

**TL MICROWAVE RADIO**  
**DESCRIPTION**  
**POWER SUPPLY**

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**1. GENERAL**

1.01 The TL power supply is located below the radio transmitter-receiver equipment and provides the following outputs.

OUTPUT	EQUIPMENT SUPPLIED
-20V dc regulated	IF and baseband units Magnetic amplifier bias (AFC) Diversity switch T1 carrier equipment
-400V dc regulated -600V dc regulated -10.5V dc regulated	Klystron resonators Klystron repellers Klystron heaters
86V ac regulated square wave -24V dc unregulated	Magnetic amplifier (AFC) Order-wire and alarm equipment Diversity switch

1.02 Basically, the supply is powered from four 6-volt batteries (KS-5361, List 151H batteries where 24-volt office battery is not available) which supply two dc regulators. One of the regulators provides the stable -20 volt dc output while the other feeds an 1800-cps inverter. The inverter output is stepped up or down in a transformer, rectified, and filtered to provide the various dc voltages for the klystrons. In most instances, the batteries are floated on a charger contained within the power supply and fed from 117-volt commercial ac. The batteries provide stand-by power approximately as shown in Fig. 1 following an ac power failure. Where 24-volt office battery is available, the charger is not required. A battery voltage alarm circuit is also furnished on an optional basis to indicate low battery voltage, a failure in the charger, or a loss of commercial ac input.

1.03 The power supply (Photographs A and B) occupies a space 19-1/4 inches long, 15-22/32 inches wide, and approximately 11-3/4 inches deep. A block diagram of the supply is shown in Fig. 2.

**2. OPERATING PRINCIPLES**

**A. -20 Volt Regulator**

2.01 The basic operating principles of the power supply will be described in terms of the simplified block schematic of Fig. 3. The -20 volt dc regulated output is obtained from the -24 volt battery through a series regulating transistor. The voltage drop in the transistor is controlled by the dc output from an error voltage amplifier fed by the difference between a reference voltage and a voltage proportional to the regulator output. The reference voltage is provided by a high stability temperature compensated Zener diode. Differences in reference diode voltage are controlled by the IF AMPL VOLTS ADJ potentiometer.

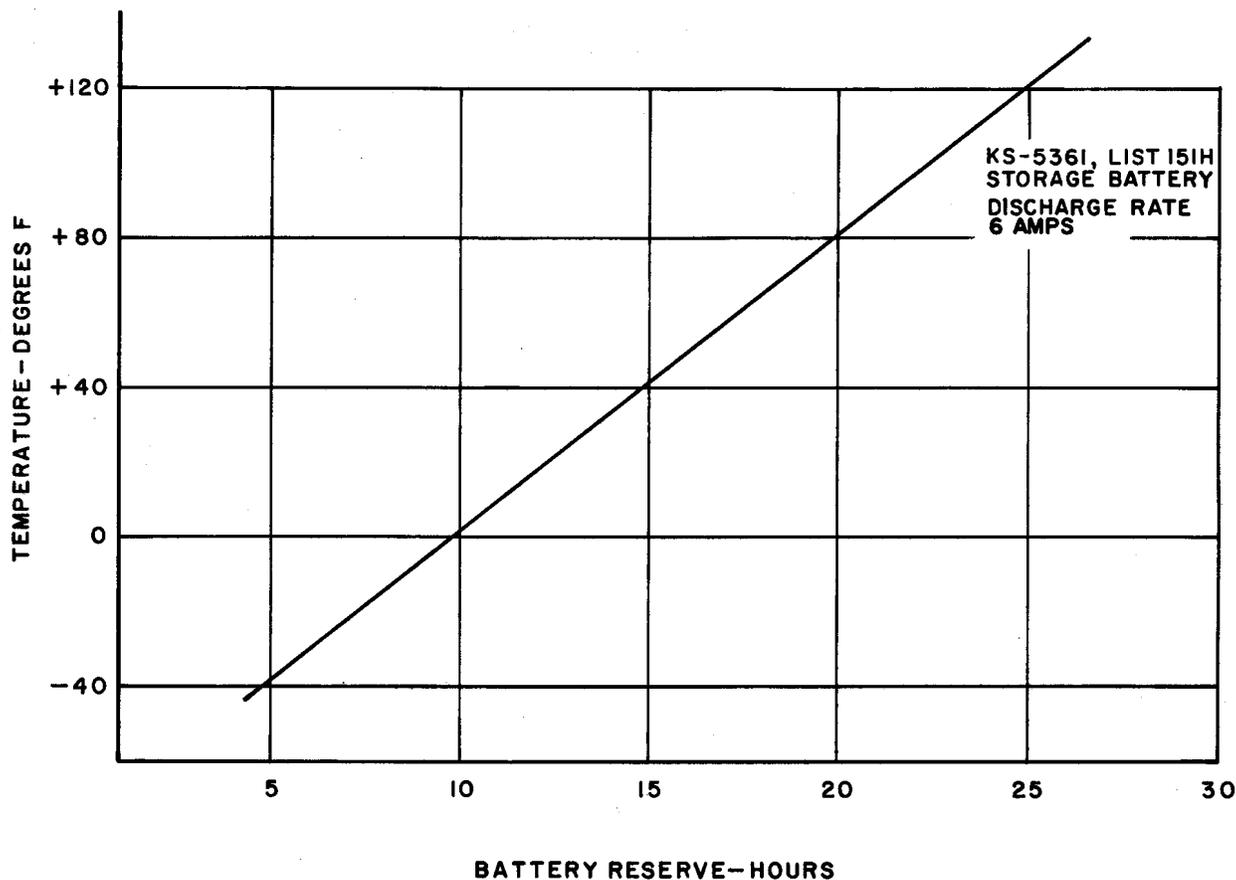


Fig. 1 - Battery Reserve Following AC Power Failure

### B. Klystron Supply Regulator and Inverter

**2.02** The klystron supply regulated voltages are obtained in somewhat the same manner as the -20 volt regulated supply shown in Fig. 3. The battery supplies the series regulating transistors which are controlled by the dc output from an error voltage amplifier fed by the difference between a reference voltage and a voltage proportional to the -400 volt output. The closed feedback loop provided in this manner automatically controls the dc input to the inverter in such a way as to provide a constant output voltage from the -400 volt rectifier. Since the other klystron supplies, -600 volts direct current, -10.5 volts direct current, and two 43 volts alternating current, are obtained from the same transformer, they will automatically track the -400 volt output and, hence, will be equally well regulated.

### C. Battery Charger

**2.03** The battery charger receives its input from commercial ac power which is fed across a ferroresonant transformer. This transformer is made up of two separate toroidal cores, one having a linear characteristic, the other non-linear. When the ac input rises above a prescribed value, the windings of the transformer are so arranged as to make the secondary relatively insensitive to further increases in line voltage because of the saturation of the nonlinear coil. A capacitor taps off part of the winding on the unsaturated coil to provide load compounding over a restricted load range. At a load in excess of the rated current, the output voltage will collapse and the current will be limited. The secondary winding of the ferroresonant transformer feeds two silicon diodes in a full-wave

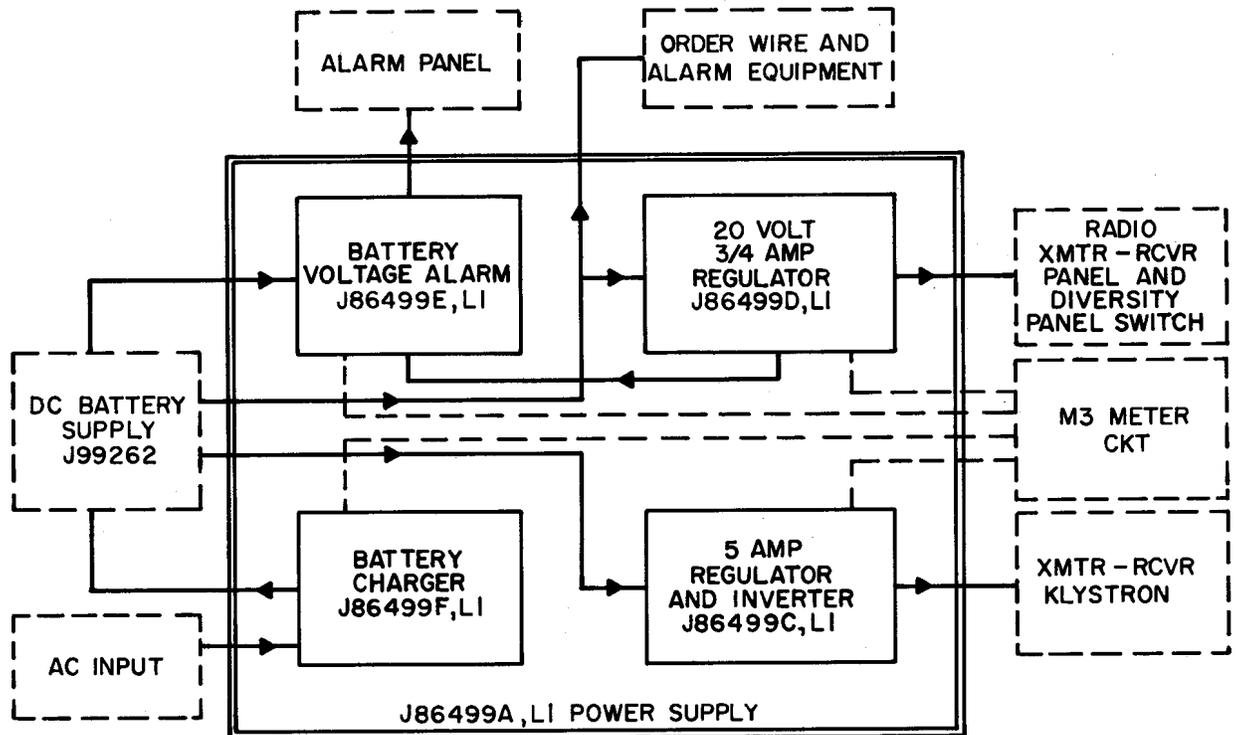


Fig. 2 - J86499A List 1 Power Supply

center tap arrangement. This regulated dc output is then applied to the batteries for floating or charging.

#### D. Battery Voltage Alarm Circuit

**2.04** The battery voltage alarm feature is obtained in the following manner. The regulated -20 volts is applied to the emitter of the alarm transistor. A signal proportional to the battery voltage is fed to the base of this transistor. Keeping the emitter voltage constant, a change in base voltage will produce a change in collector current. This change will also affect the current through the alarm relay which, when de-energized, furnishes and removes a ground to the order-wire and alarm circuit.

### 3. CIRCUIT DESCRIPTION

#### A. Klystron Supply Regulator and Inverter

**3.01** The voltage reference consists of silicon diode CR10 which is biased in the reverse direction by a current limiting resistor R36. The voltage across CR10 is a constant value between

8.2 and 9.1 volts. Compensation for this variation is obtained by adjustment of the KLYSTRON VOLTS ADJ potentiometer R39.

**3.02** The error detector differential amplifier circuit is comprised of transistors Q9, Q10, and Q11, and a voltage divider circuit consisting of resistors R17, R18, R19, R20, R21, R34, R39, and R46 which is connected across a section of the -400 volt filter. That fraction of the output voltage which appears at the base of transistor Q10 and the voltage which appears at the base of transistor Q9 determines the resultant unbalance of collector currents of transistors Q9 and Q10, consequently controlling the base current of transistor Q11. Resistor R28 is to provide for improved regulation and temperature stabilization.

**3.03** For regulation, when the base voltage of transistor Q10 changes, there results an unbalance in the collector currents of transistors Q10 and Q9. The change in voltage drop across resistor R37 modifies the bias voltage at transistor Q11, consequently changing the base current of transistor Q11. This causes a resultant

change of current through resistor R31 and, consequently, a variation of current in the series regulating transistors Q6, Q7, and Q8. The phasing is such that an increase in output voltage results in an increase in the impedance of transistors Q6 and Q7. As a result, when the load is decreased or the applied dc input voltage is increased, the output voltage is maintained within its output limits due to the action of this closed feedback circuit.

**3.04** The inverter operates at a nominal frequency of 1800 cycles which is determined by the characteristics of saturable transformer T1. Transformer T2 is a power transformer which does not saturate. Resistor R42 provides base current in transistor Q13 to initiate oscillation. Assuming transistor Q13 conducting, the phasing of transformer T1 causes a forward biasing of transistor Q13 at the same time transistor Q12 is reversed biased. This condition exists until transformer T1 saturates; then after switching, transistor Q12 conducts and transistor Q13 is nonconducting. Transformer T1 saturates again, causing the cycle to be repeated. Resistors R40 and R41 limit the base currents of Q12 and Q13, and capacitors C16 and C17 decrease the switching losses.

#### **B. -600 Volt Supply**

**3.05** The -600 volt supply consists of transformer T2, secondary winding terminals 11 through 14, and diodes CR5 through CR8. The filter is a 2-stage RC-LC filter consisting of resistor R24, inductor L1, and capacitors C5 and C6. Resistor R23 is a bleeder resistor. The output of this 2-section filter is passed through the special noise filter FL1 to suppress high-frequency noise. The -600 volt output is obtained by superimposing the -200 volt output between terminals 1 and 2 of terminal board TB3 on the -400 volt output which appears across terminals 2 and 3 of TB3.

The -200 volt supply was designed to have a load of 8.6 to 10 milliamperes between the -600 volt output terminal 1 of TB3 and the -400 volt output terminal 2 of TB3.

#### **C. -400 Volt Supply**

**3.06** The -400 volt rectifier consists of transformer T2, secondary winding terminals 7 through 10, and diodes CR12 through CR15. Resistor R22, inductor L2, and capacitors C7 and

C8 function as a low-pass filter, passing direct current and attenuating the ripple. Resistor R22 also functions as a load compounding resistor in the feedback network. The -400 volt output is supplied through filter FL2 which suppresses high-frequency noise to terminal 2 of TB3. The common ground connection is made at terminal 3 of TB3. Resistor R25 is a bleeder resistor.

This supply is designed to operate with a load variation of 10 milliamperes between 64 and 100 milliamperes.

#### **D. Klystron Filament Supply**

**3.07** The filament supply consists of transformer T2, secondary winding terminals 4 through 6, diodes CR18 and CR19, filter capacitors C11 and C12, filter inductor L3, and noise suppressing capacitors C3 and C4. The 10.5-volt dc output is connected to the -400 volt output.

**3.08** The dc output potential is set to 10.5 volts by adjusting potentiometer R39 (KLYSTRON VOLTS ADJ) when taps 8, 9, 10, and 12, 13, 14 of T2 have been selected to provide outputs within  $\pm 5$  per cent of the -400 and -600 volts, respectively. The nominal load of the 10.5-volt output is 1.76 amperes.

#### **E. 43-volt AC Supply**

**3.09** Two 43-volt ac supplies are furnished from terminals 15 through 17, and 18 through 20 on transformer T2. The output voltage is a square wave at a nominal frequency of 1800 cps.

**3.10** The frequency is determined by taps selected on transformer T1 and the dc input voltage to the inverter. Tap selection on transformer T1 is made after tap selection has been made on transformer T2 and the adjustment of potentiometer R39 (KLYSTRON VOLTS ADJ) has been completed. Taps on transformer T1 should be selected to obtain the nearest frequency to 1800 cycles when the power supply is operating on nominal loads. This is a factory adjustment and should not be changed except after component replacement.

#### **F. -20 Volt Regulator**

**3.11** The voltage reference consists of a silicon diode CR3 biased in the reverse direction by a current of approximately 10 ma through

current limiting resistor R10. The voltage across CR3 is a constant value between 8.2 and 9.1 volts. Compensation for this variation in nominal voltage value is obtained by adjustment of the IF AMPL GAIN ADJ potentiometer R13.

**3.12** The error detector differential amplifier is made up of a voltage divider, resistors R3 and R8, potentiometer R13, and transistors Q3 and Q4. That fraction of the output voltage which appears between the junction of resistors R3 and R8 and the minus output terminal is applied to the base of transistor Q4. The emitter of transistor Q4 is connected to the emitter of transistor Q3. The difference voltage between the base voltage of transistors Q3 and Q4 determines the unbalance in collector currents of transistors Q3 and Q4 and the current fed to the base of the dc amplifier transistor Q5. Resistor R6 is to provide for improved regulation and temperature stabilization. A signal proportional to the dc output of the battery is fed to the input of transistor Q3 from the voltage divider consisting of resistors R1 and R6 to improve regulation for changes of battery voltage.

**3.13** Regulation is obtained in the following manner: when the base voltage of transistor Q4 changes, there results an unbalance in the collector currents of transistors Q3 and Q4. The change in voltage drop across resistor R12 modifies the bias voltage at transistor Q5 causing a change in the base current of transistor Q5. This change is amplified by transistor Q5 and results in a large change of current through the base and collectors of transistors Q1 and Q2. The phasing is such that a decrease of regulator output voltage will result in a smaller impedance of transistor Q1. Therefore, as the load is increased or the dc input supply voltage is decreased, the output is maintained within output limits due to the action of the closed loop feedback circuit.

#### G. Battery Charger

**3.14** The battery charger consists of ferroresonant transformer T3, capacitor C10, and silicon rectifying power diodes CR16 and CR17. The ac input power is applied to terminals 1 and 2 of transformer T3. Capacitor C10 is tapped across terminals 4 and 5 of transformer T3 to provide load compounding over a restricted

range. Diodes CR16 and CR17 provide the full-wave rectified output that is applied to the batteries. The regulating action of transformer T3 is based on the separate characteristics of the two toroidal cores, one being linear and the other nonlinear. Due to the saturation of the nonlinear coil to an ac input above the prescribed voltage, the secondary is insensitive to a further increase in line voltage. Taps are provided on transformer T3 to compensate for manufacturing tolerances.

#### H. Battery Voltage Alarm Circuit

**3.15** The battery voltage alarm consists of resistors R43, R45, R47, transistor Q14, and relay K1. The -20 volt output of the IF amplifier and baseband regulator is supplied to the emitter of transistor Q14. The battery voltage is applied to the voltage divider consisting of resistors R45 and R47.

**3.16** A signal proportional to the battery voltage is fed to the base of transistor Q14. Since the emitter of transistor Q14 is held at a fixed potential, changes of input base voltage will cause changes of transistor collector current and current through relay K1. The collector current, when the batteries are fully charged, causes relay K1 to be energized and closes contacts that are connected to terminals 4 and 5 of terminal strip TB5A. Contacts on relay K1 connected to terminals 1 and 6 of terminal strip TB5A open the ground path to the alarm panel. When the battery voltage drops to 25 volts, relay K1 de-energizes since the collector current of transistor Q14 is reduced. Resistor R43 limits the power dissipated in transistor Q14 and relay K1.

**3.17** The current flowing through the alarm circuit reduces the power dissipation of transistor Q1 and results in increased over-all circuit efficiency. Battery voltage alarm fuse F3 provides circuit protection due to short circuit in the alarm circuit.

#### I. Performance Characteristics

**3.18 AC Input:** Single-phase,  $60 \pm 2$  per cent cycles per second,  $117 \pm 10$  per cent volts rms. Normal input power is 230 watts in addition to 110 volts-amperes reactive. Recharge input power is 410 watts in addition to 300 volts-amperes reactive.

**3.19 DC Input:** 24-volt DC, nominal battery. Battery voltage may be between 22 and 28.1 volts direct current during charging and discharging.

**3.20 DC Outputs:**

VOLTS	AMPERES
-600	0.010
-400	0.064 - 0.100
10.5 { -400 to -410.5 } { from ground }	1.64 - 1.88
- 20	0.630 - 0.750
- 27.6	0.5

**3.21 AC Outputs:**

VOLTS	AMPERE
43 (2 Circuits)	0.010

**3.22 DC Output Regulation:** Within the rated working limits, the regulation of the -600 and -400 volt outputs is within  $\pm 0.45$  of 1 per cent for input voltage and frequency variations. Line and load regulation on the -20 volt output is less than  $\pm 2$  per cent. The -600 and -400 volt outputs are provided with taps on transformer T2 so that the individual outputs may be adjusted within  $\pm 5$  per cent for loads within the working limits.

**3.23 DC Filament Output Regulation:** Within the working limits the load regulation is less than  $\pm 1$  per cent.

**3.24 Ambient Temperature:** The working range is from  $-40^{\circ}$  to  $+140$  Fahrenheit.

**3.25 Minimum Loads:** This power supply is designed to operate the loads as given above and should *be used only when loaded*. External loads must be provided when the power supply is tested without the normal load.

If the regulated dc (filament) current is less than specified in 3.20 above and the dc output loads are at the minimum also specified

in 3.20 above, the power supply may fail to meet the requirements at the extremes of battery voltage.

**3.26 Ripple:** The ripple output on the -600 volt supply is less than +33 db reference noise C message weighting when read with a 3A noise meter. The ripple output on the -400V supply is less than +25 db reference noise -C message weighting, measured with a 3A noise meter.

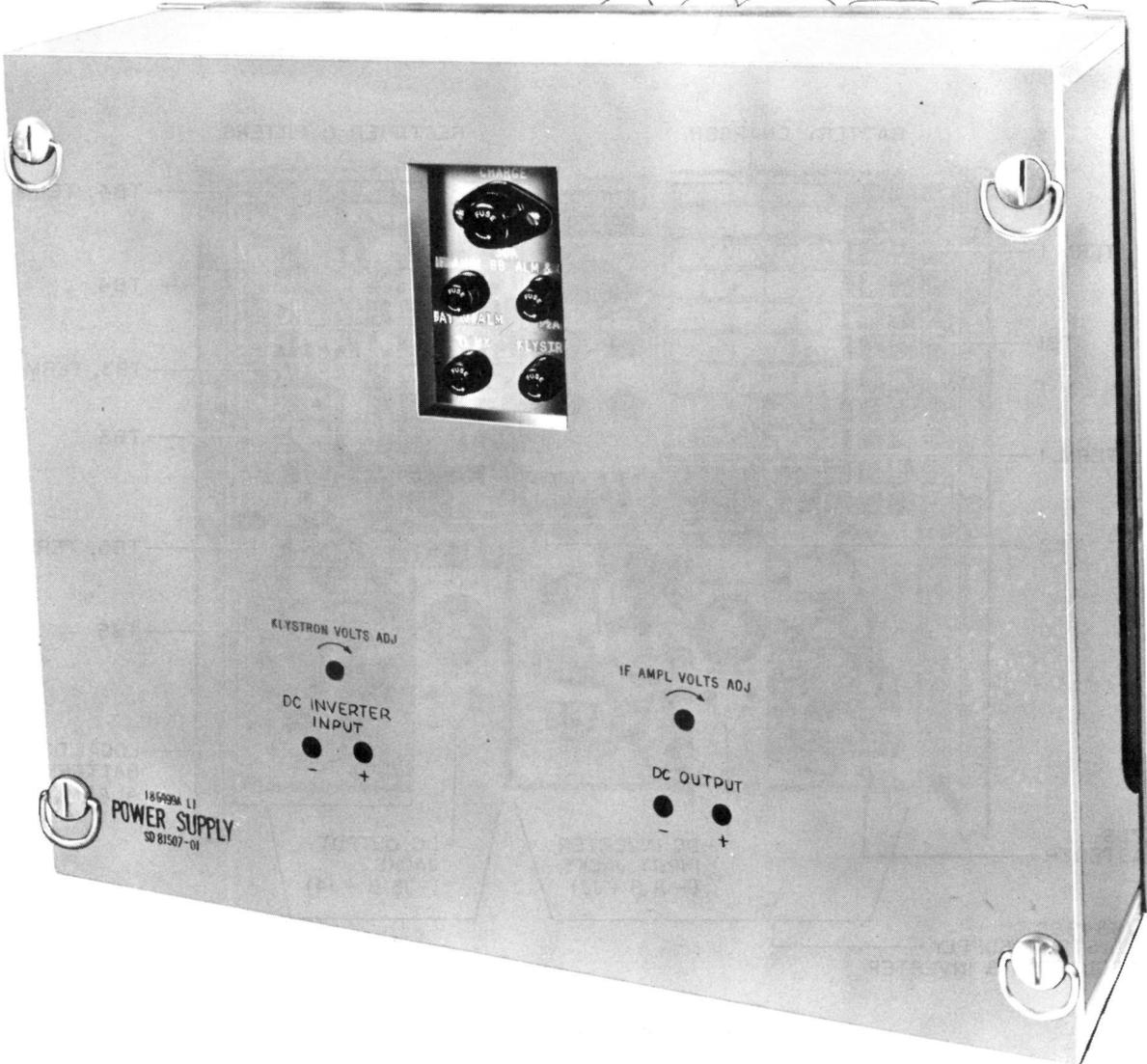
The high-frequency ripple on the -400 volt output is less than -67.5 dbm when measured across a 75-ohm impedance between 36 and 68 kilocycles and -77.5 dbm between 68 and 1000 kilocycles. Above 1 megacycle the ripple may increase 6 db per octave. The ripple on the 10.5-volt (filament) output is less than 0.85 volt peak to peak. The ripple output on the -20 volt (IF and baseband) supply is below 1 millivolt rms.

**3.27 Battery Charger:** DC output is for charging 12 cells of lead-acid high gravity batteries in series. A current limiting feature is provided for automatically recharging the battery after a power failure. The ripple output is below 300 millivolts rms at 6 amperes and 1200 millivolts at 20 amperes. The output voltage while charging the batteries is 27.1 to 28.1 volts between 2 and 11 amperes for an input voltage between 105 and 129 volts.

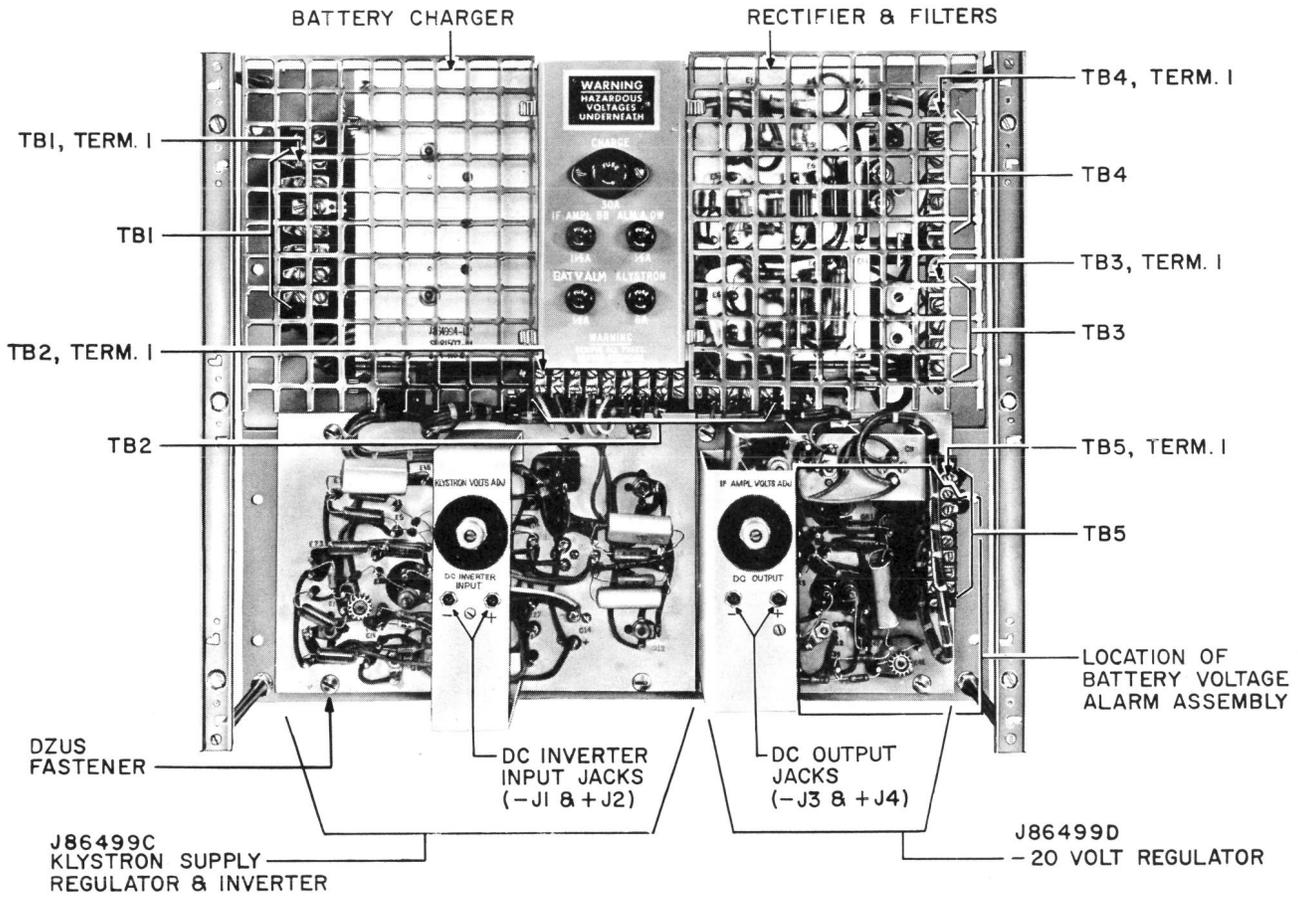
#### 4. REFERENCE LIST

**4.01** The following give additional information.

SUBJECT	DESIGNATION
TL Radio Power Supply Equipment Drawings	J86499A through F
Power Supply Circuit Description	CD-81507-01
Power Supply Schematic	SD-81507-01
TL Radio Application Schematic	SD-97035-01



J86499A Power Supply



J86499A Power Supply — Cover Removed

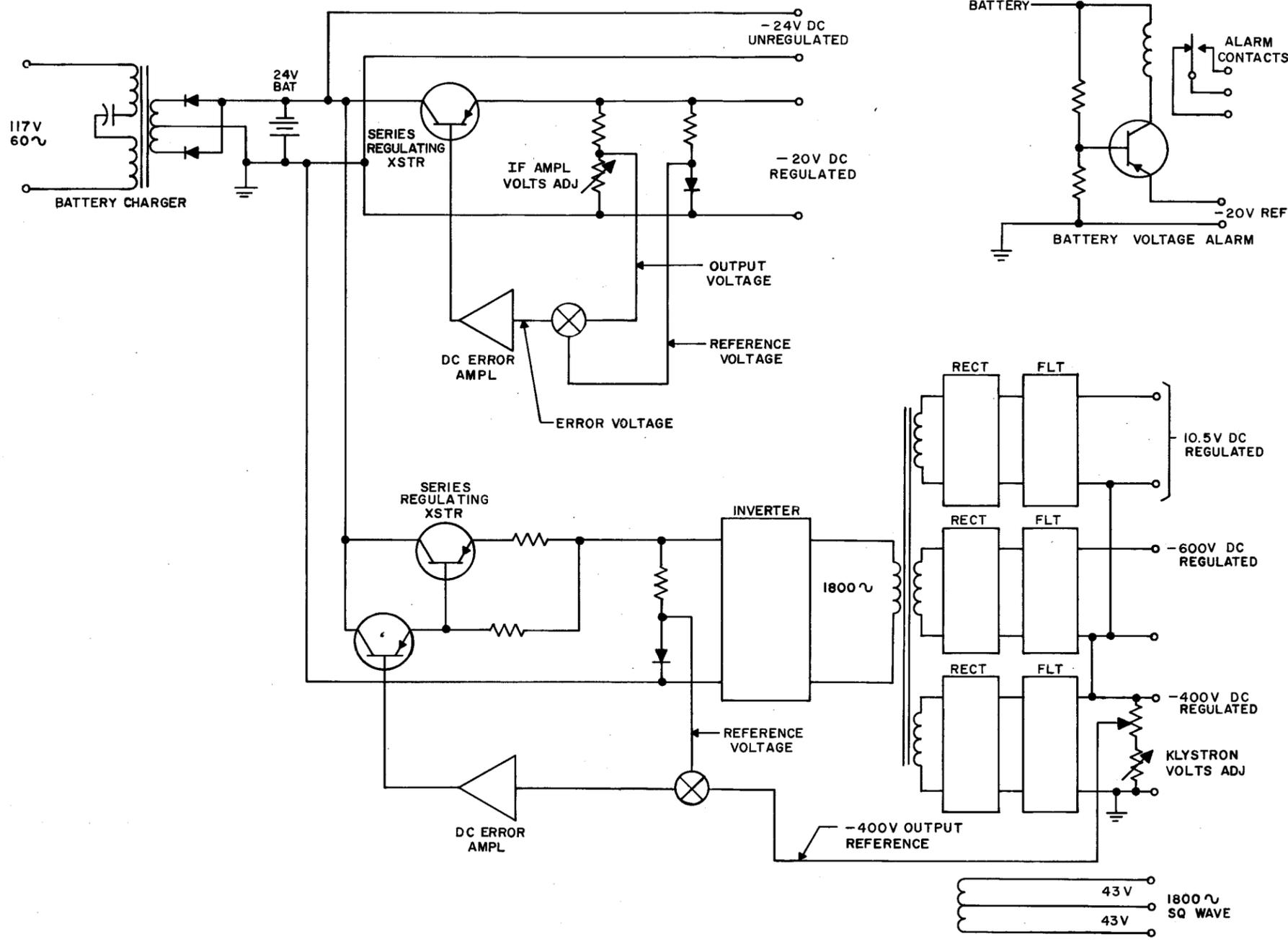


Fig. 3 - TL Radio Power Supply Simplified Schematic