A Medium-Power 144-MHz Amplifier

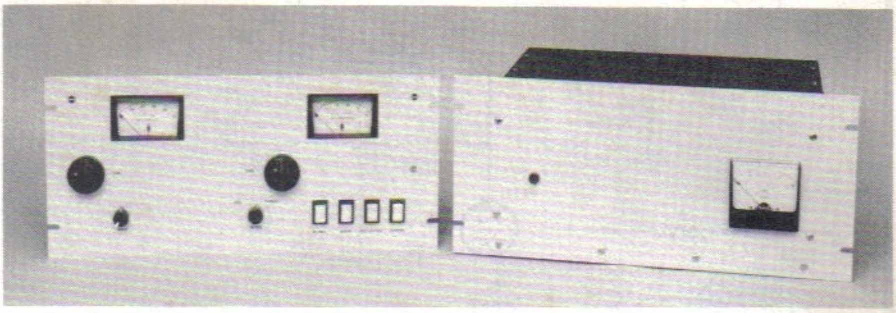

Fig. 98 — The 8930 amplifier and accompanying high-voltage power supply are built behind standard 19-in rack panels.

The typical 2-meter rig these days puts out 10 watts or so. While 10 W is adequate for local communications, it is not enough for reliable long-haul work. Although occasional band openings and enhanced conditions allow long-distance contacts with low power, something more is desirable for weak-signal work. The amplifier pictured in Figs. 98 through 110 will supply more than 300-W output for 10-W of drive. It is clean, easy to build and reliable. If the builder shops wisely, the entire amplifier can be built for less than the cost of a commercially manufactured 150-W "brick" amplifier and associated 20-A, 13.8-V regulated supply. This project was designed by Clarke Greene, K1JX, and built by Mark Wilson, AA2Z, in the ARRL lab.

Circuit Details

An 8930 tetrode (350-W plate dissipation) is used in this design. The 8930 is identical electrically to the 4CX250R, but it features a larger anode cooler for higher dissipation with lower air flow and pressure drop requirements. If the builder must purchase a new tube, the 8930 is a good choice because it is more rugged than the 4CX250. However, a commonly available 4CX250B will work fine in this circuit. Only minor mechanical changes are necessary to accommodate the 4CX250's smaller anode cooler. The amplifier and power supply are shown schematically in Figs. 99 and 100.

The input circuit consists of L2, which is series tuned by C2 and the tube input capacitance. C3 is used in parallel with C2 to preset the tuning range for a smooth vernier action. A single 15- or 20-pF variable may be used at C2, but the tuning will be more critical. Power is coupled to L2 through link L1.

Bias voltage is fed to the tube through R1. This resistor, which consists of three 820-ohm, 2-W carbon composition resistors in parallel, swamps the grid heavily. Heavy swamping is important for amplifier stability. It also raises the drive requirement to about 8 W for full output. The amplifier can be driven to full output with about 2 W if the grid swamping resistor is changed to 2000 ohms or so and the input matching is adjusted accordingly. Excessive drive, however, will make the tube run in the nonlinear region, causing splatter up and down the band. It is impossible to adequately control the drive power by adjusting the exciter mic gain control. An input circuit designed for the drive level available from the exciter makes it difficult to overdrive the amplifier, ensuring a clean signal and peaceful coexistence with nearby amateurs sharing the band.

The output circuitry consists of a quarter-wavelength strip line, L3, which is tuned by C9. A tuned link, L4 and C10, couples power to the output jack. High voltage is fed to the tube at the low-impedance (ground) end of the line through RFC1. C8 is the plate-blocking capacitor.

The filament, bias and screen voltages are all supplied by T1. EIMAC specifies filament voltage at 6.0 ±0.3 V, so R11 is included to drop the transformer voltage to the proper level.

T1 has a secondary winding of 270-0-270 V which is used for the screen and bias supplies. Screen voltage regulation is accomplished by five 60-V Zener diodes, D7 through D11. The voltage from the supply is dropped to the Zener stack voltage by current-limiting resistor R5. R7, a screen bleeder resistor, is connected in parallel with the Zener stack to allow for negative screen current developed under certain tube operating conditions.

A tetrode should not be operated without plate voltage and a load. Otherwise, the screen would act like the anode and draw excessive current. Should this happen accidentally, F2 will blow and protect the screen. F2 is placed between the Zener stack and the bleeder, rather than between the bleeder and the tube. If the tube were operated without a load on the screen, the screen potential would rise to the anode voltage, destroying the screen bypass capacitor. Should the screen voltage rise above 390 V, Z1, a metal-oxide varistor, will conduct and clamp the screen voltage to ground. The power-supply fuse should blow before any damage occurs.

Bias voltage is taken from the same secondary winding as the screen voltage. When the amplifier is in standby, −200 V is applied to the grid to cut the tube off. In transmit, D12 is switched in, supplying operating bias. R9 is used to adjust operating bias from −40 to −60 V to allow for differences among tubes. D15 is included to minimize Zener voltage drift as D14 changes temperature.

The 5-V winding on T1 supplies coil voltage for K1. Contacts K1B switch the bias from standby to operate. K1C provides "dry" contacts for antenna relay switching.

S1 applies voltage to the blower motor, while S2 energizes T1. These two switches are connected so that the blower must be switched on before filament voltage is applied. The blower may be left on after the amplifier has been turned off.

The high-voltage supply is designed to deliver 2000 V under load. The heart of the supply is a heavy-duty Hammond transformer that will run cool even under continuous use. The 234-V primary and full-wave bridge rectifier in the secondary aid voltage regulation.

The B+ supply is turned on from the amplifier front panel, so the supply may be located away from the operating position. K1 is a heavy-duty power relay with contacts large enough to handle the supply current. R1 and R2 provide inrush current protection for the rectifiers. These resistors are shorted out by the contacts of K2, applying full primary voltage after a short delay. This delay is about 0.6 second, and is determined by R3 and C1.

D1 through D4 are high-voltage rectifiers provided by K2AW. They eliminate the need for a PC board full of individual 1000-PIV units with associated capacitors and equalizing resistors. C2 is a surplus oil-filled capacitor. Individual electrolytic capacitors would work fine, if enough units are connected in series to give about 40 μF at a voltage rating of at least 2500 V.

R4 through R6 make up the bleeder resistor. Several individual resistors are used, rather than one large unit, to keep the voltage across each resistor within ratings. F2 is a high-voltage fuse that will protect the power supply and amplifier in case of a short circuit. The negative lead of the power supply floats above chassis ground so that plate current may be monitored in the negative lead in the RF deck. R8 keeps the B− lead close to chassis potential. R9, in series with the B+ lead, protects the tube and power supply from high-voltage flashovers.

Plate current is monitored by a 0- to 500-mA meter in the negative lead. A 0- to 5-mA meter monitors grid current and screen current. Shunt R6 increases the movement to a 50-mA range for the screen. The high-voltage supply has a separate 0- to 4-kV meter.

S3, used to turn on the high-voltage

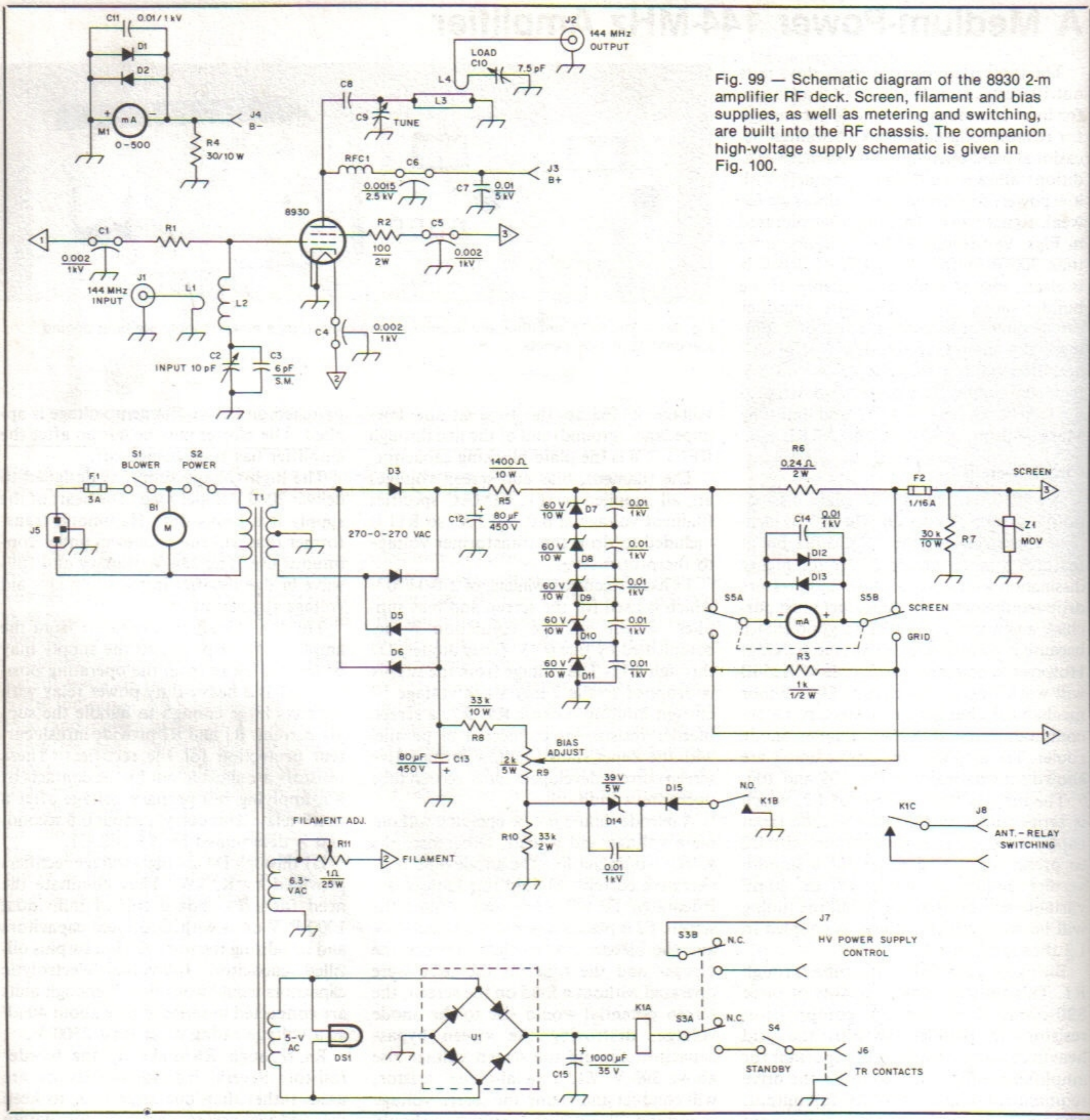

Fig. 99 — Schematic diagram of the 8930 2-m amplifier RF deck. Screen, filament and bias supplies, as well as metering and switching, are built into the RF chassis. The companion high-voltage supply schematic is given in Fig. 100.

B1 — 54 CFM blower (Dayton 4C012A or equiv.).
C1, C4, C5 — Feedthrough capacitor, 2000 pF, 1 kV (Erie 1202-005 or equiv.).
C2 — Miniature air variable, 1.8 to 8.7 pF (Cardwell 160-104 or equiv.).
C6 — Feedthrough capacitor, 1500 pF, 2.5 kV (Erie 1280-060 or equiv.).
C8 — Plate dc blocking capacitor; part of plate line assembly. See text and Fig. 104.
C9 — Flapper capacitor. See text and Fig. 104.
C10 — Air variable, 2.8 to 7.5 pF (Millen 22006 or equiv.).
D1-D6, D12, D13, D15 — Silicon diode, 1 kV, 1 A (1N4007).
D7-D11 — Zener diode, 60 V, 10 W (RCA SK192).
D14 — Zener diode, 39 V, 5 W (1N5366).
DS1 — Meter illumination lamps (see text).
J1 — BNC chassis mount.
J2 — Type N chassis mount.
J3, J4 — High-voltage connector (Millen 37001 or equiv.).
J5 — CEE-22 chassis mount power connector.
J6 — Chassis-mount phono jack.
J7 — Two-conductor socket (Cinch S-402AB or equiv.).
J8 — Terminal strip, two conductor.
K1 — DPDT relay, 6-V dc coil.
L1 — 1 turn no. 16 enam. wound over center of L2.
L2 — 4 turns no. 16 tinned wire, 3/8-in ID, 5/8-in long.
L3 — Plate line. See text and Fig. 104.
L4 — Output coupling link. See text and Fig. 104.
M1 — Plate current meter, 0-500 mA (Simpson model 1327 with custom face; Cat. no. 10552, avail. from Larson Instrument Co., Greenbush Road, Orangeburg, NY 10962).
M2 — Grid and screen current meter, 0-5 mA movement (Simpson model 1327 with custom face; Larson Instruments Co., cat. no. 10551).
R1 — Three 820-Ω, 2 W carbon composition resistors in parallel. See text.
RFC1 — 1.72 µH, 600 mA RF choke (J. W. Miller RFC-144 or equiv.).
S1, S2, S4 — SPST rocker switch.
S3 — DPDT rocker switch.
S5 — Rotary switch, 2 circuit, 2 position, non-shorting (Mallory 3222J or equiv.).
T1 — Power transformer, 117-V ac primary; secondary: 270-0- 270-V at 120 mA, 6.3-V CT at 3.5 A, 5 V at 3 A (Stancor PC-8405 or equiv.).
U1 — Bridge rectifier, 50 V, 1A.
Z1 — Metal-oxide varistor, 370-V dc continuous, 390-470 V peak (Zenamic Z275LA40A or equiv.).