TRANS WORLD ELECTRONICS

T500M
LINEAR AMPLIFIER

T500M Installation & Service Manual

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TRANS WORLD ELECTRONICS, INC.

T500M

INSTALLATION AND SERVICE MANUAL

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SCHEMATICS AND DIAGRAMS

PARTS LIST

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SECTION 1

GENERAL INFORMATION

1.1 GENERAL INFORMATION

The T500M Linear Amplifier is designed to amplify the output from medium power (600W PEP output minimum), transmitters and transceivers operating on any frequency in the range 2 - 30 MHz. The amplifier has a power gain of approximately 10dB and is rated for a power output of 500W PEP. The amplifier operates directly from a 12V power source and provides the rate output at 13.6V DC. The amplifier is suitable for mobile operation directly from a vehicle, ship or aircraft 12V system, or with a separate power source is an ideal base station amplifier.

1.2 THE T500M AMPLIFIER

The T500M Linear Amplifier is designed for reliable operation over the entire frequency range 2 - 30 MHz. The design is all solid state using 8 transistors in (4) push pull amplifiers. 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 and installation. Unlike vacuum tube amplifiers, there are no high voltages, and all circuitry operates at 12V giving the components an extended service life.

1.3 MOBILE OPERATION

The T500M Linear Amplifier operates directly from the 12V system and requires no power supply or voltage conversion. This gives much improved efficiency compared with vacuum tubes and there is no standby current drain or warmup time. The remote control facilities and the fact that there are no operating adjustments, make the amplifier ideal for trunk mounting in automobiles. The amplifier is extremely compact and installation should be simple in almost any mobile application.

1.4 BASE STATION OPERATION

The T500M is equally suited to fixed operation, if a suitable power source is provided. The PS75 power supply provides an economical 13.6V 75A peak power source for operation from 115V/230V, 50/60 Hz AC supplies. An alternate economical power source can be constructed at low cost using a standard vehicle 12V battery and a 15A battery charger. The mobile mount is constructed for simple removal so that the amplifier can be readily interchanged between mobile and fixed service.

1.5 OPERATION

The T500M has no tuning adjustments and requires no operator skills. Unlike vacuum tube amplifiers, the transistor amplifiers and combining networks use broadband transformers and combiners compensated for uniform output acros the entire HF range. The exciter frequency can be changed anywhere in the range without making a single adjustment to the amplifier. The harmonic filter selection can usually be controlled from the exciter and this means that operation is simply a matter of setting the correct drive level. If the exciter has an effective ALC system, even the driver level can be preset.

1.6 FILTERS

The T500M uses five 5 pole low ripple Tchebycheff low pass filters. The frequency range is divided into 5 bands and the correct filter for the operating range should be selected. The filters are remotely switched by the exciter channel switch or the frequency selector in synthesized equipment. Alternate a separate 5 position switch may be used for filter selection. The modern computer designed filters use toroidal inductors for efficient harmonic suppression throughout the frequency range.

1.7 METERING

A front panel meter (100A full scale) monitors the collector current. This provides an accurate monitor of amplifier performance, provided the amplifier is operated into a correctly matched load.

1.8 PROTECTIVE CIRCUITRY

A. A high speed 75A magnetic circuit breaker is provided in the positive supply line. This circuit breaker protects against short circuits, overdrive and mismatched antennas.

B. A polarity protect diode prevents the amplifier operating if the supply polarity is accidentally reversed.

C. A 75°C thermostat is mounted on the transistor heatsink. If the heatsink temperature should become excessive, the amplifier will switch off and connect the exciter to the antenna. The amplifier will switch back on as soon as the heatsink cools.

1.9 OPERATING MODES

The amplifier is primarily designed for SSB operation, but is suitable for CW or brief FSK operation at a maximum collector current of 75A. In the FSK mode, the operating time will be limited by the heatsink temperature and may be extended by the use of an external cooling fan.

1.10 REMOTE CONTROL

The amplifier is fully remote controlled. The power is switched by a heavy duty relay and the filters are also remotely selectable. All control functions are accomplished by grounding the appropriate control line.

1.11 TRANSMIT/RECEIVE SWITCHING

The amplifier is switched to the transmit mode by grounding the appropriate control line. Normally this line will be connected in parallel with the exciter microphone PTT switch. In the receive mode, the amplifier is bypassed for transceiver operation.

1.12 CONSTRUCTION

The amplifier is constructed on a large, finned aluminum heatsink which forms the main structural member of the amplifier. The heatsink is on the top of the amplifier and forms the top of the chassis which is constructed of .090 aluminum bolted to the heatsink. The baseplate serves as a cover for the amplifier and is removable for service. The entire amplifier and heatsink is finished in an attractive hard wearing black anodizing. The construction is very strong and the amplifier is suitable for use under the most severe environmental conditions.

1.13 EXCITERS

The amplifier has a 50 ohm input and provides a good match to transmitters designed for 50 ohm output. The drive level is within the capabilities of almost all modern equipment. The gain and/or ALC system should be set to limit the exciter power output to 60W PEP (approximately 120W input). The amplifier faithfully reproduces the input signal and if the input is distorted, the output will also be distorted. Similarly, the amplifier will reproduce any spurious outputs below the filter cutoff frequency. The harmonic output is determined by the output filters, however, it is desirable for the drive signal to have harmonics suppressed by at least 25dB.

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SECTION 2

TECHNICAL SPECIFICATIONS

POWER OUTPUT PEP	600W typical 500W minimum (2-24 MHz)
INTERMODULATION DISTORTION	
	2-24 MHz 500W PEP -32 dB 3rd Order 400W PEP -36 dB 3rd Order
FREQUENCY RANGE	2-30 MHz
HARMONIC FILTERS	5 pole Tchebycheff Low Pass
	Ranges: 2-3 MHz, 3-5 MHz, 5-8 MHz 8-15 MHz, 15-30 MHz
HARMONICS	-43dB minimum
DRIVE LEVEL	60W PEP 50 ohms (S0239 connector)
OUTPUT IMPEDANCE	50 ohms (S0239 connector)
POWER REQUIREMENTS	11-13.6V DC negative ground 75A maximum 40A average voice
POWER SWITCHING	Remote controlled relay - (ground control line)
TRANSMIT-RECEIVE SWITCHING	Ground control line
AMPLIFIER OFF	Amplifier is bypassed when switched off
COOLING	Convection cooled heatsink protected by 75°C thermostat.
FUSES	80A High speed magnetic circuit breaker
SIZE	10cm H X 25cm W X 47cm L (4" X 10" X 18.5")
WEIGHT	8 kilos (18 lbs.)

NOTE: All performance specifications measured with supply voltage 13.6V DC measured at amplifier under load.

SECTION 2

TECHNICAL SPECIFICATIONS (cont'd)

FUSES	80A High speed magnetic circuit breaker
SIZE	10cm H X 25cm W X 47cm L (4" X 10" X 18.5")
WEIGHT	8 kilos (18 lbs.)

NOTE: All performance specifications measured with supply voltage 13.6V DC measured at amplifier under load.

SECTION 3

INSTALLATION

3.1 MOBILE INSTALLATION

The amplifier may be mounted in any location where it is not exposed to excessive heat and where the cooling fins will not be obstructed. The amplifier is designed for mounting on any flat surface. Temporarily place the mobile mount on the amplifier and set the amplifier in the chosen position. Mark the position of the base of the mount and then remove from the amplifier. Use the mount as a template and drill holes through the mounting surface. Bolt the mount securely in place. Replace the amplifier in the mount then press the amplifier firmly down against the mounting feet and tighten the 2 retaining screws. This completes the amplifier mounting.

3.2 FIXED OPERATION

The amplifier may be placed on the desk top adjacent to the exciter or may be located in any convenient remote location. Make sure that the amplifier is kept out of direct sunlight and other sources of heat and ensure that the cooling fins are not obstructed.

3.3 POWER CONNECTIONS

The power connections to the amplifier are extremely important, as the amplifier draws instantaneous peak currents in excess of 100A. The amplifier will only deliver the rated power output when the voltage, at the amplifier at maximum current drain, is 13.6V. The ideal mobile installation is with the amplifier mounted very close to the battery so that the length of the connecting leads does not exceed 40 or 50 cm (15" to 20").

If the amplifier is mounted in the trunk of an automobile and the battery is in the front of the vehicle, it is essential to use very heavy gauge (#8 AWG) wiring to minimize the voltage drop in the connecting cables. The cables should be terminated directly on the battery terminals and the connections and must have negligible resistance. Take special care with the mounting of the cable to ensure there is no possibility of shorts to ground. Heavy gauge wiring will carry very high currents if there is a short circuit and may result in a fire.

Even when taking all possible precautions to minimize the voltage drop, there will always be some loss in long power cable runs and the output of the amplifier will be less than with direct connections to the battery. An alternate method of installation is to mount a separate battery in the trunk adjacent to the amplifier. The power connections can then be made directly to the ancillary battery. The connecting cables to the vehicle power system will then only carry the battery charging current and a small voltage drop from the generator will not affect the amplifier power output. The average battery charging current will normally not exceed 15A and 14 AWG cables may be used between the battery and the charging system.

The cables should be terminated in the lugs provided with the amplifier. Use a large soldering iron to solder the cable into the lug, making sure the solder flows into the lug to make a low resistance connection. The lugs should be connected to the brass bolts on the amplifier and the wing nuts screwed down securely.

3.4 POWER SUPPLIES - BASE STATION

The amplifier may be used with any 13.6V DC power supply capable of peak currents of 75A and an average current of 35A. The supply should maintain good voltage regulation with low ripple.

The PS75 is specially designed for use with the T500M and provides a well regulated 13.6V supply source, when operating from 115/230V 50/60 mHz power mains. The voltage sensing leads terminate at the output terminals and compensate for any voltage drop in the internal power supply leads. This ensures that 13.6V is maintained at the output at maximum load.

An alternate low cost power supply can be constructed using a 12V auto battery and a 15A charger. Although the collector currents peak over 70A, the average current on voice operation is 30 - 40A. With a 50% transmit duty cycle, the 15A charger will keep the battery charged.

3.5 GROUND CONNECTIONS - MOBILE

The amplifier should be grounded directly to the body of the vehicle. Do not rely on the mobile mount for this connection. Make sure the ground wire makes a low resistance connection and is as short as possible.

> NOTE: The vehicle body should not be used as the connection to the negative battery terminal. Always run a separate cable for the negative battery connection.

3.6 GROUND CONNECTIONS - BASE STATION

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.

3.7 ANTENNA CONNECTION

The amplifier output impedance is 50 ohms, and a heavy duty co-axial 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 reach 2-3A at full output.

3.8 ANTENNA MATCHING

Correct antenna matching is extremely important when using the T500M amplifier. The output transformers in the amplifier have been designed to provide a correct match to a 50 ohm resistive load and the amplifier is only capable of delivering the rated power output, if the load is very close to 50 ohms. A good example of this is if the amplifier operates into a 100 ohm load (or at a VSWR of 2:1). The voltage at the output of the amplifier will remain substantially constant, and with a power output of 600 watts into a 50 ohm load, the output voltage is 173V RMS. The same voltage across a 100 ohm load equals 300W ($\frac{173^2}{100}$). If the load is less than 50 ohms, the amplifier will current limit and the output will similarly be reduced.

The output circuit in a tube type amplifier is tuned and it is normally possible to adjust the amplifier to provide correct matching over a limited range of output impedance. The T500M is completely broadband with no tuning adjustments of any kind and it is not possible to compensate for any mismatch in the antenna system. This difference in operation between the true broadband amplifier and the older tuned type tube amplifiers must be clearly understood if satisfactory results are to be achieved.

The antenna matching should be checked carefully using a VSWR indicator in the co-axial cable to the antenna. The antenna or tuner should be adjusted to the lowest possible VSWR. An exact match is desirable but the amplifier will operate satisfactorily up to a VSWR of 1.5:1. Operation at VSWRs exceeding 2:1 is not recommended and even at the 2:1 level, the amplifier output is substantially reduced.

3.9 ANTENNAS

The T500M amplifier is suitable for use with any antenna with a 50 ohm feed system and a power capability of at least 600W. If the antenna system cannot be adjusted to provide a 50 ohm match to the antenna, it will be necessary to use a matching system such as an antenna tuner or the IM10 broadband impedance matcher.

The base impedance of the typical resonant mobile whip antenna will be in the range of 10-20 ohms. This will result in a VSWR in excess of 2:1 and the amplifier will not operate satisfactorily. A matching network can be placed at the base of the antenna to provide a 50 ohm match. Alternatively use the IM10 and select the tap position providing the lowest VSWR.

3.10 IM10 IMPEDANCE MATCHER

The IM10 is a broadband impedance matcher designed to correct a resistive mismatch between antenna and amplifier. This situation will frequently occur when the antenna is resonant and has no reactive component. Under these conditions, a dipole has a theoretical impedance of 70 ohms and a quarterwave antenna of 25 ohms. In practical installations, the impedance may vary substantially from these values. The IM10 is simple to use. Simply install in the co-axial cable as close as practical to the antenna. Watch the VSWR indicator and select the switch position on the IM10 to give the lowest VSWR. If the VSWR does not fall to at least 1.2:1, check that the antenna is resonant at the operating frequency.

3.11 FREQUENCY ADJUSTMENT

The T500M is fully broadband and requires no tuning or adjustment for operation on any frequency.

3.12 FILTER SWITCHING

The correct low pass filter for the operating frequency should be selected to provide maximum harmonic attenuation. The filter selection is made by grounding the appropriate control wire through the connector on the rear panel. Most transceivers have a switch section available on the channel switch for remote control of an antenna tuner or other accessories. The moving contact of this switch should be grounded and the individual channel positions are wired so that the correct filters are automatically selected. Many continuous coverage synthesized transceivers have a switching contact coupled to the "MHz" switch and this switch may be used to provide automatic filter selection. In some complex systems it may be necessary to provide a diode control matrix to provide the correct filter selection. Typical control systems are shown in the diagram.

If the transceiver has no provision for automatic control of the filter selection, a 5 position switch may be wired for manual filter selection.

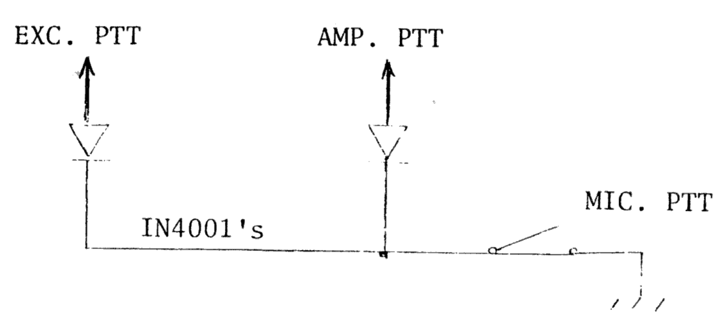
The switching power is provided by the amplifier and the switch contacts should be rated to control 12V at approximately 140 MA.

Filter Connections

Pin	1	2- 3 MHz
Pin	2	3- 5 MHz
Pin	3	5- 8 MHz
Pin	4	8-15 MHz
Pin	5	15-30 MHz
Pin	7, 8, 9	Ground

3.13 EXCITER INTERCONNECTIONS

The T500M amplifier requires only two connections to the exciter. The input to the amplifier is connected through a 50 ohm co-axial cable (RG58/u type) terminated in a PL 259 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 12V at 140 MA. If there is any interaction between the exciter and amplifier, two diodes may be installed in the switching lines to form an OR gate as shown in the diagram.



3.14 ON/OFF SWITCHING

The amplifier may be switched off by using the circuit breaker on the front panel. For remote control,the amplifier is switched on by grounding the control line Pin No. 11 on the amplifier rear contact.

3.15 DRIVE LEVEL

The normal drive level for full output should not exceed 60W. The gain of the transmitter and the ALC circuit should be adjusted so that the exciter cannot be overdriven. If the circuit breaker trips, it is a sure indication of overdrive, antenna mismatch, or incorrect filter selection.

CAUTION

Do not overdrive. Excessive drive levels can destroy the expensive power transistors. If the exciter is capable of power output in excess of 120W, it is recommended that a modification is made so that the maximum power output is restricted.

SECTION 4

OPERATION

4.1 GENERAL

The T500M amplifier requires no tuning adjustments. Provided the antenna is correctly matched and the drive level set correctly, operation is simply a matter of turning the power switch on. The transistor requires no warmup and the amplifier is ready for immediate operation.

4.2 CONTROLS

4.2.1 ON-OFF (CIRCUIT BREAKER)

The amplifier can be switched on and off using the front panel rocker switch on the circuit breaker. If the collector current exceeds 75A, the circuit breaker will trip and is reset by the rocker switch. If the circuit breaker trips repeatedly, the drive level is excessive or the antenna is not matched correctly. The circuit breaker will also trip if there is a short circuit or fault in the amplifier.

4.2.2 ON-OFF (REMOTE)

If the amplifier is remote controlled, the circuit breaker is left on. The relay in the amplifier is then used to switch the amplifier on and off via the remote switch.

4.2.3 FILTER SELECTION

The filter selection is usually made automatically as the exciter channel is selected. If there is no provision for automatic switching, the remote control filter selection switch should be turned to the correct range. Be careful to select the correct filter. The selection of a filter with a cutoff frequency below the channel frequency will often cause the circuit breaker to open. Although the transistors are rated for operation at infinite VSWR, the collector currents may be excessive if the incorrect filter is selected causing a possibility of early transistor failure.

4.3 DRIVE ADJUSTMENT

Before setting the drive level, make sure that the amplifier is operating into a 50 ohm load.

4.3.1 SSB

Increase the drive level until the collector current reaches 70A on voice peaks. Do not increase the drive level beyond this point or peak flattening will occur. If the circuit breaker trips, it is an indication of severe overdrive. The meter reading is dependent on the voice characteristics and it is recommended that an oscilloscope is used to monitor the output waveform, particularly when setting the initial drive level. When using an oscilloscope, set the drive level so that there is no indication of peak flattening on voice peaks. If the exciter is provided with adjustable ALC, set the level to limit the drive to the maximum level required to drive the amplifier to full output.

4.3.2 CW/FSK

Adjust the drive level for a maximum collector current of 70A. Do not hold the key down for long periods.

4.4 DUTY CYCLE COOLING

The T500M is rated for a 50% transmit/receive duty cycle on SSB voice operation or on CW at a maximum ambient temperature of 25°C. At higher ambient temperatures, the transmit duty cycle must be reduced. The amplifier is not designed for FSK operation and if used in this mode, the duty cycle should be restricted. At ambient temperatures of not more than 25°C, a maximum transmit period of 5 minutes is recommended. Sufficient time between transmissions should be allowed for the heatsink temperature to drop. The duty cycle of the amplifier can be extended by directing a fan at the cooling fins.

The amplifier is protected by a 75°C thermostat mounted on the heatsink and should the duty cycle be exceeded, the thermostat will open, switching the amplifier off, and connecting the exciter to the antenna. This ensures that no damage can result from overheating.

4.5 MEASURING POWER

4.5.1 METHODS

The two most widely used methods of measuring power are input power and output power. It is simpler to measure input power and in the amateur service amplifiers are usually rated in terms of input power. In commercial service, it is normal to rate amplifiers according to their power output.

4.5.2 INPUT POWER

The T500M is rated at a power input of 1000W. At a supply voltage of 13.6V this represents a collector current of 73.5A. On CW setting, the input power is simply a matter of adjusting the drive for a collector current of 73.5A. On voice operation, it is usual to adjust the drive level so that the meter indicates the correct collector current on peaks. The ballistics (damping) of the meter are such that the input power will not exceed 1000W on normal voice operation. If the amplifier is operated from a battery, it is not possible for the supply voltage to exceed 13.6V under load. The PS75 AC power supply is fully regulated and apart from the initial adjustment of the output voltage, it is not necessary to measure the supply voltage. If an adjustable or unregulated power supply is used, it will be necessary to use a separate voltmeter in order to comply with some government regulations. (Required in the USA).

4.5.3 OUTPUT POWER

The amplifier output power will vary according to the input power and the amplifier efficiency. The best method of measuring SSB output power is to use a peak reading RF voltmeter (calibrated RMS) connected across a non-reactive 50 ohm load. The output power is then $\frac{E^2}{50}$ = W PEP (500W = 158V RMS, 400W = 141V RMS). An oscilloscope is another peak reading instrument and a calibrated oscilloscope may be used to measure the peak-to-peak voltage across the load (500W = 447V P.to P., 400W = 399V P. to P.). The frequency response of oscilloscopes frequently falls off at the top end of the HF range and the oscilloscope must be calibrated at the operating frequency. The peak reading voltmeter or oscilloscope can be used to measure power output using voice waveforms, two tone test signals and CW.

The conventional wattmeter or directional coupler measures the average power output and is only accurate on a CW signal. PEP output should be measured using a 2 tone test signal. The wattmeter will indicate 50% of the PEP output (500W PEP = 250W Av., 400W PEP = 200W Av.). On a voice waveform, the average power is even lower and the indicated output power will depend on the meter characteristics. The reading may only be 20 to 40% of PEP and is not a very meaningful indication of output.

4.5.4 POWER SUPPLY VOLTAGE

To achieve rated output power, the amplifier must be operated at a supply voltage of 13.6V measured under load across the amplifier power input terminals. The PS75 AC power supply is rated to supply 13.6V at a supply current of 75A. When operating in a mobile installation, it is difficult to maintain the supply voltage at 13.6V under load. Even with the alternator operating at maximum charge and maintaining the battery voltage at 13.6V, it is inevitable that there will be some voltage drop in the supply leads at currents as high as 70A. For this reason, the power output measured on CW or on two tone test signals in mobile installations are likely to be disappointing. The problem is that we are reaching the limitations of a 12V supply system when operating at these power levels.

Fortunately the SSB voice signal has lower energy requirements than the test tones, and on voice operation, the voltage drop to the amplifier will be much lower than is indicated on the test signals. An oscilloscope or peak reading voltmeter will show that on SSB voice operation, the output power is similar to that attained on the regulated power supply.

SECTION 5

TECHNICAL DESCRIPTION

5.1 GENERAL

The T500M amplifier consists of four push-pull amplifiers with input and output impedances of 200 ohms. The 4 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 one of the 5 low pass filters.

5.2 AMPLIFIERS

Each of the 4 basic amplifiers use a simple push-pull design using two high power broadband linear power transistors. These newly developed transistors use an emitter ballasted chip design to control impedance and gain over a bandwidth of more than a decade.

The schematic diagram shows how each pair of transistors are connected in a conventional transformer coupled push-pull circuit. Special ferrite loaded broadband transformers provide the correct impedance transformation, with high efficiency over the range 2 - 30 MHZ.

For maximum efficiency and good linearity, the amplifiers all operate in CLASS AB. The low impedance bias source is provided by the transistors Q1 and Q2. The thermal compensation for the 2mV/^{o}C emitter/base voltage change of the output transistors is provided by Q1 which is mounted on the heatsink. The bias regulator provides a stiff current source with excellent thermal tracking.

5.3 INPUT CIRCUIT

Matching the 4 amplifier inputs over the frequency range of nearly four octaves provides a complex design problem. The base impedance of the RF transistor varies greatly 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 8 dB.

If each amplifier was identical in all respects, the four 200 ohm inputs could be paralleled to give a combined input impedance of 50 ohms. In practice, the mismatch between amplifiers would prevent satisfactory operation. The input combiner is used to parallel the inputs while providing good port to port isolation. The unbalance components in the inputs then appear across the non-inductive resistors used in the combiner and are dissipated as heat.

The excellent transfer characteristics of the input transformers and the combiner make it possible to use a single compensation network at the 50 ohm input instead of individually compensating at the bases of all 8 transistors. The computer designed input network uses a combination of inductors, resistors and capacitors to provide a low input VSWR and substantially level gain across the operating range.

5.4 OUTPUT CIRCUIT

The output circuit is similar to the input and it would not be possible to combine the outputs without considerable interaction between the amplifiers. The output combiner is similar in design to the input combiner and the unbalance components of the output are dissipated in the balance resistors.

5.5 OUTPUT FILTER

A broadband transistor amplifier has a relatively high level of harmonic output. The even order harmonics tend to balance in the push-pull output transformers, but the odd order (3rd, 5th, etc.) are not attenuated and a filter is essential to ensure satisfactory spectral purity. The filter design used is a low loss 5 pole Tchebycheff with a low reflection coefficient.

Five filters are used to cover the frequency range. Separate relays are used at the input and output of each filter so that the filters may be selected by remote control.

5.6 CONTROL CIRCUITRY

The amplifier transmit/receive switching is accomplished by the 2 relays, RLY 1 and RLY 14. In the receive or off position the input and output connectors are connected together so that the amplifier is completely bypassed. In the transmit mode, the relay RLY 1 connects the input terminal to the input combiner and also switches on the bias to the amplifiers. RLY 14 connects the amplifier output to the antenna connector.

The positive supply voltage passes through the circuit breaker and the on/off relay RLY 2. The circuit breaker is used for local ON/OFF switching and the RLY 2 for remote ON/OFF switching. The diode D3 prevents RLY 2 operating if the supply polarity is reversed. The thermostat is connected so that RLY's 1 and 14 open if the heatsink temperature exceeds 75°C.

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SECTION 6

SERVICE-MAINTENANCE

6.1 INTRODUCTION

The T500M requires no routine maintenance. The power transistors are rated for an extended service life and replacement is recommended only in event of a failure. The entire amplifier operates directly from a 13.6V supply source and no high voltages are present in the amplifier. This low voltage operation makes a major contribution to low maintenance requirements. The only special precautions to take to ensure reliability and a long service life are to ensure that the amplifier is operated into a correctly terminated load and is not overdriven. It should be noted that although the transistors are rated for operation at infinite VSWR, prolonged operation when operating into mismatched loads causes excessive dissipation and early device failure.

6.2 AMPLIFIER ACCESS

6.2.1 COVER REMOVAL

The cover is removed by unscrewing the 6 retaining screws in the base and 3 on each side. This gives complete access to the entire amplifier.

6.2.2 FILTER BOARD REMOVAL

The filter board may be removed for relay or filter component replacement by unscrewing the 6 screws securing the board to the heatsink. The circuit board can usually be lifted sufficiently to give access to the components for replacement. If necessary, the appropriate cables can be temporarily disconnected to provide further clearance.

6.2.3 AMPLIFIER CIRCUIT BOARD

Most of the amplifier components can be replaced without removing the circuit board. If it is necessary to lift the circuit board, remove the two circuit breaker mounting screws and swing the breaker clear of the board. Remove the 6 retaining screws, the 16 RF power transistor retaining screws and the 2 bias transistor mounting screws. The circuit board can then be lifted. Take special care, when replacing the board, to ensure there is adequate heatsink compound under the transistors and that no strain is exerted on the transistor leads when the transistor mounting screws are tightened.

6.2.4 RF TRANSISTOR REPLACEMENT

The components in the feedback network above each transistor should be moved to one side by unsoldering the resistor from the output transformers and pushing to one side. Unsolder the transistor leads taking care not to damage the circuit board foil. It will be helpful to use a desoldering tool to remove as much solder as possible and then lift the lead up from the board while the solder is molten. Unscrew the two mounting screws and remove the transistors. The replacement transistor should have the leads trimmed to fit the circuit board and the mounting base should be liberally coated with heatsink compound. Position the transistor carefully with the collector lead towards the output transformer. Replace the 2 mounting screws and tighten. Check that there is no strain on the transistor leads and solder in place. The soldering iron should have sufficient thermal capacity to melt the solder rapidly. If the iron is too small, a prolonged application will be required to melt the solder. This will give sufficient time for the heat to be conducted through the lead and cause damage to the transistor.

6.3 GENERAL

Fault location is relatively simple as the basic circuitry is simple and there are only 2 transistors in each of the four amplifiers. The high power levels usually mean that if a component fails, there will be heating and physical evidence of the damage. The operation of the switching circuitry is simple and can be checked by using a VOM to make continuity measurements.

6.4 AMPLIFIER SERVICE

The failure of one of the four amplifiers will cause the amplifier to run at half power even though 3 amplifiers are still operating. The unbalance in the combiners causes one of the amplifiers to dissipate its full output in the balance resistor on the combiners. Low power output and overheating of the balance resistor on the output combiner is a sure indication of a fault in one of the amplifiers.

The faulty amplifier can usually be located by measuring the collector currents in turn. The lead to the output transformer center-tap should be lifted and the collector currents should be measured while the amplifier is driven to a moderate output level. The faulty amplifier will show a substantial difference in collector current from the other 3 amplifiers.

Check the defective amplifier for any obvious fault such as broken or disconnected wires and defective input or output transformers. If everything appears normal, one or both of the transistors are defective. The amplifier will have very low output even if only one of the transistors is defective. The faulty transistor can be located by placing a .1 μF capacitor across the base and collector of each transistor to ground in turn. When the defective transistor is bypassed, the output will show a substantial increase.

When the defective amplifier is repaired check the balance resistors. The resistors will usually take moderate overload without damage, however, it is advisable to check the resistance of any balance resistors that show evidence of having been overheated.

6.5 BIAS CIRCUIT

Check that the total quiescent collector current is set at approximately 1.6 - 2A. (NOTE: The total quiescent current will include the bias currents, subtract the current in R5 from the total to get actual collector current.) If necessary adjust the bias potentiometer to set the collector current to the correct level. Under quiescent conditions, the bias voltage at the bases of the transistors should be approximately .625V and should not increase by more than a fraction of a volt at full drive. If the bias circuit does not appear to be operating correctly, check that the emitter/base voltage differential of the 2 bias transistors is approximately .7V. Any substantial variation indicates that the device is defective. The quiescent current should be reset after any transistor change.

6.6 FILTERS

A filter defect is usually only apparent on one filter range. If the defect is present on more than one range, check the filter switch wiring and for sticking relay contacts. If the fault is confined to one filter, check the input and output relays and the filter components.

CAUTION

Although the highest dc voltage in the amplifier should not exceed 13.6V, quite high RF voltages are present at full output. While the RF voltages are not lethal, they can cause unpleasant burns and care should be taken when servicing the amplifier. The amplifier power supply or the vehicle battery system are capable of very high currents and great care should be taken to avoid short circuits. Apart from the fire hazard, short circuits are likely to cause severe physical and electrical damage to the amplifier.

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T500M

PARTS LIST

Reference	Part Number	Description
C1	211103	Capacitor, Ceramic Disc .01µF 500V
C2	211103	Capacitor, Ceramic Disc .01µF 500V
C3	212390D	Capacitor, Ceramic Disc 39pF 3kV
C4	212201D	Capacitor, Ceramic Disc 20pF 3kV
C5	212560D	Capacitor, Ceramic Disc 56pF 3kV
C6	240020	Capacitor, Tantalum 2.2µF
C7	240020	Capacitor, Tantalum 2.2µF
C8	210104	Capacitor, Ceramic Disc .1 µF 25V
C9	220821	Capacitor, DM15 820pF
C10	210104	Capacitor, Ceramic Disc .1 µF 25V
C12	220821	Capacitor, DM15 820pF
C13	210104	Capacitor, Ceramic Disc .1µF 25V
C14	210104	Capacitor, Ceramic Disc .1µF 25V
C15	220821	Capacitor, DM15 820pF
C16	210104	Capacitor, Ceramic Disc .1µF 25V
C17	210104	Capacitor, Ceramic Disc .1µF 25V
C18	220821	Capacitor, DM15 820pF
C19	210104	Capacitor, Ceramic Disc .1µF 25V
C20	224122	Capacitor, DM19 1200pF
C21	224122	Capacitor, DM19 1200pF
C22	224122	Capacitor, DM19 1200pF
C23	224122	Capacitor, DM19 1200pF
C24	210104	Capacitor, Ceramic Disc .1µF 25V
C25	210104	Capacitor, Ceramic Disc .1µF 25V
C26	210104	Capacitor, Ceramic Disc .1µF 25V
C27	210104	Capacitor, Ceramic Disc .1µF 25V
C28	211103	Capacitor, Ceramic Disc .01µF 500V
C29	211103	Capacitor, Ceramic Disc .01µF 500V
C30	211103	Capacitor, Ceramic Disc .01µF 500V
C31	211103	Capacitor, Ceramic Disc .01µF 500V
C32	230202	Capacitor, Electrolytic 2000µF 16V
C33	230202	Capacitor, Electrolytic 2000µF 16V
C34	230202	Capacitor, Electrolytic 2000µF 16V
C35	211103	Capacitor, Ceramic Disc .01µF 500V
C36	211103	Capacitor, Ceramic Disc .01µF 500V
C37	211103	Capacitor, Ceramic Disc .01µF 500V
C38	211103	Capacitor, Ceramic Disc .01µF 500V
C39	211103	Capacitor, Ceramic Disc .01µF 500V
C40	211103	Capacitor, Ceramic Disc .01µF 500V
C41	211103	Capacitor, Ceramic Disc .01µF 500V
C42	211103	Capacitor, Ceramic Disc .01µF 500V
C43	211103	Capacitor, Ceramic Disc .01µF 500V
C44	211103	Capacitor, Ceramic Disc .01µF 500V
C45	211103	Capacitor, Ceramic Disc .01µF 500V

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T500M

PARTS LIST (cont'd)

Reference	Part Number	Description
C46		See Filter Parts List for Capacitors C46 thru C60.
C47		
C48		
C49		
C50		
C51		
C52		
C53		
C54		
C55		
C56		
C57		
C58		
C59		
C60		
C61	211103	Capacitor, Ceramic Disc .01μF 500V
C62	211103	Capacitor, Ceramic Disc .01μF 500V
C63	211103	Capacitor, Ceramic Disc .01μF 500V
C64	211103	Capacitor, Ceramic Disc .01μF 500V
C65	211103	Capacitor, Ceramic Disc .01μF 500V
C66	211103	Capacitor, Ceramic Disc .01μF 500V
C67	211103	Capacitor, Ceramic Disc .01μF 500V
C68	211103	Capacitor, Ceramic Disc .01μF 500V
C69	211103	Capacitor, Ceramic Disc .01μF 500V
C70	211103	Capacitor, Ceramic Disc .01μF 500V
D1	320102	Diode, Silicon 1N4001
D2	320103	Diode, Silicon 3 amp
D3	320102	Diode, Silicon 1N4001
FX1	490501D	Sleeve Ferrite
FX2	490501D	Sleeve Ferrite
FX3	490501D	Sleeve Ferrite
FX4	490202D	Sleeve Ferrite
FX5	490202D	Sleeve Ferrite
FX6	490202D	Sleeve Ferrite
FX7	490202D	Sleeve Ferrite
FX8	490202D	Sleeve Ferrite
FX9	490202D	Sleeve Ferrite
FX10	490202D	Sleeve Ferrite
FX11	490202D	Sleeve Ferrite
FX12	490202D	Sleeve Ferrite
FX13	490202D	Sleeve Ferrite

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T500M

PARTS LIST (cont'd)

Reference	Part Number	Description
FX14	490302	2X Bead, Ferrite
FX15	490302	2X Bead, Ferrite
FX16	490302	2X Bead, Ferrite
FX17	490302	2X Bead, Ferrite
FX18	490302	2X Bead, Ferrite
FX19	490501D	Sleeve, Ferrite
L1	430101D	Inductor Special
L2	430102D	Inductor Special
L3		For L3 thru L12 see appropriate filter Parts List
L4		
L5		
L6		
L7		
L8		
L9		
L10		
L11		
L12		
M1	740003D	Meter 100 amp scale
Q1	310024D	Transistor, MJE29A
Q2	310025D	Transistor, MJE3055K
Q3	310030D	Transistor, Rf Power
Q4	310030D	Transistor, Rf Power
Q5	310030D	Transistor, Rf Power
Q6	310030D	Transistor, Rf Power
Q7	310030D	Transistor, Rf Power
Q8	310030D	Transistor, Rf Power
Q9	310030D	Transistor, Rf Power
Q10	310030D	Transistor, Rf Power
R1	4X 153201D	4X Resistor Metal Film 200Ω 2W
R2	4X 153221D	4X Resistor Metal Film 200Ω 2W
R3	170301D	Pot Preset 5Ω W.W.
R4	144471	Resistor Carbon 470Ω 1W
R5	160005	Resistor WW 5Ω 10W
R6	133027	Resistor Carbon 2.7Ω ½W
R7	133027	Resistor Carbon 2.7Ω ½W
R8	133027	Resistor Carbon 2.7Ω ½W

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PARTS LIST (cont'd)

Reference	Part Number	Description
R9	133027	Resistor Carbon 2.7 ½W
R10	154470	Resistor Carbon 47Ω 2W
R11	154470	Resistor Carbon 47Ω 2W
R12	154470	Resistor Carbon 47Ω 2W
R13	154470	Resistor Carbon 47Ω 2W
R14	154470	Resistor Carbon 47Ω 2W
R15	154470	Resistor Carbon 47Ω 2W
R16	154470	Resistor Carbon 47Ω 2W
R17	154470	Resistor Carbon 47Ω 2W
R18	154470	Resistor Carbon 47Ω 2W
		Resistor Carbon 47Ω 2W
RLY1	540005	Relay DPDT 5 Amp 12V
RLY2	540006D	Relay SPDT 50 Amp 12V
RLY3	540005	Relay DPDT 5 Amp 12V
RLY4	540005	Relay DPDT 5 Amp 12V
RLY5	540005	Relay DPDT 5 Amp 12V
RLY6	540005	Relay DPDT 5 Amp 12V
RLY7	540005	Relay DPDT 5 Amp 12V
RLY8	540005	Relay DPDT 5 Amp 12V
RLY9	540005	Relay DPDT 5 Amp 12V
RLY10	540005	Relay DPDT 5 Amp 12V
RLY11	Not Used	
RLY12	540005	Relay DPDT 5 Amp 12V
RLY13	540005	Relay DPDT 5 Amp 12V
RLY14	540005	Relay DPDT 5 Amp 12V
S01	610003	Socket Coax SO239
S02	610003	Socket Coax SO239
S03	610014D	Socket Jones Type 12 Pin
	610015D	Plug Jones Type 12 Pin
T1	450306D	Transformer Ferrite Driver
T2	450306D	Transformer Ferrite Driver
T3	450306D	Transformer Ferrite Driver
T4	450306D	Transformer Ferrite Driver
T5	450307D	Transformer Ferrite Output
T6	450307D	Transformer Ferrite Output
T7	450307D	Transformer Ferrite Output
T8	450307D	Transformer Ferrite Output
TH1	560001	Thermostat N/C 75°C

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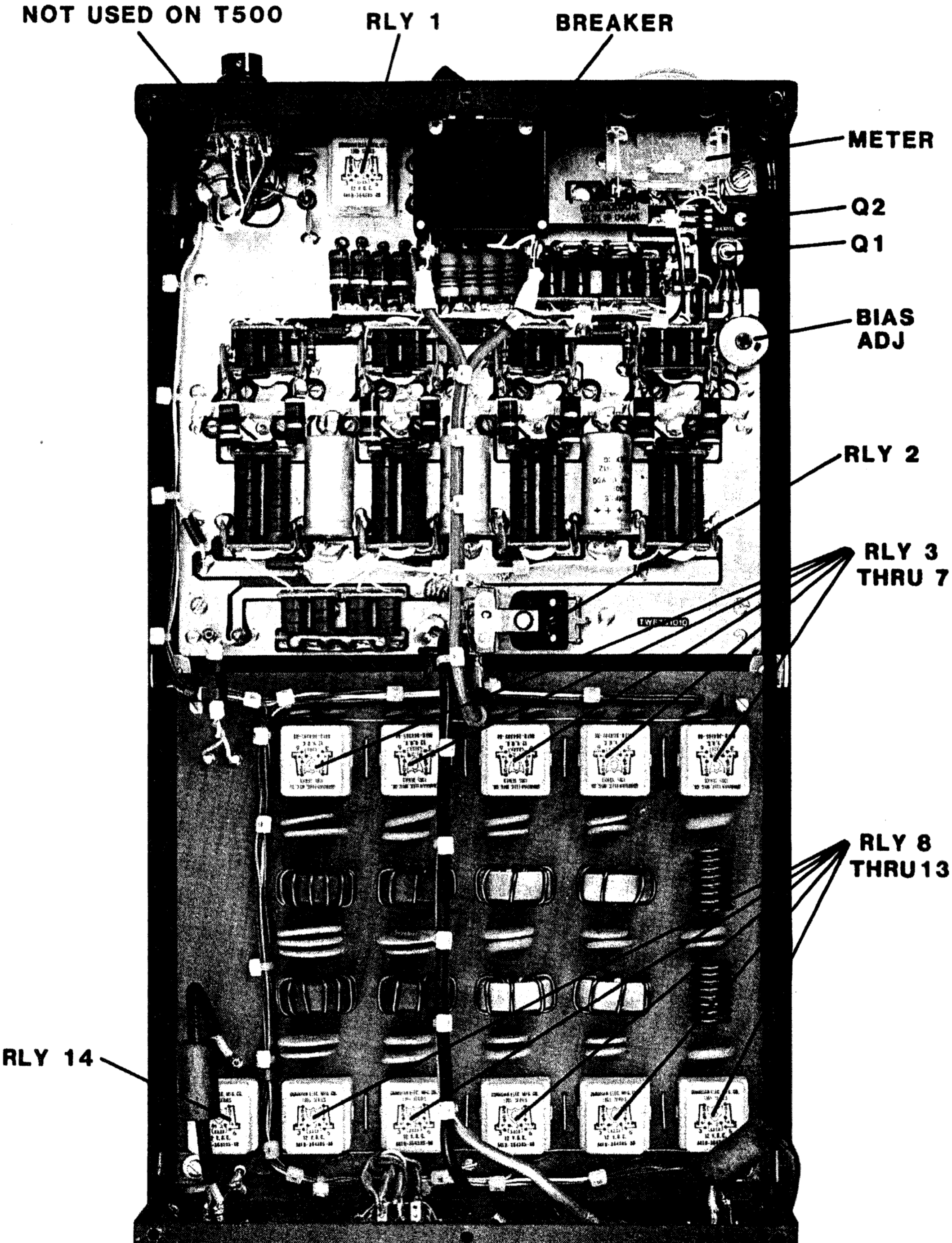
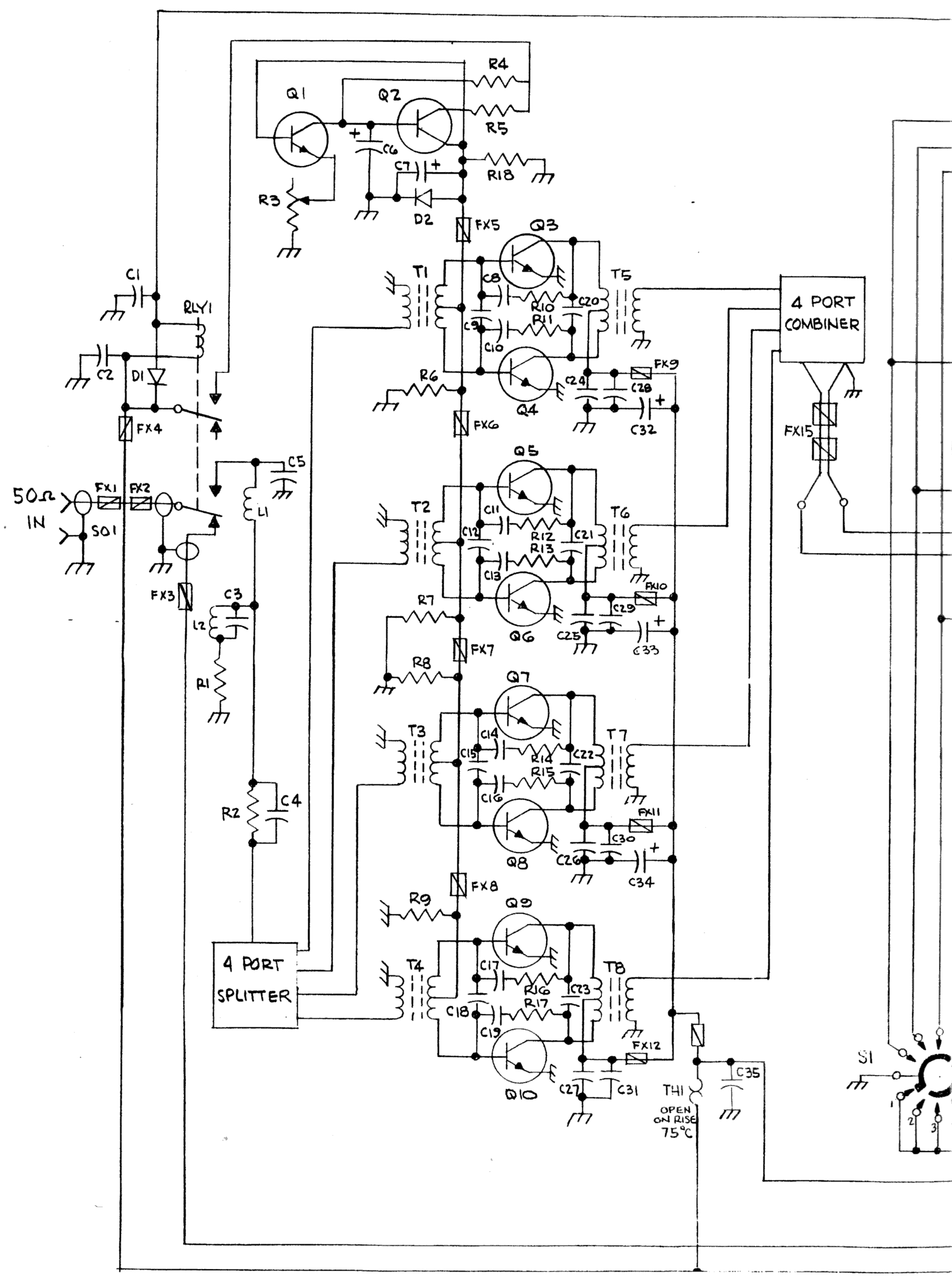
PARTS LIST (cont'd)

Reference	Part Number	Description
	910020D	Heatsink
	910021D	Panel Front
	910022D	Panel Rear
	910023D	Cover
	910024D	Bracket Mounting
	570003D	Breaker Magnetic 75A
	731010D	Board, Circuit Amplifier
	731011D	Board, Circuit Filter
	700103D	Combiners (4)

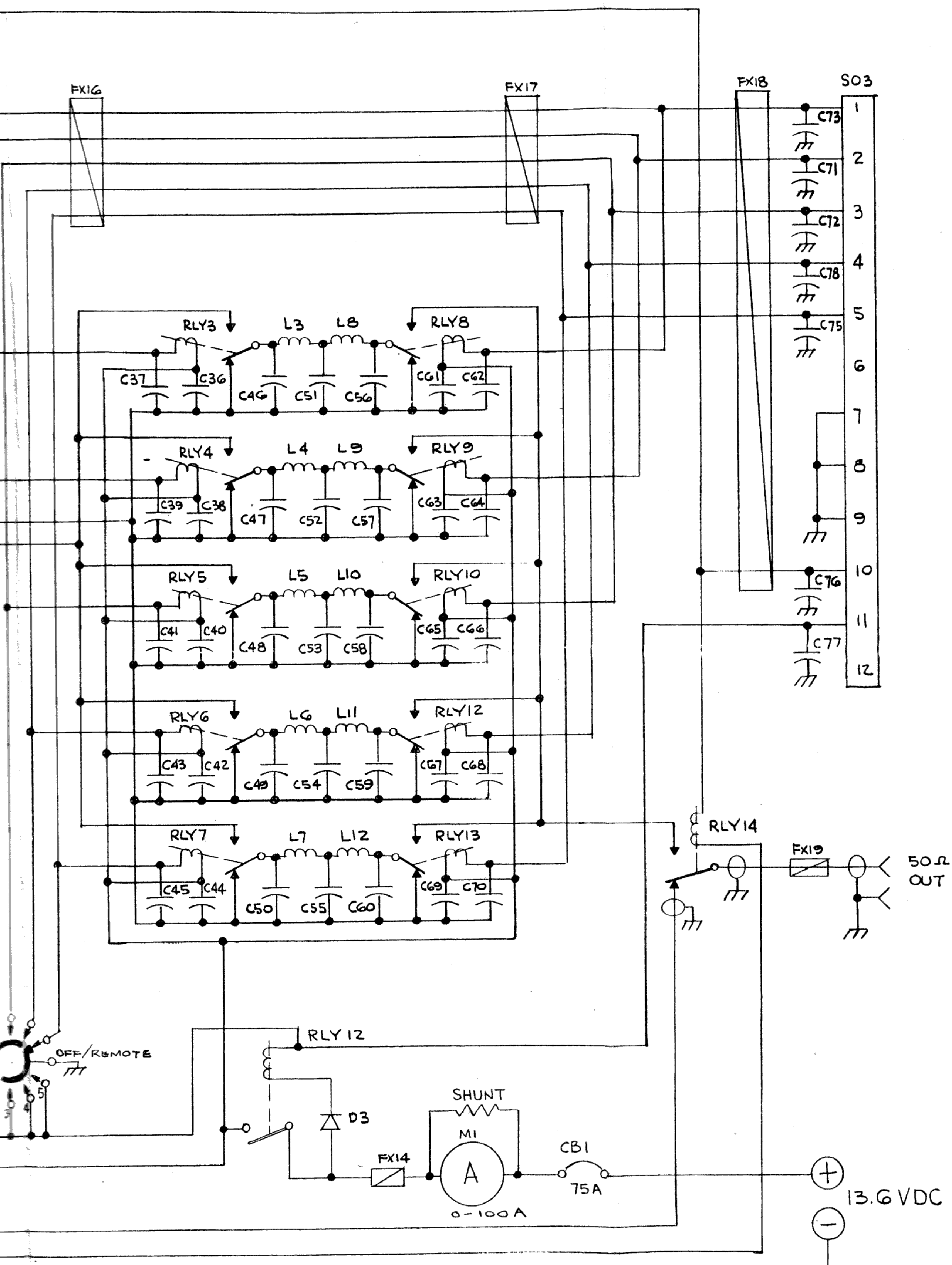
Filter Components

Reference	Part Number	Description
C46/C56	212391D	Capacitor, Disc 390pF 2kV
	212431D	Capacitor, Disc 430pF 2kV
C47/C57	212391D	Capacitor, Disc 390pF 2kV
	212121D	Capacitor, Disc 120pF 2kV
C48/C58	212271D	Capacitor, Disc 270pF 2kV
	212470D	Capacitor, Disc 47pF 3kV
C49/C59	212820D	Capacitor, Disc 82pF 5kV
	212820D	Capacitor, Disc 82pF 5kV
C50/C60	212820D	Capacitor, Disc 82pF 5kV
C51	212751D	Capacitor, Disc 750pF 2kV
	212681D	Capacitor, Disc 680pF 2kV
	212271D	Capacitor, Disc 270pF 2kV
C52	212751D	Capacitor, Disc 750pF 2kV
	212271D	Capacitor, Disc 270pF 2kV
C53	212431D	Capacitor, Disc 430pF 2kV
	212201D	Capacitor, Disc 200pF 2kV
C54	212201D	Capacitor, Disc 200pF 2kV
	212151D	Capacitor, Disc 150pF 2kV
C55	212560D	Capacitor, Disc 56pF 2kV
	212121D	Capacitor, Disc 120pF 3kV
L3/8	450608D	Inductor 2 - 3 MHz
L4/9	450607D	Inductor 3 - 5 MHz
L5/10	450606D	Inductor 5 - 8 MHz
L6/11	450605D	Inductor 8 -15 MHz
L7/12	430201D	Inductor 15-30 MHz


NOT USED ON T500
RLY 1
BREAKER
METER
Q2
Q1
BIAS ADJ
RLY 2
RLY 3 THRU 7
RLY 8 THRU13
RLY 14



T500M LINEAR AMPLIFIER



ADDED R18

5-29-79
1A