resistor and a capacitor across it to offer protection in the event the voltage division across the diodes is unequal. S2 is the HV ON switch and has a transient suppressor across it to prevent damage to the switch when it is cycled.

Three computer-grade capacitors are series-connected at the output of the rectifier to provide 110-µF at 1350 volts. Each capacitor has a 47,000-ohm resistor across it to assure equal voltage drop. DS2 is the high-voltage ON indicator. Output from T2 is for the filament supply.

**Operation**

Approximately 50 watts of peak driving power are required to operate this amplifier at its rated 800 watts (PEP) input. If the transceiver being used as a driver has more power output than 50 watts, merely turn the transceiver’s audio-gain control down until the power output is correct.

With a 50-ohm dummy load attached to J2, and with operating voltages applied, apply a small amount of drive until an increase in plate current is evident (approximately 100 mA). Adjust C2 until a dip in plate current occurs. Increase drive until 300 mA of plate current is indicated on M1. Quickly dip the plate current and remove drive. Warning: Do not allow continuous plate current in excess of 100 mA to flow for more than 30 seconds at one time. Allow 30 seconds for cooling between tests. Next, apply drive until approximately 800 mA of plate current is obtained at dip. C3 should be adjusted for proper loading, making the dip in plate current somewhat broad and shallow. The amplifier is now ready for use and will have a dc input of 800 watts at this setting. Tests made with a spectrum analyzer showed that the IMD (intermodulation distortion) was very good at this power level. The third-order products were down some 27 decibels, and the fifth-order products were down in excess of 50 dB. The second harmonic product was measured at 35 dB down. If the operator does not mind the risk of shortened tube life, the power level can be 1000 watts PEP input. The efficiency of the amplifier is approximately 65 percent.

Other types of tubes can be substituted in this circuit, but few will permit the power level discussed in this amplifier. A good substitute might be the 6LQ6.

**THE SS-2000 AMPLIFIER**

The SS-2000 linear amplifier is designed to handle the legal maximum power input on cw and ssb. Because of the high plate-dissipation rating of the tube there is plenty of safety margin to prevent tube damage in the event of accidental mistuning. This amplifier is carefully shielded and filtered for the reduction of TVI. Though a 3-1000Z tube is used, the popular 4-1000A can be substituted as mentioned later. Both tubes have a maximum plate dissipation of 1000 watts. A suitable power supply for this amplifier (3000 volts) is described in the chapter on power supplies.

**Circuit Description**

Referring to Fig. 2, the amplifier is connected for grounded-grid operation. Excitation is applied through a switchable pi-section input tuned circuit. This network serves a twofold purpose: It reduces the amount of drive needed, by virtue of proper impedance matching between the exciter and the amplifier. It improves the IMD of the amplifier by providing the exciter with a better load than might otherwise exist. Approximately 50 watts of drive will be ample for the 3-1000Z. Roughly 125 watts
of excitation will be needed if a 4-1000A is used in
this circuit.
A pi-network plate tank is used in the output
side of the amplifier. It uses homemade coils
wound with 1/4-inch diameter copper tubing. The
L-C ratio was chosen for operation at 3000 volts.
Lower plate voltages will permit power in excess of
1 kW, but a different set of coil taps will be
required if a suitable Q is to be maintained. The
lower plate voltages will necessitate the use of
more C and less L in the tank.
A tuning/loading-indicating circuit is connected
between the grid and plate terminals of the tube. It
samples the input and output waveforms, rectifies
them, and compares their different voltage by
means of a zero-center microampere meter, M2. If
the amplifier is mistuned, or is looking into an
improper load, the meter will deflect off zero and
indicate a nonlinear condition. Those not wishing
to use the linearity detector may omit it from the
circuit. Additional metering is provided for by M2
– plate voltage, grid current, and forward and
reflected power. The SWR metering is made
possible by the bridge shown at the upper right of
Fig. 2. It is patterned after a design in the
Measurements chapter, and can be made to serve as
a zero to 2000-wattmeter by selecting the
proper-value resistors at R3 and R4. By substituting
25,000-ohm potentiometers for the fixed-value
calibrating resistors, the job should be a bit less
tedious. A power calibration scale can be plotted
for M2 by checking power output with an rf

![Fig. 1 — The front panel of the 2-kW PEP amplifier has the controls grouped at the left. The panel has been sprayed with gray enamel, and black decals identify the controls. The hardware visible in this photograph secures the TVI shielding.](image)

ammeter, or by comparing meter readings with a
commercial wattmeter. T2 is a toroidal transformer
consisting of 60 turns of No. 30 enameled wire,
close-wound on an Amidon T-68-2 form. The
bridge is built in a Minibox and is mounted on the
rear-outer wall of the amplifier case. A zero to
1-ampere panel meter, M1, monitors the plate
current of the 3-1000Z.

![Fig. 2 — In this bottom view of the amplifier, the filament transformer is visible at the upper right, just above the filament choke which runs along the right wall of the chassis. Relay K1 is located between the transformer and the tube socket. The slug-tuned coils of the cathode network are at the left, with the pi-section filters for the power leads just below. A ceramic feedthrough bushing is used to carry the 3000-volt lead up through the chassis.](image)
Fig. 3 – Schematic diagram of the 3-10000Z amplifier. Fixed-value capacitors are disk ceramic unless noted differently, and fixed-value resistors are 1/2-watt carbon, except where noted otherwise.
Construction Notes

The SS-2000 is built on a 13 X 17 X 4-inch chassis (Bud AC-428), and uses surface-shield panels for the front and rear walls of the enclosure. The front panel is 15 3/4 inches high, and 19 inches wide (Bud SFA-1839). The rear panel measures 14 X 19 inches (Bud SFA-1838). If a 4-1000A tube is to be used it is recommended that the next size larger panels be used to allow clearance inside the cabinet for the tube. (The 4-1000A is somewhat taller than the 3-1000Z.)

The input tuned circuit is housed on a bracket near the center of the chassis bottom. Between this cathode network and the tube itself, a parasitic suppressor, Z1, is included to kill any tendency toward vhf oscillation. Locating this choke in the cathode lead eliminates the losses common in 21- and 28-MHz operation when parasitic suppressor is placed in the plate lead.

An Eimac SK-510 tube socket, and an Eimac SK-506 chimney are used in this amplifier. Grid grounding is effectively done by passing the leads through the slots in the side of the tube socket which were provided for this purpose. Grid-pin connections are made to long solder lugs which are bolted to the chassis at the tube socket. Short leads of heavy-gauge wire or copper strips are vital to good amplifier stability.

Layout of the major components can be seen in the photos. It is important that a good ground connection be made between C2, C3, and the panel. Similarly, the panels should be securely grounded to the chassis. A heat-dissipating anode connector is used as an aid to tube cooling.

A 100-ft²/m grid blower is mounted on the bottom cover of the amplifier, slightly off center from the tube base. Its final positioning should be set for best air flow through the tube socket.

The terminal connections provided on T1 are much too bulky to be easily handled. They were replaced by smaller lugs that will accept No. 10 screws which thread into the ceramic pillars that are used as standoff insulators for the filament tie points.

The SWR bridge is housed in a 4 X 2 1/4 X 2 1/4-inch Minibox. Lead lengths should be kept short and as symmetrical as possible to assure proper operation. Good electrical balance is essential if the unit is to be balanced properly, thus assuring that it is truly bilateral. The dashed lines indicate shield compartments, Fig. 2.

Capacitor C4 in the linearity-detector circuit must be able to withstand high voltage and must be very low in capacitance value — on the order of 0.25 pF. In this model a glass piston trimmer is used for C4. The piston is removed and discarded. Connections for C4 are made by soldering to the foil wrap, top and bottom, with a low-heat soldering iron. An air-dielectric homemade capacitor could be fashioned from two copper tabs spaced 1/2 inch or more apart, firmly mounted on ceramic pillars.

Amplifier Adjustment

Initial testing should be carried out with a 50-ohm dummy load connected to the output of
the amplifier. If a Variac is available, gradually increase the high voltage to make certain that no short circuits or wiring errors are present, then increase the B plus to 3000 volts. At this point there should be no grid-current reading, but the resting plate current should be roughly 110 mA. Next, apply a small amount of driving power and observe the SWR meter. Tune the plate tank for maximum forward power, thus indicating resonance. Now, increase single-tone or cw drive until the resonant plate current is 330 mA. The grid current will now be approximately 75 mA. Operating in this manner the amplifier is adjusted for 1-kW dc input. Peak plate current for 2-kW ssb conditions will be 667 mA, and the grid current will be approximately 220 mA. All amplifier adjustments for arriving at the 2-kW PEP dc-input level must be made while using a dummy load if pulsed-tone or steady-carrier drive is applied to the amplifier. Stay legal by not exceeding the legal 1 kW maximum dc input level when the antenna is connected.

When adjusting the linearity detector the bottom cover of the amplifier is removed (beware of high voltage) and the amplifier is operated at an intermediate power level. With a voltmeter, check between point B and ground. The voltage, typically, will be between 0.5 and 1.5 volts. The voltage is then checked at point A, and C1 is adjusted to give the same voltage as is present at B. R1 is then set (amplifier operating at 2-kW into a dummy load) to give a reading of zero on M2. The meter reading is maintained at zero, thereafter, when the amplifier is properly adjusted and operating into a 50-ohm antenna.

In adjusting the SWR bridge, connect a dummy load to J5 and apply drive from the exciter to J4. Set M2 to read reflected power and place 1 shorting wire across R3. Adjust C6 for minimum meter deflection. Now, reverse the connections to J4 and J5, remove the short from R3 and place it across R4. Adjust C5 for minimum meter reading. Check for minimum reflected power at 28 and 3.5 MHz. It should be the same if the bridge is properly nulled. The values of R3 and R4 will have to be selected to give best accuracy at the 2000-watt input level. If an accurate wattmeter is available it can be used for calibrating the bridge. Small "trim pots" could be substituted for the fixed-value resistors to make adjustment easier. Their maximum resistance should be 50,000 ohms.

A ONE-KILOWATT AMPLIFIER USING A 3-500Z

Circuit design for high-power linear amplifiers hasn't changed much in recent years. The differences between various types of grounded-grid units are usually more mechanical than electrical. The degree of circuit complexity is determined primarily by the number of features desired and if the power supply and control circuits are included on the same chassis as the amplifier. Described below is a power amplifier designed to operate in a standard 1 kW as the primary mode. A suitable exciter is described earlier in the chapter. Other equipment combinations were shown in QST for December 1971.

The Power Supply

A voltage-doubler circuit connected to the secondary of T1 provides approximately 2600 volts dc. See Fig. 1. The primary of T1 can be operated from either a 117-volt line or a 220-volt source; the latter voltage is preferred. U1 and U2 are suppressors included to prevent transients from damaging the high-voltage capacitor bank or the rectifier diodes. Since T1 has two 117-volt primary windings, a suppressor is connected across each. The windings and suppressors are connected in parallel for 117-volt operation, and they are series connected for a 220-volt line.

A relay (K1) is necessary to switch the high-current inrush when the supply is activated. Ordinary toggle switches cannot be used to activate the power supply directly. Surge protection is accomplished by placing R1 in series with one lead of the ac line. K3B shorts out this resistor a few seconds after the main power switch (S1) is actuated. A separate line cord for the power supply allows this section to be operated on 220 volts while permitting other circuits in the amplifier to operate on 117 volts.

The Amplifier Circuit

A single 3-500Z triode tube develops 1-kW input on cw and 1-kW PEP on ssb. The output circuit is a conventional pi network which tunes the hf amateur bands from 3.5 to 30 MHz. The T-R switch, similar to the one used in the T-9er, is coupled to the tank circuit via C1. This capacitor is constructed of RG-8A/U and is 3 inches long.

Filament voltage is applied to the 3-500Z through a bifilar-wound rf choke. Drive power is coupled to the filament circuit via C2, a disk-ceramic capacitor.

Two Zener diodes are used to develop grid bias. S3C selects either CR18 for 27 volts (cw) or CR19 for a 7.5-volt bias (ssb). Since the lower bias voltage increases the standing plate current to approximately 80 mA, R7 is placed in series with the cathode-return lead to cut off the tube during standby periods. Protection for the power supply is assured by placing a 1-amper fuse in series with the Zener diodes. This procedure could save a tube or a meter (not to mention power supply components!) in the event a high current surge or arc occurs in the output circuit.

The Multimeter

A 1-ma meter is used to measure grid current, plate voltage, and power output. R4, mounted on the rear chassis apron, allows adjustment of the