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

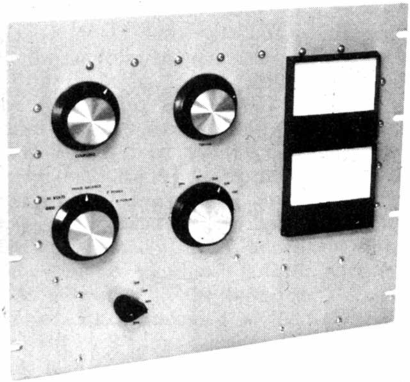

Fig. 1 – The front panel of the 2-kW PEP amplifier has the controls grouped at the left. The panel has been sprayed with gray enamel, and black decals identify the controls. The hardware visible in this photograph secures the TVI shielding.

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.

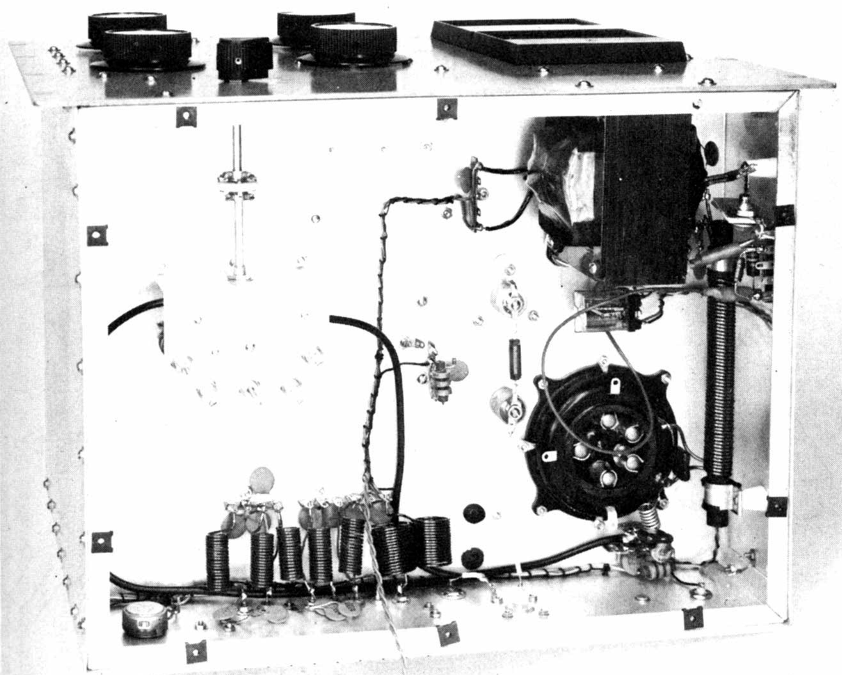

Fig. 2 – In this bottom view of the amplifier, the filament transformer is visible at the upper right, just above the filament choke which runs along the right wall of the chassis. Relay K1 is located between the transformer and the tube socket. The slug-tuned coils of the cathode network are at the 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.

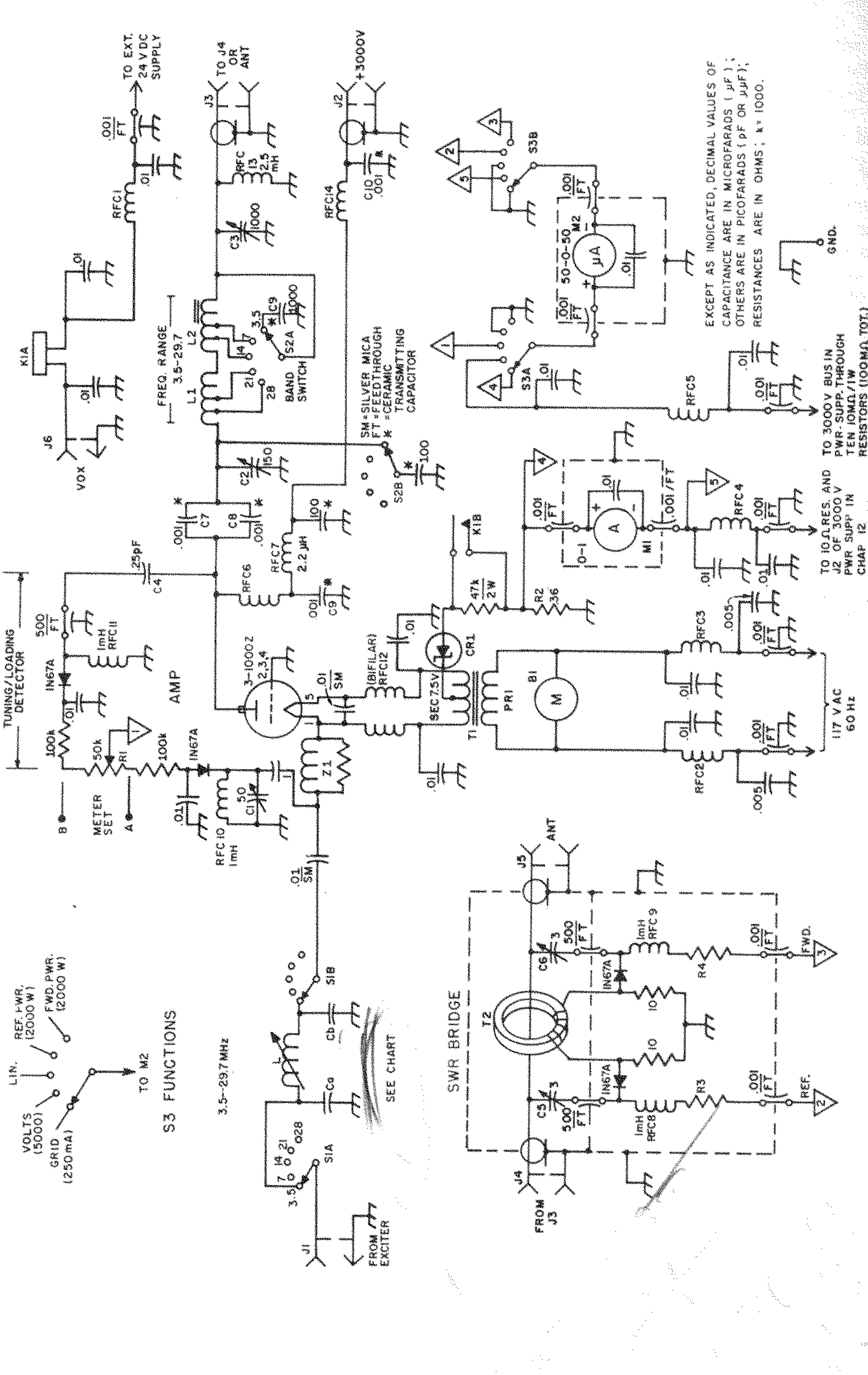

Fig. 3 — Schematic diagram of the 3-1000Z amplifier. Fixed-value capacitors are disk ceramic unless noted differently, and fixed-value resistors are 1/2-watt carbon, except where noted otherwise.

B1 — 117-V ac, 100-ft^3/m blower (Burstein-Applebee 41A4003).
Ca, Cb — See table.
C1 — Trimmer, 50 pF (Centralab 822AN).
C2 — Transmitting air variable, 150 pF (Johnson 154-15).
C3 — Transmitting air variable, 1000 pF (Johnson 154-30).
C4 — See text.
C5, C6 — Piston trimmer, 0.5 to 3 pF (JFD 25G).
C7-C10, incl. — Transmitting type (Centralab 858S-1000).
CR1 — Zener, 6.8V, 50 W (International Rectifier 23305-C).
J1, J6 — Phono jack, panel mount.
J2 — HV coaxial connector, chassis mount, type HN.
J3, J4, J5 — SO-239-style chassis-mount connector.
K1 — Spst 24-volt dc relay.
L — See table.
L1 — 11 turns, 1/4-inch dia copper tubing, 1 1/2-inches ID, space turns so that the entire coil is 3 1/4 inches long. Tap at 5 turns for 28 MHz and 9 turns for 21 MHz.
L2 — 10 turns, 1/4-inch dia copper tubing, 3 1/2 inches ID, space turns so that the entire coil is 4 inches long. Tap at 2 turns for 14 MHz, 7 turns for 7 MHz, and use the entire coil for 3.5 MHz. Inside the 3.5-MHz end of the coil is a package of eight 2-inch long, 1/2-inch dia ferrite rods (cut from the stock specified for RFC12).
M1 — 0 to 1-A meter (Simpson 17565).
M2 — 50-0-50-μA meter (Simpson 17597).
R1 — 50,000-ohm linear-taper composition control.
R2 — 0.36 ohms, 25 turns of No. 30 enam. wire on the body of a 1/2-watt composition resistor.
R3, R4 — Selected to give full-scale deflection (forward power) on M2 at 2000 watts. (See text for details.)
RFC1, RFC4, RFC5 — Rf choke, 18 turns No. 14 enam. wire, close-wound, 1/2-inch dia.
RFC2, RFC3, RFC14 — Rf choke, 24 turns No. 14 enam. wire, close-wound, 1/2-inch dia.
RFC6 — Rf choke (National Radio R-175A or B&W 800).
RFC7 — 2.2-μH rf choke (Miller 74F226AP or equiv.).
RFC8, RFC9 — 1-mH rf choke (Millen J300-1000).
RFC10, RFC11 — 1-mH rf choke (Miller 4652).
RFC12 — Bifilar filament choke, 28 turns of No. 10 enam. wire, close-wound on 1/2 X 7 1/2-inch ferrite rod (Newark Electronics 59F1521 ferrite rod suitable).
RFC13 — 2.5-mH rf choke (National R-100 or equiv.).
S1 — Ceramic rotary switch, 2-section, 6 position (5 used), 2 pole, non-shorting contacts (Centralab 2511).
S2 — Ceramic rotary power switch, 2 pole, 1 section, 8 position (5 used), non-shorting contacts (Centralab JV-9033).
T1 — Filament transformer, 7.5 volts, 21 A (Triad F28U).
T2 — Toroidal transformer (see text).
Z1 — Rf choke, 6 turns No. 16 on the body of a 100-ohm, 1-watt composition resistor.

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-guage 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-ft^3/m 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 a 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 break-in cw 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-ampere 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