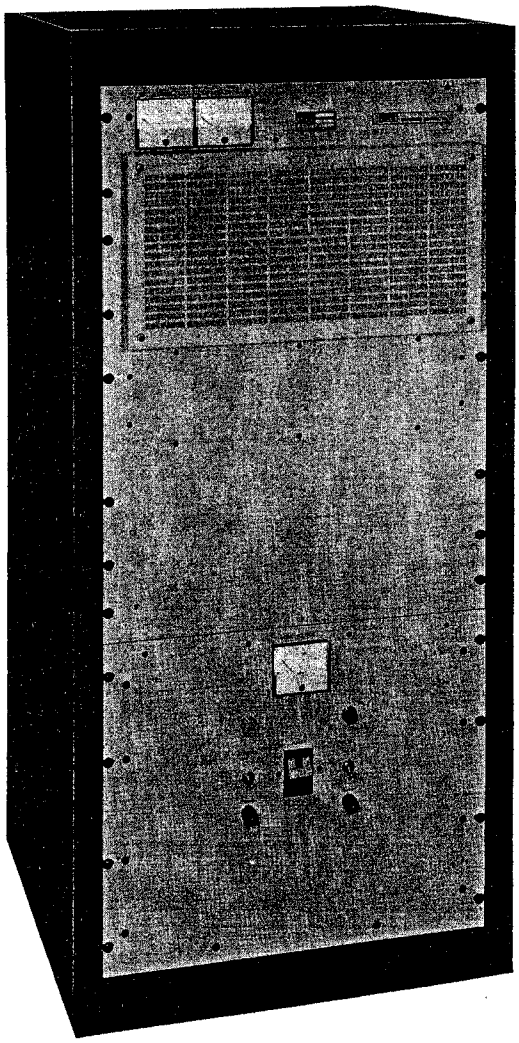
communication associates, inc.

Engineers and Manufacturers

# CL-36
# 1KW LINEAR AMPLIFIER
# INSTRUCTION MANUAL



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# 1. DESCRIPTION

## 1.1 General:

The CL-36 Linear Amplifier is a ten band servo tuned high frequency amplifier nominally rated at 1000 watts PEP (output power) in the single sideband mode. The frequency range covered by the amplifier is from 2 MHz through 23 MHz in ten preset ranges corresponding to those of the driving transceiver. When the driving transceiver is programmed so that one or more bands have several frequencies grouped within the band, some of which may be considerably offset, the amplifier will retune to each frequency to maintain maximum power output and efficiency over the entire range.

The heart of this feature is a sensitive phase detector network that responds to a differential phase angle existing between the input and output circuits of the power amplifier tube. The response of the detector is coupled to a high gain servo amplifier network that energizes a powerful motor to readjust the plate tuning capacitor. This detecting and tuning sequence commences when the amplifier is keyed, and lasts for barely more than the first spoken syllables of a transmission, when in the A3J mode (fully suppressed carrier). In the A3A (pilot carrier) and A3H (full carrier) modes, the sequence is almost instantaneous due to the presence of the carrier.

The CL-36 features automatic selection of either high power (1000 watts or 400 watts) or low power (150 watts) when it is coupled to one of several mating transceivers. This pre-programmed selection capability is incorporated in the system in order to bypass the amplifier on those frequencies (typically, some frequencies in the 2-3 MHz marine bands) that are restricted to 150 watts output maximum. Furthermore, when the CL-36 is installed close to the radio operator, he can choose at will, low power operation for any frequency normally programmed for high power by simply turning off the PLATE switch on the power supply front panel. In all cases where the output is 150 watts maximum, the transceiver operates directly to the antenna, or antenna coupler if used.

The CL-36 includes an automatic envelope compression circuit (AEC) with two independent adjustment controls. One can be used to set the 1000 watt output level for those bands where this power level is permitted and desired, while the other can be set at an intermediate level (usually 400 watts) where this level is desired.

Coupled directly to the CL-36 Amplifier is a filter tray housing the control circuitry and filter modules needed to attenuate higher order harmonics. When used with the filter tray, the CL-36 meets or exceeds all specifications for Federal Communications Commission type acceptance, under Parts 81, 83, 89, 91 of the Commission's rules for 2.8 A3H, 2.8 A3A and 2.8 A3J emissions. Furthermore, the CL-36 is type accepted under Parts 81, 83 and 89 for 0.16 A1 emission and under Parts 81 and 83 for 0.3 F1 emission. This acceptance applies to both 400 watts PEP and 1000 watts PEP.

## 1.2 Specifications:

| | |
|---|---|
| Bands: | 10. |
| Frequency Range: | 2 to 23 MHz overall:<br><br>Band 1 - 2.00 to 2.22 MHz,<br>Band 2 - 2.22 to 2.45 MHz,<br>Band 3 - 2.45 to 2.70 MHz,<br>Band 4 - 2.70 to 3.00 MHz,<br>Band 5 - 4.05 to 4.45 MHz,<br>Band 6 - 6.20 to 6.55 MHz,<br>Band 7 - 8.20 to 8.60 MHz,<br>Band 8 - 12.30 to 12.80 MHz,<br>Band 9 - 16.40 to 16.80 MHz,<br>Band 10 - 22.00 to 22.75 MHz. |
| Power Output:<br>(maximum ratings) | 1000 watts PEP on SSB.<br>1000 watts on CW (telegraphy).<br>500 watts on RTTY (100% duty factor).<br>250 watts on AM (carrier power). |
| Driver Requirements: | 150 watts PEP on SSB.<br>150 watts on CW or RTTY.<br>37.5 watts on AM (carrier power). |
| Input Impedance: | 50 ohms, unbalanced. |
| Output Impedance: | 50 to 75 ohms, unbalanced.<br>Maximum VSWR 3:1. |
| Intermodulation Distortion Products: | Greater than 30 db down. |
| Spurious and Harmonic Emission: | Greater than 70 db down. |
| Line Voltage: | 115/230 vac, 50/60 Hz, single phase. |
| Power Consumption:<br>(230 vac) | 230 watts-standby, high voltage off.<br>2900 watts-transmit SSB (1 KW, PEP output).<br>3000 watts-transmit CW and RTTY (1000 watts output).<br>2700 watts-transmit AM (250 watts carrier output). |
| Dimensions: | 47" high x 22" wide x 22" deep.<br>(120 cm x 56 cm x 56 cm). |
| Weight: | 345 lbs. net.<br>(156 kg.) |

## 2. THEORY OF OPERATION

### 2.1 General:

The CL-36 Linear Amplifier is designed for use with the CA-35MS series transceivers. The design revolves around a straightforward grounded grid ceramic triode operating in class AB2. The 3CX1500A7 utilizes a segmented cathode resulting in extremely low grid interception. Consequently, the output tends to be very linear for a tube of this power capacity. Furthermore, the power gain is relatively high so that maximum output is achieved with very little input power. Maximum grid dissipation is typically 25 watts.

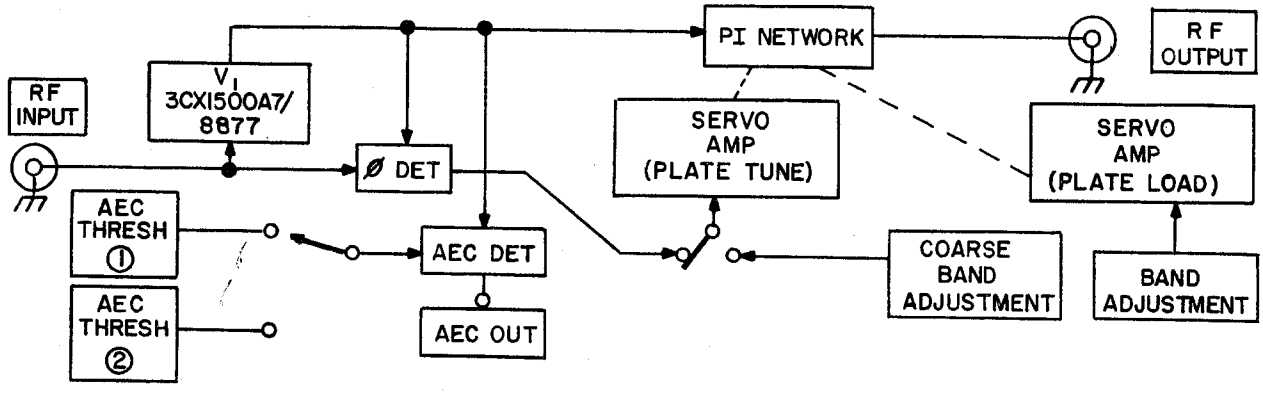



Fig. 2-1. Linear Amplifier Block Diagram

### 2.2 Amplifier Circuits:

#### 2.2.1 Amplifier:

A negative bias type 3CX1500A7/8877 triode is employed. The plate tank circuit is a standard pi network, designed to transform the high plate impedance into the low output impedance.

Rf drive voltage from the exciter, fed in through input jack J1, passes through a 3 db attenuator pad R2 through R7, to the cathode through the blocking capacitors C11 and C12. Positive cathode bias for the tube is provided by the zener diode CR1 which is returned to ground through the grid current meter. This line is decoupled at the cathode end of the tube by RFC1 in conjunction with capacitor C42 to effectively block the rf drive voltage on the cathode from the metering circuits. Filament voltage for the 3CX1500A7/8877 tube is supplied by transistor Q4 acting as a switching regulator. VR1 sets the correct voltage for Q4.

The control voltage, filament supply and 115V ac fan supply originate at T102 and are controlled by SW101. The fan supply is taken from half of the dual primary of T102 so that when the operating line voltage is changed, no rewiring is necessary in the amplifier itself. The secondary of T102 feeds an encapsulated full wave bridge rectifier assembly. This dc output is filtered by C107 and C109 and bled by R105. This output is then split three ways. First, it is used to drive the rotary solenoid and the servo tuning circuits. Secondly it supplies power for the antenna transfer relay through Q101 and, lastly, it supplies power to the filament voltage circuit through F102. This fuse is specially calibrated to absorb the high initial current surge of a cold tube. It will, however, blow should there be a circuit fault.

Power switch/circuit breaker CB101 provides power to feed the high voltage transformer, T101, through the power contactor, K102. Plate switch SW102 is connected in series with the safety interlock SW103 and the coil of relay K101, thus completing the push-to-talk circuit in the power supply. By opening any one of these switches, the HV relay circuit, K102, is effectively opened. When the correct conditions exist (all contacts closed), relay K102 can be energized, and thus supply the high voltage necessary to operate the amplifier. Relay K101 is activated by a nominal 18 volt source (transmit condition only) from the transceiver. The ground return for this circuit is located in the amplifier to facilitate cabling on certain special applications. Normally, however, this return line is grounded at pins 11 and 12 of P1 in the amplifier.

## 2.4 Filter Tray and Filter Module Circuits:

The CL-36 system utilizes four filter modules mounted in a specially designed tray located directly beneath the amplifier chassis. The proper filter module to be selected is slaved to the bandswitch of the linear amplifier through an externally connected control cable. Rotation of bandswitches SW1 and SW2, found in the filter tray, is accomplished by rotary solenoid B1. The network, consisting of L1, C2 and C3 on the output side of the filter network, is an 88 MHz trap, used to attenuate higher order harmonics found in the system.

The four filter modules (FL1 through FL4) contain m derived pi type, low pass filter networks specifically designed to handle the full output power of the amplifier. The cutoff frequency of each filter section is positioned so that all frequencies above the highest frequency of the particular band in use are attenuated a minimum of 35 db. In module FL1, the 2 to 3 MHz module, a two section filter network is used, whereas the remaining modules (FL2, 3 and 4) contain two one section networks that cover two adjacent bands of operation. This network is summarized in Table 2-1.

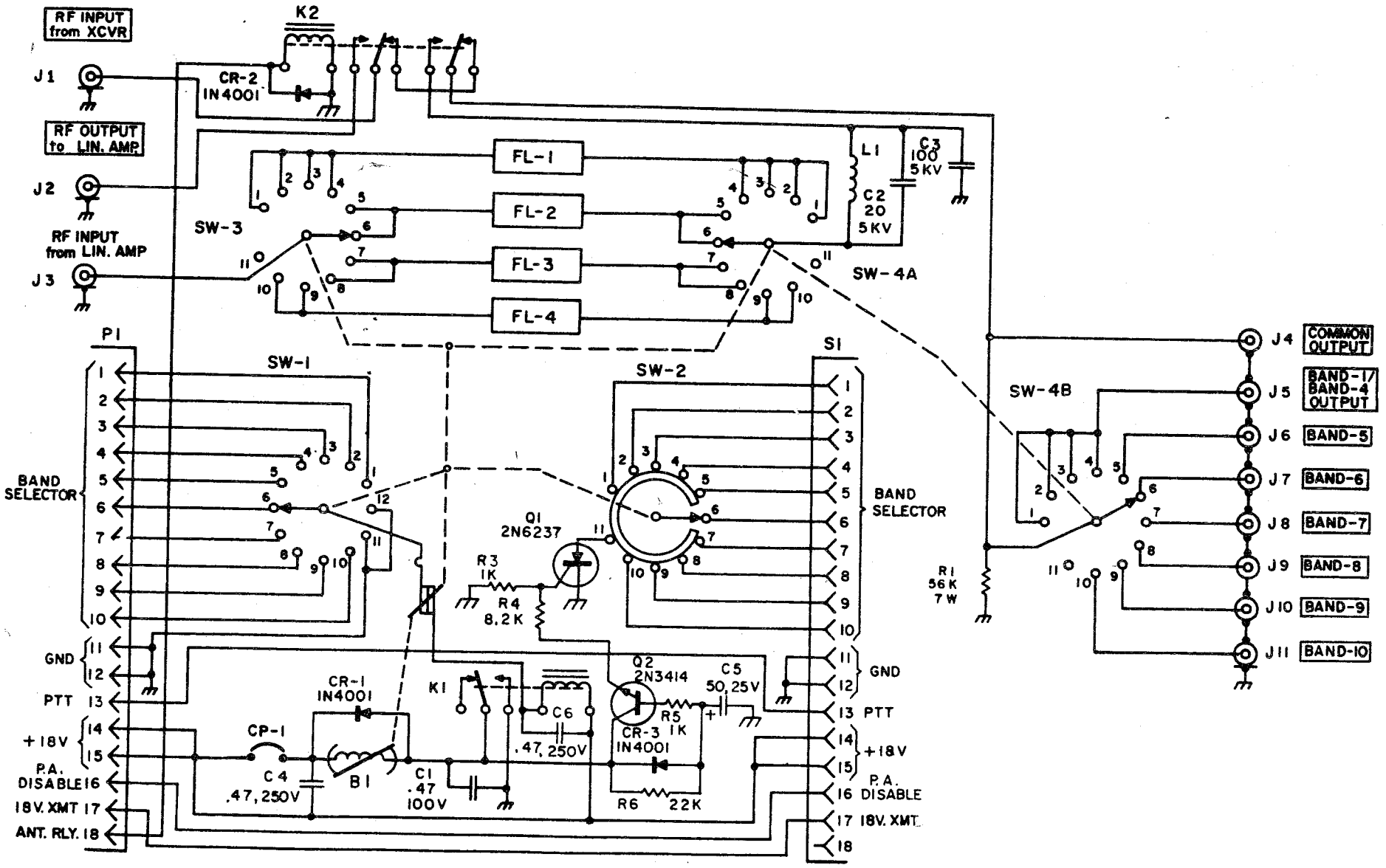
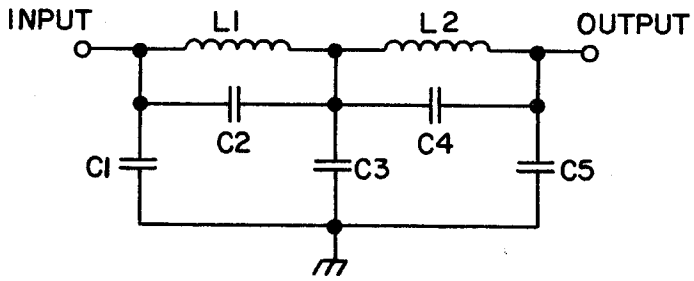



Fig. 2-5. Filter Tray Schematic (P/N 1114-502-2G)

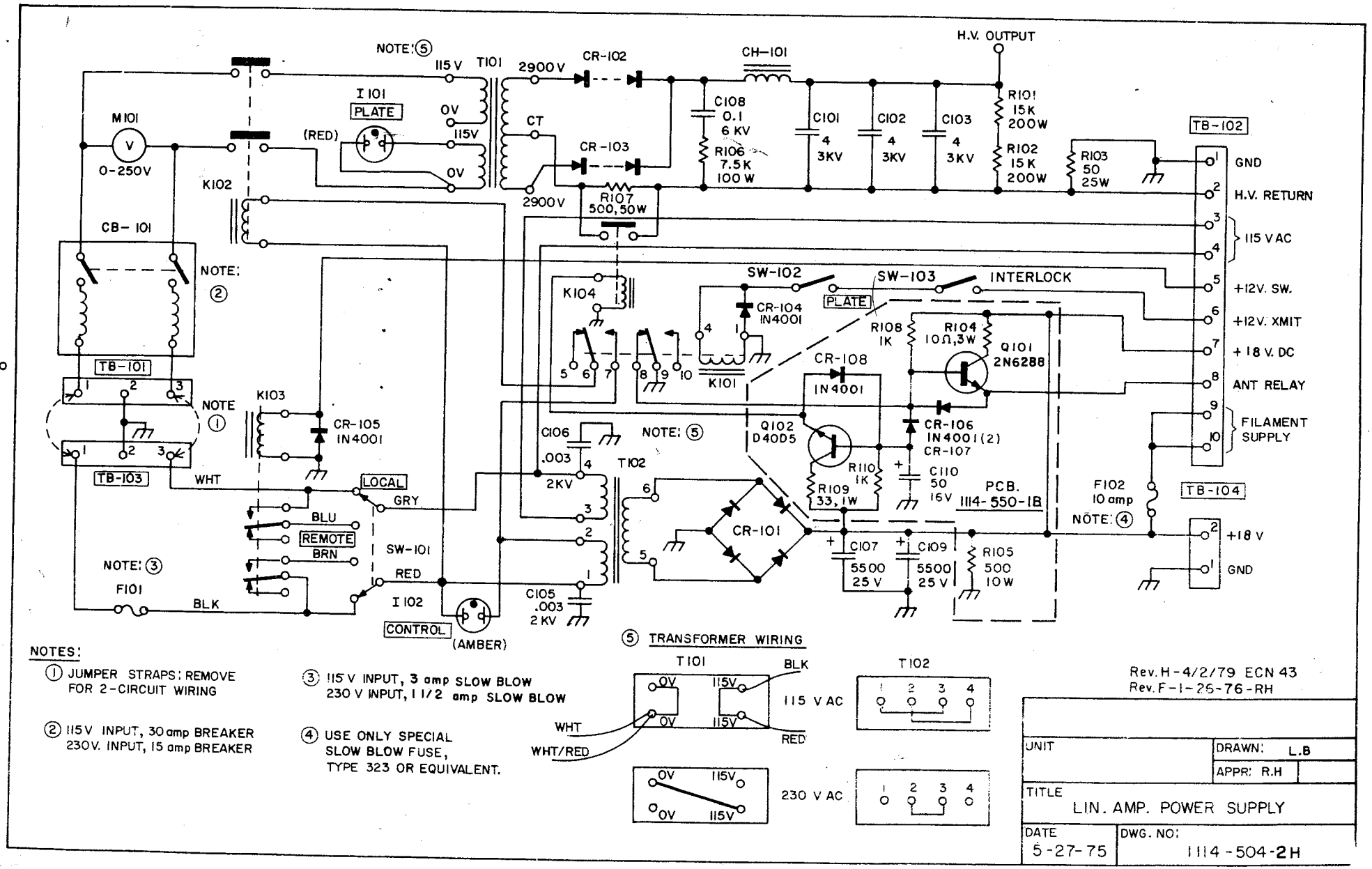
| Module | Assigned Frequencies | Bands |
|---|---|---|
| FL1 | 2 to 3 MHz | 1 thru 4 |
| FL2 | 4 & 6 MHz | 5 & 6 |
| FL3 | 8 & 12 MHz | 7 & 8 |
| FL4 | 16 & 22 MHz | 9 & 10 |

Table 2-1. Filter Network Summary




| | FL1 | FL2 | FL3 | FL4 |
|---|---|---|---|---|
| L1 | 2.6 uh | 1.45 uh | 0.72 uh | 0.366 uh |
| L2 | 1.8 uh | 0.95 uh | 0.47 uh | 0.237 uh |
| C1 | 1635 pf | 500 pf | 250 pf | 125 pf |
| C2 | 288 pf | 120 pf | 60 pf | 30 pf |
| C3 | 2230 pf | 770 pf | 370 pf | 200 pf |
| C4 | 863 pf | 396.2 pf | 190 pf | 95 pf |
| C5 | 1145 pf | 360 pf | 180 pf | 90 pf |

Fig. 2-6. Harmonic Filters and Schematic (P/N 1114-505-1A)




NOTES:

① JUMPER STRAPS: REMOVE FOR 2-CIRCUIT WIRING

② 115 V INPUT, 30 amp BREAKER
230 V. INPUT, 15 amp BREAKER

③ 115 V INPUT, 3 amp SLOW BLOW
230 V INPUT, 1 1/2 amp SLOW BLOW

④ USE ONLY SPECIAL SLOW BLOW FUSE, TYPE 323 OR EQUIVALENT.

Rev. H - 4/2/79 ECN 43
Rev. F - 1 - 26 - 76 - RH

| | |
|---|---|
| UNIT | DRAWN: L.B |
| | APPR: R.H |
| TITLE: LIN. AMP. POWER SUPPLY | |
| DATE: 5-27-75 | DWG. NO: 1114-504-2H |

The plate voltage enters through the high voltage connector P2. Two rf chokes, RFC2 and RFC3, together with bypass capacitors C27 through C30, form an effective decoupling network to prevent rf from getting into the power supply.

The output of the tube passes through a parasitic suppressor (PS1), and blocking capacitors C31 and C32 to the pi network. This network is composed of C26, C33, L1, L2 and C57. Switch section SW1A adds the second section of the two section variable tuning capacitor for the lower frequencies. Section SW1B selects the correct inductance tap of the tank coil, while SW1C switches the additional loading capacitors C47 through C56. The output of the pi network is fed to the output connector J2. As a safety precaution, RFC4 is shunted across the output of the pi network to short out the B+ voltage in case C31 or C32 short.

2.2.2 AEC Circuit:

The AEC voltage is developed by sampling the rf plate voltage through dividers C34 and C35. This voltage is rectified by CR4 and CR5 in a voltage doubler circuit. The AEC threshold is set by varying the bias on CR4 by either R13 or R14. Wafer SW6 selects the correct control for each band. The output voltage is then fed through a shielded cable to TB1-4. R1 and C8 form a low pass filter to smooth the output voltage. R12 serves as a load resistor to prevent this line from floating in case the interchassis cable is not connected.

2.2.3 Control and Servo Drive Circuits:

Band selection information is received on pins 1 through 10 of P1. A ground at one of these pins causes K4 to energize. The rotary solenoid B3 cogs one notch causing the spring loaded contacts, which are part of SW2, to open. Then relay K4 is deenergized. This sequence continues rapidly until the solenoid has rotated to a position where there is an open circuit on one of the pins of P1. This position is the required band. C60 is an arc suppressor used to prolong the life of the contacts of K4 and CR11 is used as a transient suppressor to short out the back emf of the rotary solenoid coil.

The positioning of the plate tuning capacitor, C33, occurs in a two step sequence. When a change of band is signalled, a ground pulse, initiated by K4, energizes K2 momentarily. Simultaneously this pulse resets Q3 and Q9. With Q3 off, Q2 is held on through R24. K2 is now energized putting an error voltage on the inverting input of IC2. As long as this voltage differs from V ref appearing on pin 3 of IC2, IC2 will be driven either high or low depending on the magnitude of the error voltage

with respect to V ref. IC3 inverts the output of IC2 so that the drive transistors Q5 through Q8 will be saturated in complementary pairs. Thus bidirectional motor rotation results. Since either IC2 or IC3 must be high with an input error signal, CR7 or CR8 will conduct and forward bias Q9 which insures that K2 remains energized for the total preset period. When C33 reaches its preset position as determined by one of the trimmers R37 through R46, IC2 and IC3 return to their quiescent states each having V ref on pin 6. Thus Q9 is no longer saturated and Q2 turns off. Thus K2 is de-energized and the input to IC2 is switched from the preset controls to the phase detector.

RF input voltage is sampled by the divider C19 and C20. Furthermore, the rf output voltage is sampled by C23. C23 and R8 provide a 90° phase shift necessary to turn on Q1. Diodes CR2 and CR3 are used as back-to-back clippers which form a square wave output. R10 is a load resistor while R9 is for gate biasing. When the rf input and output voltages are in phase, Q1 is cut off and IC2 remains balanced since the reference voltage appears at both terminals. When these voltages are out of phase, Q1 is turned on which produces a differential voltage to IC2. In response to this voltage, the servo amp network is energized and the plate tuning capacitor rotates in the proper direction until the phase detector output is again zero. The automatic switching feature is defeated by supplying a permanent ground to the low side of K2 through SW7.

The servo drive circuit, which controls the position of the loading capacitor C57, is essentially the same circuit as the tuning capacitor C33, except there is no phase detector. SW4 selects one of the ten "master" potentiometers, R51 through R60. R61 is coupled to the capacitor shaft and is the slave potentiometer. The error voltage is fed into the inverting input of IC4. The reference voltage is fed into the non-inverting input of IC4. The output of this operational amplifier is connected to the bases of Q10 and Q12 and to the inverting input of IC5. The output of IC5 is connected to the bases of Q11 and Q13. When the output of IC4 is low, IC5 goes high and the complementary pair Q11 and Q12 are turned on. Thus, bi-directional rotation of the capacitor results. Limiting resistors R47, R48, R49 and R50 are used to reduce voltage excursions of the "master" potentiometers R37 through R46 and R51 through R60.

2.2.4 High Power Lockout Circuit:

Federal Communications Commission regulations limit rf output power in the 2 to 3 MHz marine bands to 150 w PEP. Therefore, the CL-36 Amplifier must be automatically disabled when one of these frequencies is chosen. To meet this requirement, an automatic high power lockout is incorporated in the transceiver/amplifier system. On these frequencies, the transceiver is programmed to restrict the +18 V input at pin 16 of P1. Thus, no voltage is available at TB102 #5 to operate the PTT relay in the amplifier power supply, and the amplifier remains in the "standby" condition with maximum power output limited to that of the transceiver alone.

2.2.5 Meter Circuits:

Direct reading GRID and PLATE current meters are always in their respective circuits and require no switching. Since the grid of V1 is at chassis ground, a complete loop exists in the cathode-to-grid circuit through CR1 and M3. Furthermore, another complete loop exists in the cathode-to-plate circuit of V1, since the PLATE current meter M2 is fed from this same zener diode CR1 to the negative side of the high voltage supply.

2.3 Power Supply Circuit:

The power supply produces all the required operating voltages for the amplifier. High voltage is obtained from T101 in a full wave circuit using solid state rectifiers CR102 and CR103. The high voltage input of the rectifiers is fed to the filter network consisting of CH101, C101, C102 and C103. C108 and R106 remove voltage transients to protect the rectifiers. Bleeder resistors, R101 and R102, are connected across the high voltage dc output to discharge the filter network when the high voltage is turned off. The center tap of T101 is not grounded but goes through the PLATE current meter on the amplifier chassis. A resistor, R103, is connected between the negative high voltage return line and ground to prevent this line from "floating" should the negative line be opened for any reason.

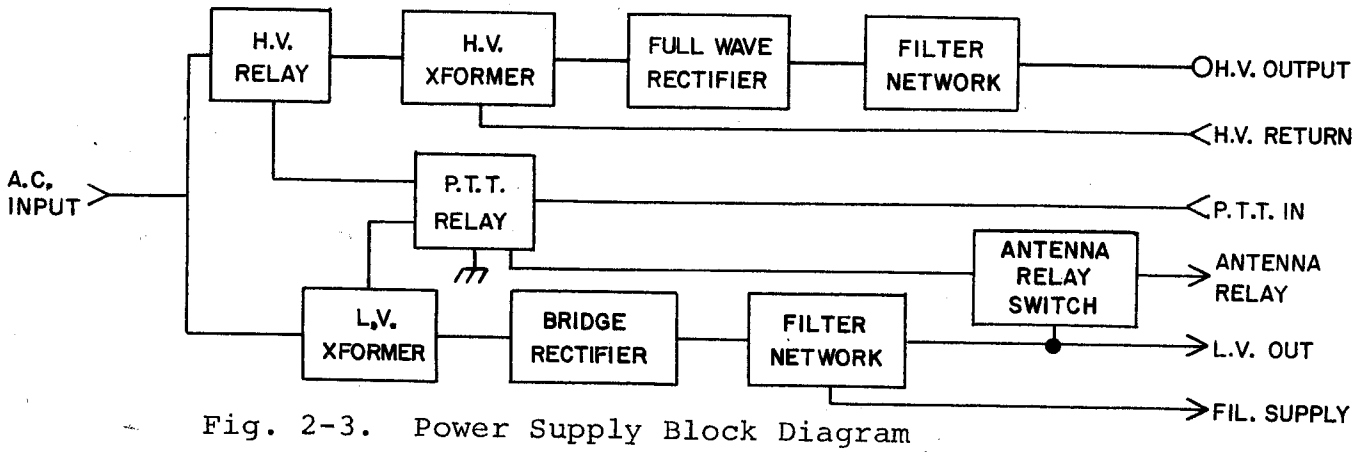
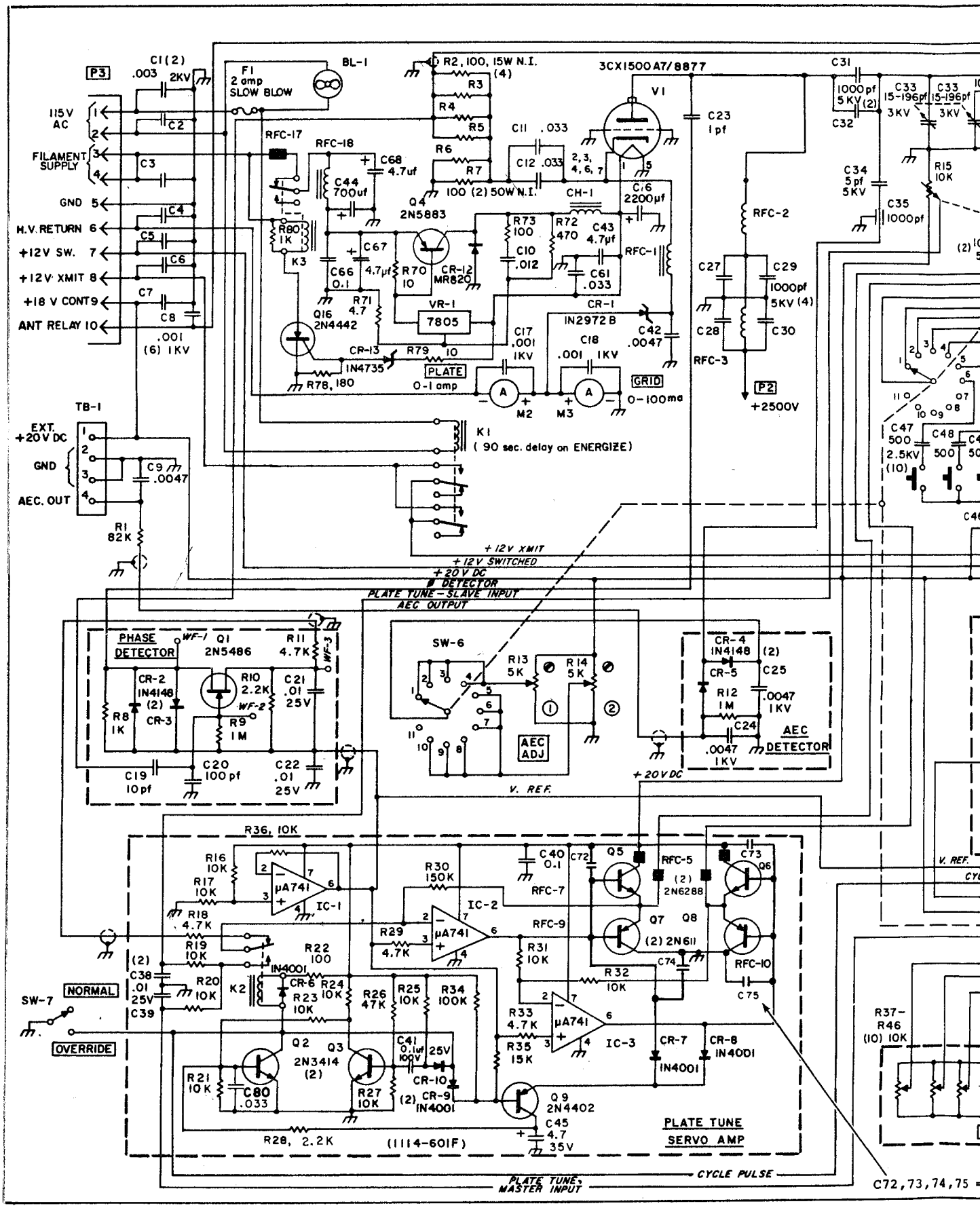
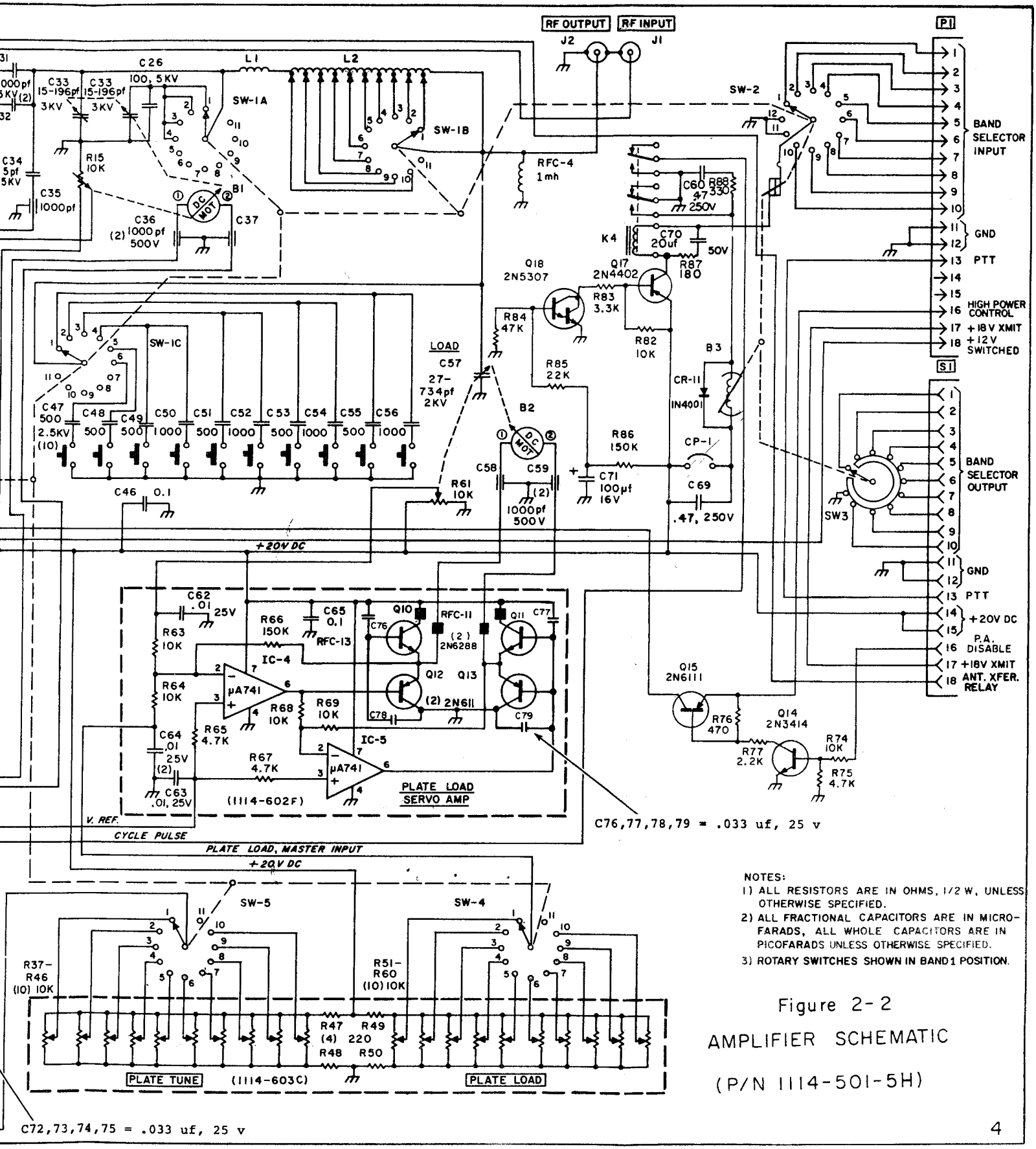



Fig. 2-3. Power Supply Block Diagram


P3
115V AC
FILAMENT SUPPLY
GND
H.V. RETURN
+12V SW.
+12V XMIT
+18 V CONT
ANT RELAY
C1(2) .003 2KV
C2
C3
C4
C5
C6
C7
C8 .001 (6) 1KV
F1 2 amp SLOW BLOW
BL-1
RFC-17
RFC-18
C68 4.7uf
C44 700uf
R80 1K
K3
C67
C66 0.1
4.7µf
R70 10
CR-12 MR820
R71 4.7
Q16 2N4442
CR-13
1N4735
R78, 180
R79 10
PLATE 0-1 amp
R2, 100, 15W N.I. (4)
R3
R4
R5
R6
R7
100 (2) 50W N.I.
Q4 2N5883
C11 .033
C12 .033
CH-1
R73 100
C10 .012
R72 470
C43 4.7µf
C61 .033
RFC-1
VR-1
7805
CR-1 1N2972B
C17 .001 1KV
C18 .001 1KV
C42 .0047
GRID 0-100ma
M2
M3
3CX1500A7/8877
V1
2, 3, 4, 6, 7
C16 2200µf
C23 1pf
RFC-2
C27
C28
C29 1000pf 5KV (4)
C30
RFC-3
P2 +2500V
C31 1000pf 5KV (2)
C32
C33 15-196pf 3KV
C34 5pf 5KV
C35 1000pf
R15 10K
K1 (90 sec. delay on ENERGIZE)
TB-1
EXT. +20V DC
GND
AEC. OUT
C9 .0047
R1 82K
+12V XMIT
+12V SWITCHED
+20V DC
RF DETECTOR
PLATE TUNE - SLAVE INPUT
AEC OUTPUT
PHASE DETECTOR
WF-1
Q1 2N5486
R11 4.7K
WF-3
CR-2 IN4148 (2) CR-3
R10 2.2K
WF-2
C21 .01 25V
R8 1K
R9 1M
C19 10pf
C20 100 pf
C22 .01 25V
SW-6
R13 5K
R14 5K
AEC ADJ
V. REF.
CR-4 IN4148 (2)
CR-5
C25 .0047 1KV
R12 1M
C24 .0047 1KV
AEC DETECTOR
+20V DC
R36, 10K
R16 10K
R17 10K
µA741
IC-1
R18 4.7K
R19 10K
R30 150K
IC-2
R29 4.7K
C40 0.1
RFC-7
RFC-9
R31 10K
R32 10K
C72
Q5
RFC-5 (2) 2N6288
C73
Q6
Q7 Q8 (2) 2N6111
C74
RFC-10
C75
(2) C38 .01 25V C39
R20 10K
R22 100
IN4001
K2
CR-6
R24 10K
R23 10K
R26 47K
R25 10K
R34 100K
R33 4.7K
R35 15K
IC-3
CR-7 IN4001
CR-8 IN4001
SW-7
NORMAL
OVERRIDE
Q2 Q3 2N3414 (2)
C41 0.1µf 100V 25V
CR-10
(2) CR-9 IN4001
R21 10K
C80 .033
R27 10K
Q9 2N4402
C45 4.7 35V
R28, 2.2K
(1114-601F)
PLATE TUNE SERVO AMP
CYCLE PULSE
PLATE TUNE MASTER INPUT
R37-R46 (10) 10K
C72,73,74,75 =




NOTES:

1) ALL RESISTORS ARE IN OHMS, 1/2 W, UNLESS OTHERWISE SPECIFIED.
2) ALL FRACTIONAL CAPACITORS ARE IN MICROFARADS, ALL WHOLE CAPACITORS ARE IN PICOFARADS UNLESS OTHERWISE SPECIFIED.
3) ROTARY SWITCHES SHOWN IN BAND 1 POSITION.

Figure 2-2

AMPLIFIER SCHEMATIC

(P/N 1114-501-5H)