc 200pF 3kV
C74A	212560	Filter Assy.	Capacitor, Disc 56pF 3kV
C74B	212560	Filter Assy.	Capacitor, Disc 56pF 3kV
C74C	212680	Filter Assy.	Capacitor, Disc 68pF 5kV
C75A	212560	Filter Assy.	Capacitor, Disc 56pF 3kV
C75B	212560	Filter Assy.	Capacitor, Disc 56pF 3kV
C75C	212680	Filter Assy.	Capacitor, Disc 68pF 5kV
C76	211103	Rear Panel	Capacitor, Disc 500V .01
C77	211103	Rear Panel	Capacitor, Disc 500V .01
C78A	212101	Filter Assy.	Capacitor, Disc 100pF 3kV
C78B	212820	Filter Assy.	Capacitor, Disc 82pF 5kV
C78C	212820	Filter Assy.	Capacitor, Disc 82pF 5kV
C79A	212390	Filter Assy.	Capacitor, Disc 39pF 5kV
C79B	212470	Filter Assy.	Capacitor, Disc 47pf 5kV
C80A	212121	Filter Assy.	Capacitor, Disc 120pF 3kV
C80B	212121	Filter Assy.	Capacitor, Disc 120pF 3kV
C80C	212560	Filter Assy.	Capacitor, Disc 56pF 3kV
C81	212470	Filter Assy.	Capacitor, Disc 47pF 5kV
C82A	212470	Filter Assy.	Capacitor, Disc 47pF 5kV
C82B	212470	Filter Assy.	Capacitor, Disc 47pF 5kV
C82C	212390	Filter Assy.	Capacitor, Disc 39pF 5kV
C83A	212390	Filter Assy.	Capacitor, Disc 39pF 5kV
C83B	212390	Filter Assy.	Capacitor, Disc 39pF 5kV
C83C	212390	Filter Assy.	Capacitor, Disc 39pF 5kV
C84A	212100	Filter Assy.	Capacitor, Disc 10pF 3kV
C84B	212100	Filter Assy.	Capacitor, Disc 10pF 3kV
C85A	212820	Filter Assy.	Capacitor, Disc 82pF 5kV
C85B	212820	Filter Assy.	Capacitor, Disc 82pF 5kV
C85C	212470	Filter Assy.	Capacitor, Disc 47pf 5kV
C86A	212470	Filter Assy.	Capacitor, Disc 47pF 5kV
C86B	212470	Filter Assy.	Capacitor, Disc 47pF 5kV
C87A	212680	Filter Assy.	Capacitor, Disc 68pF 5kV
C87B	212680	Filter Assy.	Capacitor, Disc 68pF 5kV
C87C	212560	Filter Assy.	Capacitor, Disc 56pF 3kV
C88A	212390	Filter Assy.	Capacitor, Disc 39pF 5kV
C88B	212390	Filter Assy.	Capacitor, Disc 39pF 5kV
C89	210103	Rear Panel	Capacitor, Disc 500V .01
C90A	212390	Filter Assy.	Capacitor, Disc 39pF 5kV
C90B	212390	Filter Assy.	Capacitor, Disc 39pF 5kV
C91	211103	Rear Panel	Capacitor, Disc 500V .01
C92	211103	Chassis	Capacitor, Disc 500V .01
C93	211103	Chassis	Capacitor, Disc 500V .01
C94			Not Used.

TABLE 3. Parts List
(Except Amplifier, Control and ALC Modules), Continued.

Ref.	Part Number	Location	Description
C95	230201	Chassis	Capacitor, Electrolytic 16V 200
C96			Not Used.
C97			Not Used.
C98	211103	Rear Panel	Capacitor, Disc 500V .01
C99	211103	Rear Panel	Capacitor, Disc 500V .01
D1	320104	Chassis	Diode, 85 Amp 200 Piv Reverse Polarity
D2	320104	Chassis	Diode, 85 Amp 200 Piv Reverse Polarity
D3			Not Used.
D4			Not Used.
D5	320002	Swr. Board	Diode, 1N4148
D6	320002	Swr. Board	Diode, 1N4148
D7			Not Used.
D8			Not Used.
D9			Not Used.
D10			Not Used.
D11			Not Used.
D12			Not Used.
D13			Not Used.
D14			Not Used.
FAN	770001	Rear Panel	Fan 110V
FA	490501	Various	Sleeve, Ferrite .1" X 1.12"
FB	490302	Various	Bead, Ferrite .2" X .35"
FC	490202	Various	Bead, Ferrite .2" X .45"
F1	550006	Chassis	Fuse, 15A for 230V
	550007	Chassis	Fuse, 30A for 115V
K1	540008	Input Relay	Relay, DPDT 12V
K2	540013	Output Relay	Relay, SPDT 12V
K3	540013	Filter Assy.	Relay, SPDT 12V
K4	540013	Filter Assy.	Relay, SPDT 12V
K5	540013	Filter Assy.	Relay, SPDT 12V
K6	540013	Filter Assy.	Relay, SPDT 12V
K7	540013	Filter Assy.	Relay, SPDT 12V
K8	540013	Filter Assy.	Relay, SPDT 12V
K9	540013	Filter Assy.	Relay, SPDT 12V
K10	540013	Filter Assy.	Relay, SPDT 12V
K11	540013	Filter Assy.	Relay, SPDT 12V
K12	540013	Filter Assy.	Relay, SPDT 12V
K13	540013	Filter Assy.	Relay, SPDT 12V
K14	540013	Filter Assy.	Relay, SPDT 12V
L1	450105	Comp. Network	Inductor, Special
L2	D450106	Comp. Network	Inductor, Special
L3			Not Used.
L4			Not Used.
L5	450411	Filter Assy.	Inductor, Air 20-30MHz
L6	450411	Filter Assy.	Inductor, Air 20-30MHz
L7	450412	Filter Assy.	Inductor, Air 20-30MHz

TABLE 3. Parts List
(Except Amplifier, Control and ALC Modules), Continued.

Ref.	Part Number	Location	Description
L8	450501	Filter Assy.	Inductor, Toroidal 2-3MHz
L9	450502	Filter Assy.	Inductor, Toroidal 2-3MHz
L10	450502	Filter Assy.	Inductor, Toroidal 2-3MHz
L11	450503	Filter Assy.	Inductor, Toroidal 3-5MHz
L12	450504	Filter Assy.	Inductor, Toroidal 3-5MHz
L13	450504	Filter Assy.	Inductor, Toroidal 3-5MHz
L14	450505	Filter Assy.	Inductor, Toroidal 5-8MHz
L15	450506	Filter Assy.	Inductor, Toroidal 5-8MHz
L16	450506	Filter Assy.	Inductor, Toroidal 5-8MHz
L17	450508	Filter Assy.	Inductor, Toroidal 8-13MHz
L18	450507	Filter Assy.	Inductor, Toroidal 8-13MHz
L19	450509	Filter Assy.	Inductor, Toroidal 13-20MHz
L20	430202	Filter Assy.	Inductor, Air 13-20MHz
L21	450510	Filter Assy.	Inductor, Toroidal 13-20MHz
L22	450507	Filter Assy.	Inductor, Toroidal 8-13MHz
L23			Not Used.
L24	450140	Comp. Network	Inductor, Special
M1	740005	Front Panel	Meter, Special
M2	740008	Front Panel	Meter, 50 Amp DC Scale
M3	740008	Front Panel	Meter, 50 Amp DC Scale
PL2	670901	Chassis	AC Plug
Q1	330132	Chassis	IC UA7812KC
Q2			Not Used.
Q3			Not Used.
Q4			Not Used.
R1A	153201	Comp. Network	Resistor, Flameproof 2W 200
R1B	153201	Comp. Network	Resistor, Flameproof 2W 200
R1C	153201	Comp. Network	Resistor, Flameproof 2W 200
R1D	153201	Comp. Network	Resistor, Flameproof 2W 200
R1E	153201	Comp. Network	Resistor, Flameproof 2W 200
R2A	153221	Comp. Network	Resistor, Flameproof 2W 220
R2B	153221	Comp. Network	Resistor, Flameproof 2W 220
R2C	153221	Comp. Network	Resistor, Flameproof 2W 220
R2D	153221	Comp. Network	Resistor, Flameproof 2W 220
R3	170104	Swr. Board	Resistor, Trimmer 50K
R4	124470	Swr. Board	Resistor, Film 1/4W 5% 47
R5			Not Used.
R6			Not Used.
R7	144101	Input Comb.	Resistor, Film 1W 5% 100
R8	144101	Input Comb.	Resistor, Film 1W 5% 100
R9	144101	Input Comb.	Resistor, Film 1W 5% 100
R10	144101	Input Comb.	Resistor, Film 1W 5% 100
R11			Not Used.
R12			Not Used.
R13			Not Used.
R14			Not Used.

TABLE 3. Parts List
(Except Amplifier, Control and ALC Modules), Continued.

Ref.	Part Number	Location	Description
R15			Not Used.
R16			Not Used.
R17			Not Used.
R18			Not Used.
R19			Not Used.
R20			Not Used.
R21			Not Used.
R22			Not Used.
R23A	153201	Output Comb.	Resistor, Flameproof 2W 200
R23B	153201	Output Comb.	Resistor, Flameproof 2W 200
R24A	153201	Output Comb.	Resistor, Flameproof 2W 200
R24B	153201	Output Comb.	Resistor, Flameproof 2W 200
R25A	153201	Output Comb.	Resistor, Flameproof 2W 200
R25B	153201	Output Comb.	Resistor, Flameproof 2W 200
R26A	153201	Output Comb.	Resistor, Flameproof 2W 200
R26B	153201	Output Comb.	Resistor, Flameproof 2W 200
R27			Not Used.
R28			Not Used.
R29			Not Used.
R30			Not Used.
R31			Not Used.
R32			Not Used.
R33			Not Used.
R34			Not Used.
R35			Not Used.
R36			Not Used.
R37			Not Used.
R38	154182	Comp. Network	Resistor, 2W 1.8K
R39	153221	Comp. Network	Resistor, Flameproof 2W 220
R40	153220	Comp. Network	Resistor, 2W 22
R41			Not Used.
R42			Not Used.
S1	530201	Front Panel	Switch, Rocker Power
S2	510025	Front Panel	Switch, Rotary 1 Pole 12 Position
S3	570005	Front Panel	Circuit Breaker 100 Amp
S4			Not Used.
S5			Not Used.
S6	530001	Front Panel	Switch, Pushbutton
S03	610014	Rear Panel	Socket, 12 Pin
S01	610003	Rear Panel	Socket, Coax S0239
S02	610003	Rear Panel	Socket, Coax S0239
TH1	560001	Heatsink	Thermostat N/C 75 C
TH2	560003	Output Comb.	Thermostat N/C 85 C
TH3	560002	Heatsink	Thermostat N/O 60 C
T1	410018	Chassis	Transformer CVT 28V

TABLE 3. Parts List
(Except Amplifier, Control and ALC Modules), Continued.

Part Number	Location	Description
630101	Front Panel	Socket LED
870005	Various	Terminal Insulated Bifurcated
700101	Combiner Assy.	Input
700102	Combiner Assy.	Output
530301	Pushbutton Assy.	(Consists of 2x pushbutton switches, 2x P.C. Boards and mounting plates.)
731004	Filter Assy.	Printed Circuit Board
731008	Swr./Metering	Printed Circuit Board
731009	Compensating Network	Printed Circuit Board

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

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

Ref.	Part Number	Description
C1	211103	Capacitor, Disc 500V .01
C2	210104	Capacitor, Disc 25V .1
C3	210104	Capacitor, Disc 25V .1
C4	211103	Capacitor, Disc 500V .1
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 60V 1
C10	240010	Capacitor, Tantalum 60V 1
C11	230201	Capacitor, Electrolytic 16V 200
C12	215102	Capacitor, Chip 100V .001
C13		Not Used.
C14		Not Used.
C15		Not Used.
C16		Not Used.
D1	320103	Diode, Silicon 3 Amp 50V
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	Resistor, Flameproof 2W 220
R6	153221	Resistor, Flameproof 2W 220
R7		Not Used.
R8		Not Used.
R9		Not Used.
R10		Not Used.
R11		Not Used.
R12	124047	Resistor, Film 1/4W 5% 4.7

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

Table 5. Parts List, Control Board.

C1	210102	Capacitor, Disc 25 V .001
C2	210102	Capacitor, Disc 25 V .001
C3	210102	Capacitor, Disc 25 V .001
C4	210103	Capacitor, Disc 25 V .01
C5	210103	Capacitor, Disc 25 V .01
C6	210103	Capacitor, Disc 25 V .01
C7	241010	Capacitor, Tantalum 1
C8-C18		Not Used.
C19	241010	Capacitor, Tantalum 1
C20-C111		Not Used.
C112	210102	Capacitor, Disc 25 V .001
C113	241226	Capacitor, Tantalum 22
D1	320101	Diode, 1N4005
D2	320101	Diode, 1N4005
D3	320101	Diode, 1N4005
D4	320101	Diode, 1N4005
D5	320101	Diode, 1N4005
D6	320101	Diode, 1N4005
D7	320101	Diode, 1N4005
D8	320101	Diode, 1N4005
D9	320002	Diode, 1N4148
Q1	310027	Transistor, 2N5306
Q2	310027	Transistor, 2N5306
Q3	310027	Transistor, 2N5306
Q4	310053	Transistor, NPN TIP120
Q5	310053	Transistor, NPN TIP120
Q6	320602	SCR EC103Y
R1	124102	Resistor, Film 1/4W 5% 1K
R2	124272	Resistor, Film 1/4W 5% 2.7K
R3	124102	Resistor, Film 1/4W 5% 1K
R4	124222	Resistor, Film 1/4W 5% 2.2K
R5	124104	Resistor, Film 1/4W 5% 100K
R6	124223	Resistor, Film 1/4W 5% 22K
R7	124221	Resistor, Film 1/4W 5% 220
R8	124103	Resistor, Film 1/4W 5% 10K
R9	124473	Resistor, Film 1/4W 5% 47K
R10	124470	Resistor, Film 1 4W 5% 47
R11	170103	Resistor, Trimmer 5K
R12	124101	Resistor, Film 1/4W 5% 100
R13	124103	Resistor, Film 1/4W 5% 10K
R14	124222	Resistor, Film 1/4W 5% 2.2K
R15	144471	Resistor, 1W 470
R16	144471	Resistor, 1W 470
R17	124472	Resistor, Film 1/4W 5% 4.7K
R18	124104	Resistor, Film 1/4W 5% 100K
R19	124472	Resistor, Film 1/4W 5% 4.7K
R20-R26		Not Used.
R27	124681	Resistor, Film 1/4W 5% 680

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

TABLE 6. Parts List, ALC Board.

C76	220431	Capacitor, Mica DM15 430pF
C77	210102	Capacitor, Disc 25V .001
C78-C88		Not Used.
C89A	220150	Capacitor, Mica DM15 15pF
C89B	220150	Capacitor, Mica DM15 15pF
C90		Not Used.
C91	220431	Capacitor, Mica DM15 430pF
C92	210103	Capacitor, Disc 25V .01
C93	210103	Capacitor, Disc 25V .01
C94	210103	Capacitor, Disc 25V .01
C95	210103	Capacitor, Disc 25V .01
C96	210103	Capacitor, Disc 25V .01
C97	241001	Capacitor, Tantalum .1
C98	241020	Capacitor, Tantalum 2.2
C99	210103	Capacitor, Disc 25V .01
D10	320002	Diode, 1N4148
D11	320002	Diode, 1N4148
D12	320002	Diode, 1N4148
D13	320002	Diode, 1N4148
D14	320002	Diode, 1N4148
D15	320002	Diode, 1N4148
L3	490202	Inductor, Bead
R29	134470	Resistor, Film 1/2W 5% 47
R30	124222	Resistor, Film 1/4W 5% 2.2K
R31	170106	Resistor, Trimmer 500K
R32	124102	Resistor, Film 1/4W 5% 1K
R33	124103	Resistor, Film 1/4W 5% 10K
R34	170101	Resistor, Trimmer 10K
T4	490401	Transformer, RF

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

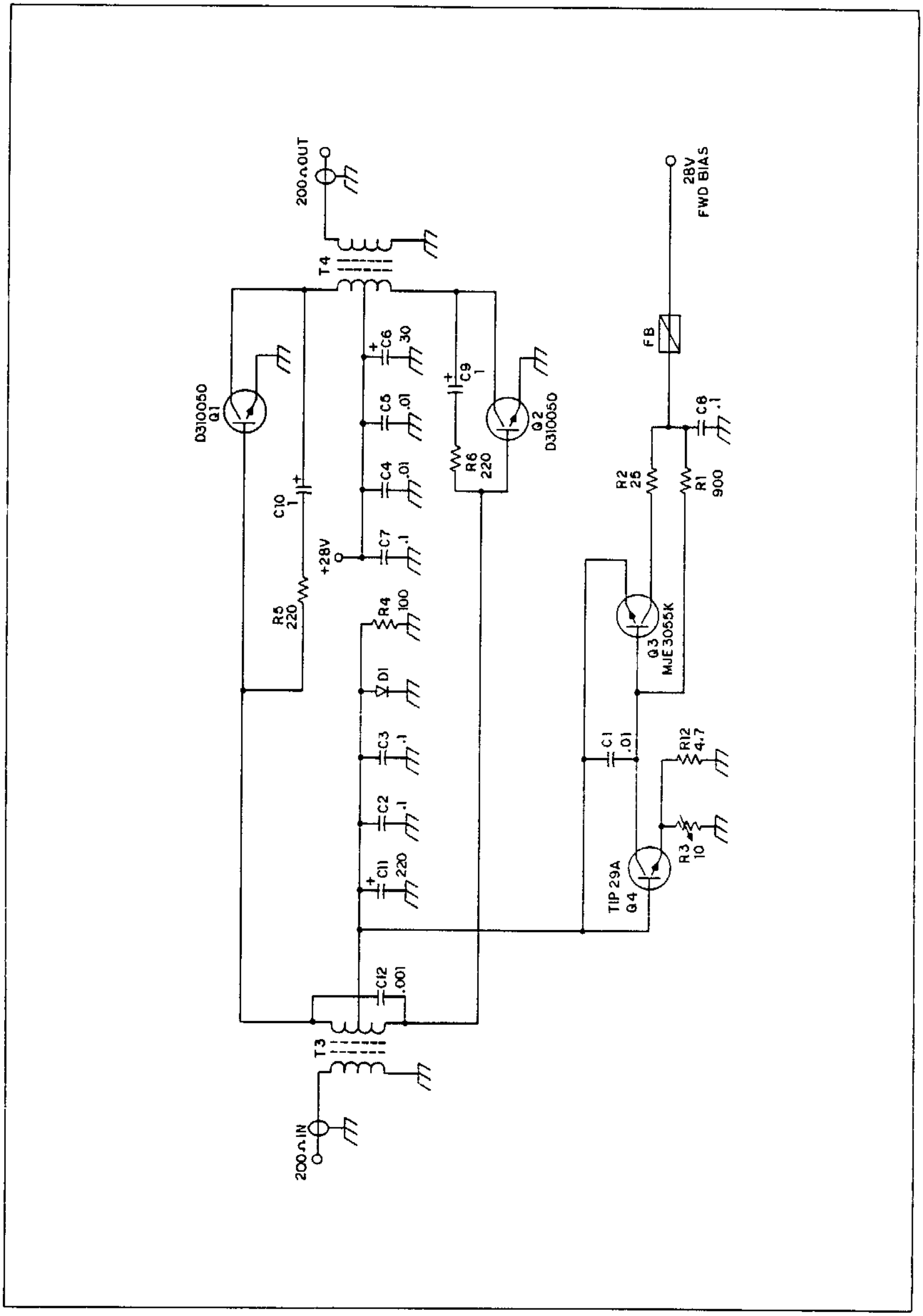
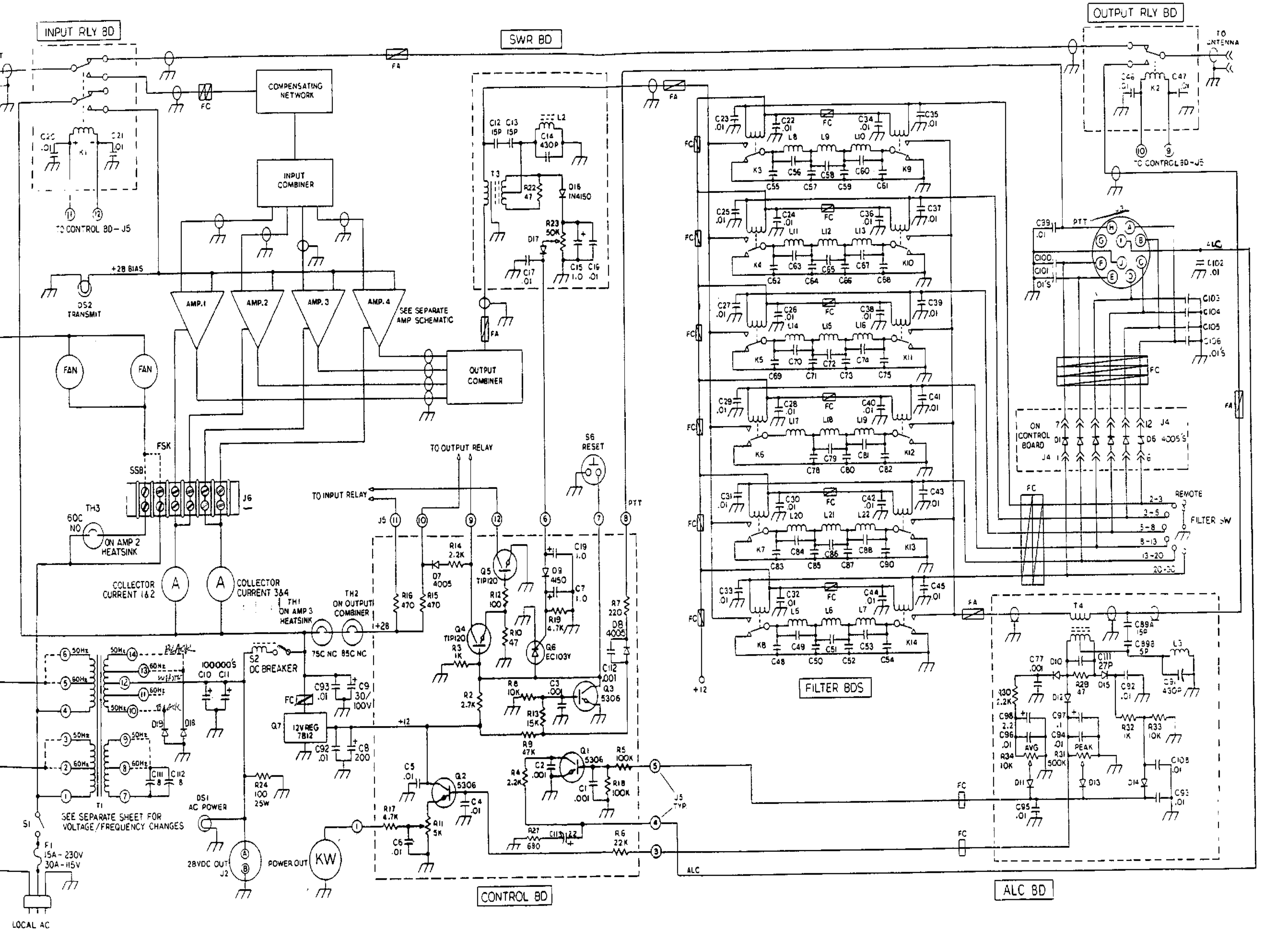


Figure 8. Schematic Diagram, Amplifier Module.


INPUT RLY BD
SWR BD
OUTPUT RLY BD
TO ANTENNA
COMPENSATING NETWORK
INPUT COMBINER
TO CONTROL BD-J5
+28 BIAS
DS2 TRANSMIT
AMP.1
AMP.2
AMP.3
AMP.4
SEE SEPARATE AMP SCHEMATIC
OUTPUT COMBINER
FAN
FAN
FSK
SSB
J6
TH3
60C NO
ON AMP 2 HEATSINK
COLLECTOR CURRENT 1&2
COLLECTOR CURRENT 3&4
TH1 ON AMP 3 HEATSINK
TH2 ON OUTPUT COMBINER
75C NC
85C NC
TO OUTPUT RELAY
TO INPUT RELAY
S6 RESET
PTT
S2 DC BREAKER
Q7 12V REG 7812
SEE SEPARATE SHEET FOR VOLTAGE/FREQUENCY CHANGES
DS1 AC POWER
28VDC OUT J2
POWER OUT
KW
F1 15A-230V 30A-115V
LOCAL AC
J5 TYP.
ALC
CONTROL BD
FILTER BDS
ON CONTROL BOARD
J4
D6 4005'S
REMOTE
FILTER SW
ALC BD