A Compact 650-Watt Amplifier

Compactness in the high-power amplifier shown in Figs. 6-77 through 6-82 is achieved through the use of germanium rectifiers in the power supply and tubes of the radial-beam type. When driven by an exciter delivering about 30 watts output, the amplifier runs at about 650 watts input and gives an output of about 400 watts on c.w. or p.e.p. s.s.b. It covers 80 through 10 meters by means of band switching and has a fixed 50-ohm output impedance.

Two 4X250B tubes operating Class AB_2 are used in a grounded-cathode circuit (see Fig. 6-78). No grid tuning is used, since an exciter of the size mentioned will drive the grids directly across the 110-ohm resistance. L_1 is a series peaking coil to increase the drive on 10 meters. A parallel-tuned tank with fixed-link output coupling is used in the plate circuit. This system has the advantage that series plate feed can be used, and no large output capacitance is needed. Tuning is straightforward and the coupling, once adjusted holds over a wide frequency range.

The link circuit is grounded through a removable jumper at the output connector, so that a balanced load can be fed if desired.

The small 15-$\mu\mu$f. capacitor (CRL Type 850), from the plates to ground, provides a short path for harmonic currents and keeps them out of the output coil. On the 3.5- to 4-Mc. range a fixed 100-$\mu\mu$f. capacitor is connected across the coil, so that a proper L-to-C ratio can be maintained at 4 Mc. When switched out of the circuit, the coil and fixed capacitor resonate around 5 Mc., which is sufficiently removed from any of the other ranges to avoid any difficulty.

The 10-ohm resistor in the B + lead serves as a fuse in case of a shorted tube or other fault that might endanger the power supply.

Power Supply

The plate supply uses two voltage doublers in series; see Fig. 6-81. Two 325-volt windings on T_2 feed strings of germanium rectifiers in full-wave voltage-doubler connections. Each doubler capacitance is 160 μf., made up of two parallel 80-μf. 450-volt cartridge type units with cardboard sleeves. The chassis is lined with insulating material under the C_5 and C_6 capacitors, since their outer cans run as high as +1300 volts. The ripple is around 3 per cent r.m.s., and the regulation from no load to full load is about 15 per cent. Sixteen cells are used. Each group of four cells in one side of a voltage doubler has two 560 K resistors connected across pairs of cells to equalize the reverse voltage drop. Other 560 K resistors are connected as bleeders only as a safety measure, since no bleeders are needed for proper circuit operation. But even with the bleeders, the capacitors can retain a charge for several minutes, so be careful!

Grid bias is furnished by a 75-volt winding on T_1, a half-wave rectifier and an 80-μf. capacitor. About −90 volts is developed across C_9 and applied to the tubes during stand-by periods. The operating bias is adjustable from −30 to −60 volts by R_3.

Screen voltage is taken from the +375-volt point of the plate supply (junction C_7 and C_8). It is dropped through the 6BF5 regulator to deliver a low-impedance output adjustable from about 250 to 325 volts at up to 75 ma. Since this type of regulator will not handle reverse current, bleeder R_2 (Fig. 6-78) is provided to offset no-signal negative screen current to the 4X250Bs and make the screen meter read on scale.

When in operating condition, the "reference" voltage for the screen regulator is the −90 volt bias supply. In stand-by condition the reference is switched down to the tap on R_3, thus reducing the screen voltage from its nominal +300 or so to a lower value. This action, together with the increased grid bias, insures that the 4X250Bs

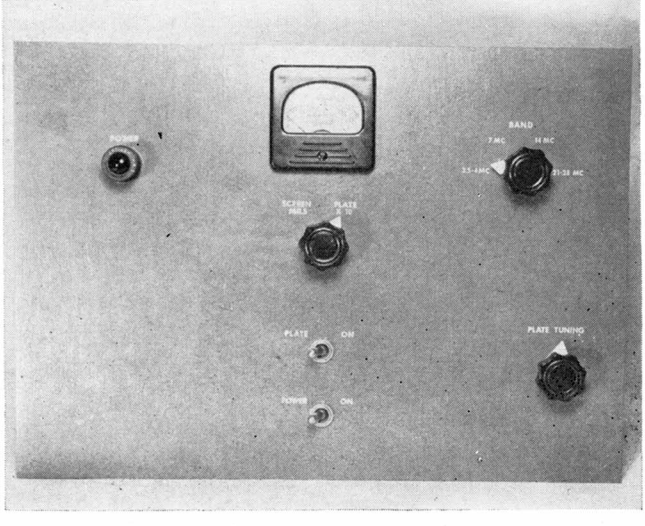

Fig. 6-77—The panel of this 650-watt amplifier built by W9LZY measures only 10 by 14 inches. Below the meter are the meter switch, high-voltage switch and filament/bias switch. To the right are controls for the band switch (above) and the tank capacitor (below).

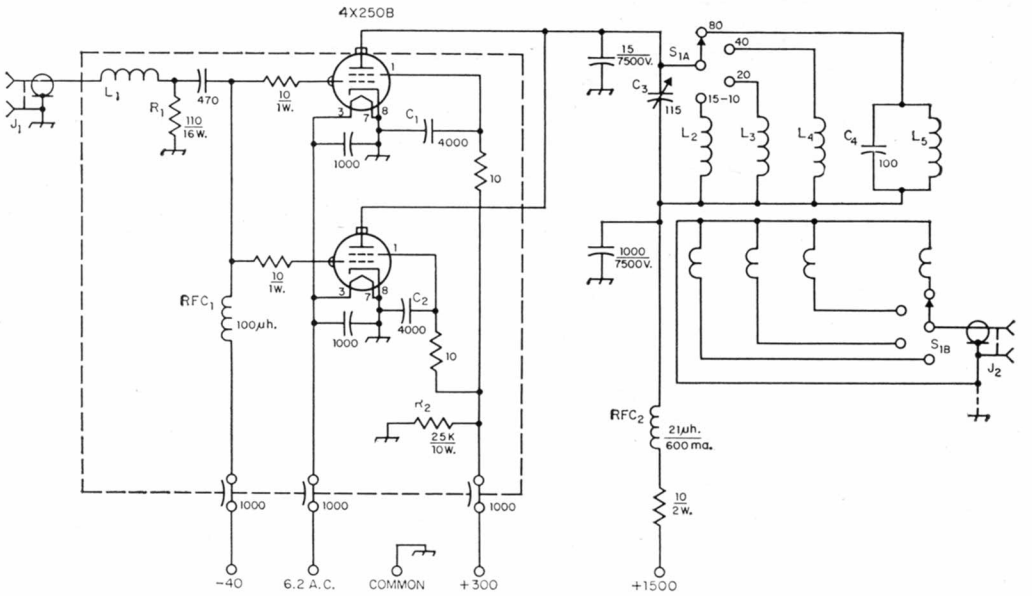

Fig. 6-78—Circuit diagram of the r.f. portion of the amplifier. Unless otherwise indicated, capacitances are in $\mu\mu$f., resistances are in ohms, resistors are ½ watt. The 1000-$\mu\mu$f. plate bypass is a CRL Type 858-S; the 1000-$\mu\mu$f. feed-through capacitors are 500-volt ceramic.

C_1, C_2—Four 1000-$\mu\mu$f. 500-volt disk ceramic capacitors in parallel.
C_3—115-$\mu\mu$f. variable, 2000-volt spacing. See text.
C_4—Two 25-$\mu\mu$f. NPO ceramic and one 50-$\mu\mu$f. N750 ceramic in parallel, 7500-volt rating.
J_1—UG-291/U BNC panel jack (Amphenol 31-001).
J_2—SO-239 UHF panel jack (Amphenol 83-1R).
L_1—6 turns No. 20, ⅜-inch diam., ½ inch long.
L_2—4½ turns ⅛-inch copper tubing, 1¼ inches long, 1⅛-inch diam. Link is 3 turns No. 16 wire, ¾ inch long, ¾-inch diam
L_3—6 turns ⅛-inch copper tubing, 1½ inch long, 1⅝-inch diam. Link is 2 turns No. 12, ½ inch long, 1⅛-inch diam.
L_4—8½ turns No. 12, 1⅛ inches long, 2⅛-inch diam. Link is 3 turns No. 12, ⅝ inch long, 1½-inch diam.
L_5—Two coils, see text. Outer is 10 turns No. 12, 1⅜ inches long, 2⅛-inch diam. Inner coil is 6½ turns No. 12, ¾ inch long, 1¾-inch diam., inside plate end of outer coil. Link is 4 turns No. 12, ½ inch long, 1½-inch diam.
RFC_1—100-μh. r.f. choke (National R-33-4).
RFC_2—21-μh. 600-ma. r. f. choke (Ohmite Z-28).

draw no current in standby condition. In operation the grid, screen, and plate voltages all tend to vary in proportion to line-voltage changes.

The screen current is measured by switching the 0-75 milliammeter across 22 ohms in the lead to the screen-voltage regulator. The resistor has negligible shunting effect. For measuring plate current the meter is switched across a low resistance R_6, connected between the two sections of the plate supply. R_5 was adjusted for

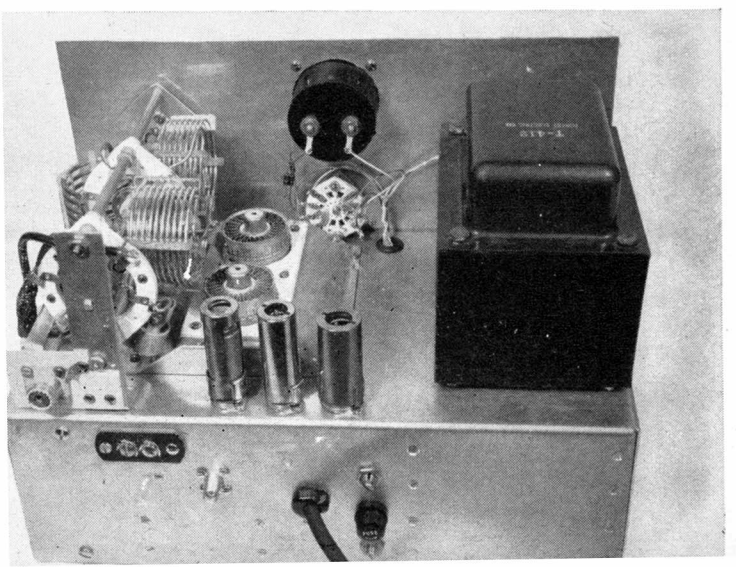

Fig. 6-79—Rear view of the 650-watt amplifier showing mounting of the 4X250Bs and the plate transformer. Shields in the foreground enclose voltage-regulator tubes and a relay. The shaft protruding from the rear edge of the chassis operates the bias potentiometer.

650-Watt Amplifier

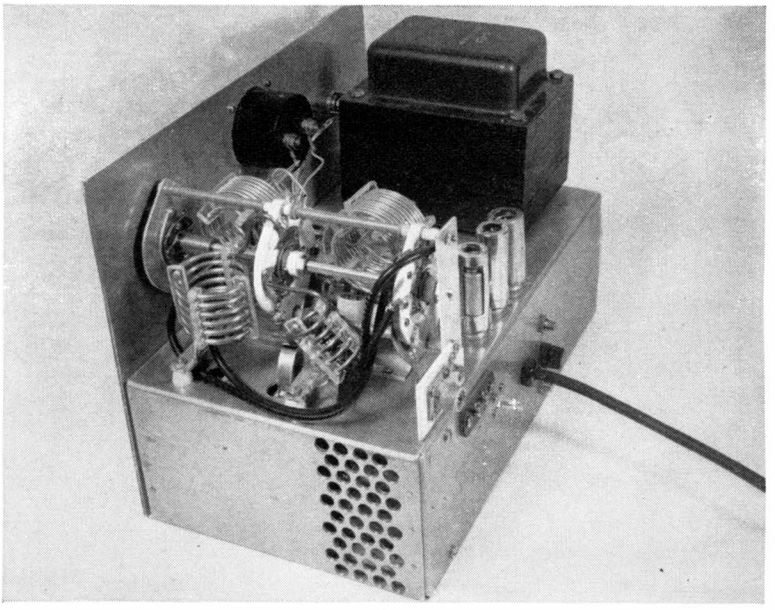

Fig. 6-80—Side view of the 4X250B amplifier showing mounting of the band switch and tank coils. The chassis is perforated for ventilation.

full-scale meter reading at 750 ma. There is a maximum of 425 volts between switch contacts and 850 volts from contacts to ground.

The stand-by relay K_1 is one that plugs into a 7-pin miniature socket. It operates from 115 volts a.c. and a half-wave power supply. The input is brought out to two terminals on the rear of the chassis, where connection is made across the antenna relay coil.

Construction

The amplifier is built on an 8 × 14-inch chassis with a 10 × 14-inch panel. The chassis is 4½ inches deep, to provide space for the filter capacitors and cooling fan underneath. As can be seen by studying the photographs, the plate power supply occupies the left end of the chassis, and the r.f. circuits take most of the remaining space. The heater and bias supply is stowed under the right rear corner of the chassis behind the plate tuning capacitor. The screen regulator and stand-by relay are at the rear of the chassis in the center.

The controls are few and simple. The band switch has four positions, for the 80-, 40-, 20- and 15- and 10-meter bands. Other controls are the plate tuning capacitor, plate-current/screen-current meter switch, power and plate voltage switches.

The plate tank capacitor is one from a BC-375 tuning unit, mounted under the chassis on four ceramic feed-through bushings. (Any other capacitor of equivalent rating, such as the Johnson 155-4 may be substituted.) Four holes were drilled and tapped in the ¼-inch square frame rods on the right-hand side of the capacitor, and 6-32 threaded rod was screwed into the holes and passed through the insulators. The four screws project above the insulators at the top of the chassis, where the B+ ends of the plate coils connect to them via copper strips. An insulated shaft extension goes through the panel to the tuning knob.

The wire from each coil was wrapped around a pipe of suitable diameter. Four Plexiglass strips were drilled with clearance holes at the desired spacing, then the coil wire was fed through the holes. The 80-meter coil was made with two concentric sections in series to get enough inductance into the available space. The 80- and 40-meter links were also threaded through strips, while the 20- and 10-meter links are self-supporting. All links are a push fit inside the insulating strips of their respective coils, and are held with a drop or two of cement after adjustment.

The two band-switch wafers are each single-pole, 4-position, 60-degree throw (Communications Products Co., Type 86). A 60-degree index-and-shaft assembly from an Oak Type H switch was used. The rest of the switch was made up from 6-32 threaded brass rod, ¼-inch o.d. tubing, 1/16-inch aluminum sheet, and miscellaneous ceramic spacers and fiber washers from junked rotary switches.

The front wafer switches the plate coils. The links are connected to the rear wafer through RG-58/U cable, except the 80-meter link which goes direct. The cold sides of all links are soldered to a strip of copper running around the wafer, supported by 2-56 screws through the unused holes between contacts. The u.h.f.-type output connector is mounted on a strip of bakelite fastened to the rear switch bracket; its shell is grounded through a couple of solder lugs shown. T_2 weighs about twenty pounds; the chassis should be at least 0.08-inch aluminum to be strong enough to carry it.

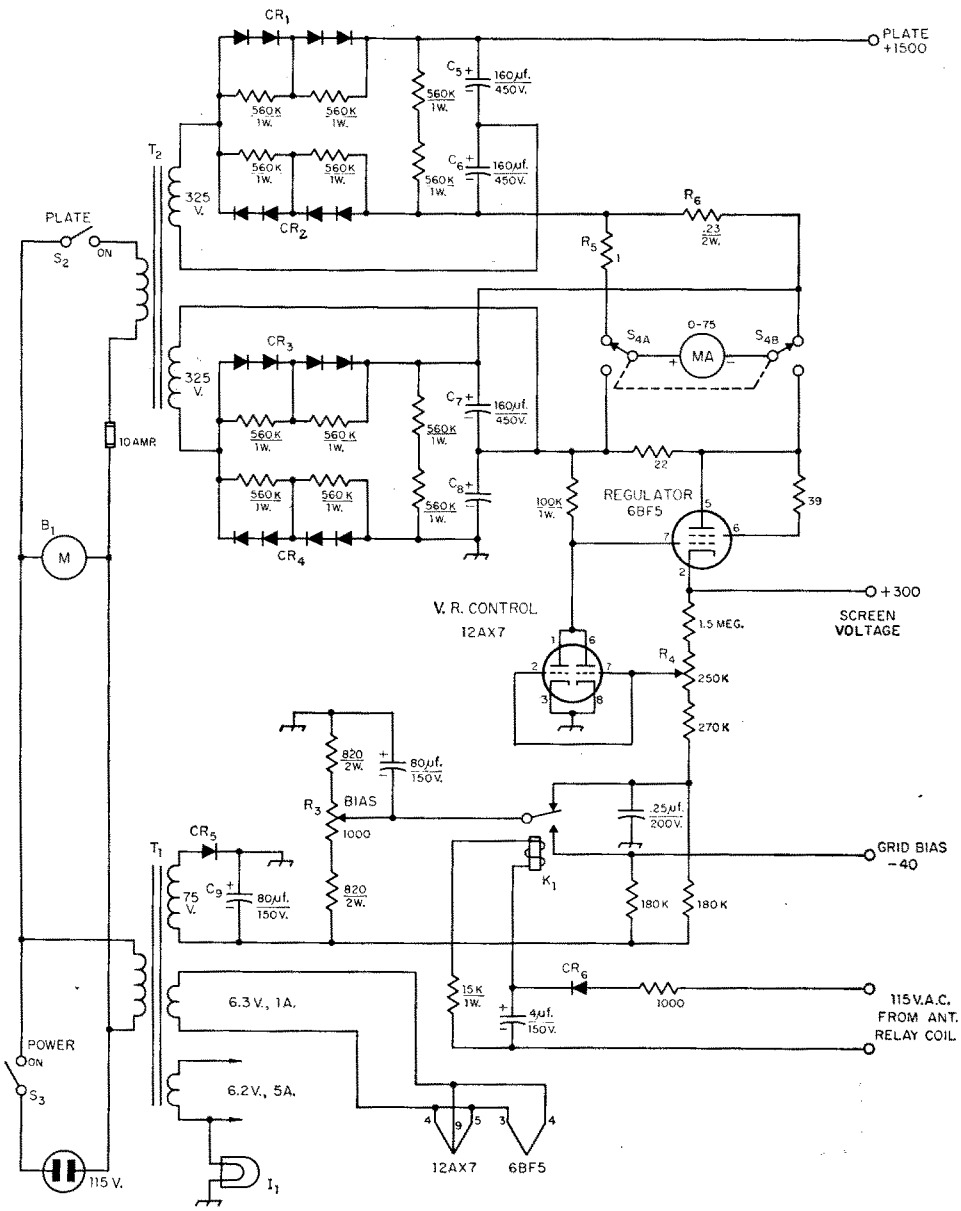

Fig. 6-81—Circuit of the power supply. Unless otherwise indicated, resistances are in ohms, resistors are ½ watt.

B_1—3250-r.p.m. motor with 4-inch fan blade (Rotron* 92-AS motor).

C_5 C_6, C_7, C_8—Two 80-μf. electrolytics in parallel (Sprague TVA-1716). Insulate as described in text.

CR_1—CR_4—Four 500-ma. 300-volt peak inverse (1N153 or equiv.).

CR_5—100-ma. 380-volt peak inverse.

CR_6—65-ma. 380-volt peak inverse (Federal 1002A).

I_1—150-ma. 6-8 volts (GE No. 47).

K_1—5000-ohm coil, 4 ma. pull-in (Terado Series 600 or equivalent).

R_3—2-watt linear potentiometer (Ohmite CU-1021).

R_4—2-watt linear potentiometer (Ohmite CU-2541).

S_2, S_3—15-amp. 125-volt toggle (Cutler-Hammer 7501-K13).

S_4—Two-pole 2-throw 60-degree throw ceramic rotary switch, non-shorting. See text.

T_1—6.2 volts at 5.5 amp., 6.3 volts at 1 amp., 75 volts at 100 ma. (Forest Electric Co.** T-423).

T_2—Two-secondaries, each 325 volts, 1 amp. (Forest** T-412).

*Rotron Mfg. Co., 7 Schoonmaker Lane, Woodstock, New York.

**Forest Electric Co., 7216 Circle Rd., Forest Park, Ill.

650-Watt Amplifier

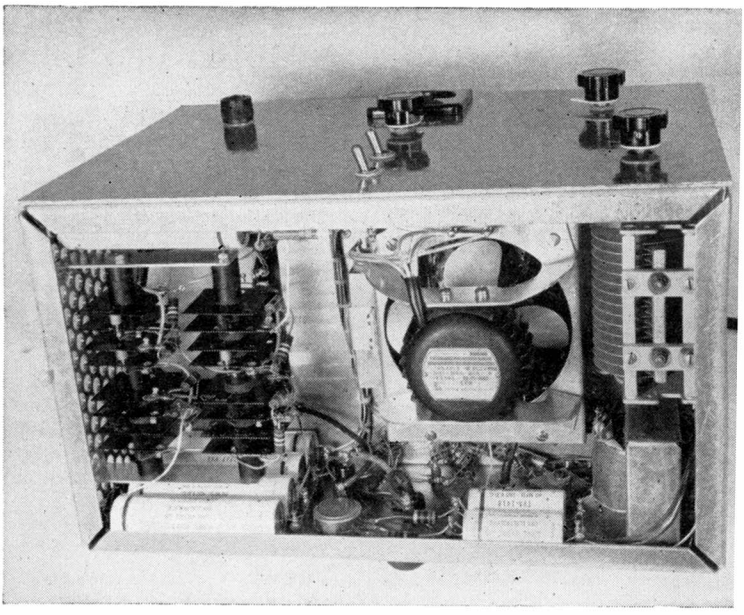

Fig. 6-82—This bottom view show the ventilating fan, tank capacitor, rectifier stacks and filter capacitors.

A bottom cover and a perforated-metal shield over the top, sides and rear should be added, for safety as well as TVI-proofing. An opening should be cut above the r.f. tubes and covered with hardware cloth.

Cooling

Each 4X250B tube requires at least 3.6 cubic feet of air per minute through the anode cooler. The base also requires some air. The tube is ordinarily mounted in an Eimac "air-system" socket so that the air flows first over the base, then through the anode cooler. This leads to a fairly large pressure drop, which is ordinarily considered to require a centrifugal blower. Since a blower of this type requires considerable space, the design has been altered to permit the use of a fan. Only the insulating rings and contacts from Eimac sockets are used, mounted by the cathode tabs in oversized holes in the chassis. Many small holes are drilled in the chassis to provide additional air passage. A small aluminum housing above the chassis directs all the air through the anode coolers. It comes to within ¼ inch of the anode coolers. The opening is closed by a piece of Fiberglas-base plastic fitting on top. It comes to within 1/16 inch of the tubes, so that a small amount of the air flows around the outside of the coolers.

All of the left end and part of the right end of the chassis are perforated by ⅜-inch holes. The air drawn in by the fan passes over the plate rectifier fins and past the heater transformer. The whole air path is direct and free from large obstructions and sharp bends.

The fan is a 4-inch blade driven by a Rotron Mfg. Co. Type 92-AS motor at 3250 r.p.m. It is mounted in a hole 4⅛ inches in diameter in the grid housing, with about ⅛ of the blade thickness projecting into the housing. The motor is a capacitor-run type. The 1-μf. 600-volt phasing capacitor mounts on the side of the grid housing. The motor, housing and capacitor can be removed as a unit, leaving only the front and rear walls of the housing in place.

Under the conditions described, the pressure *vs.* flow curves of the fan and of the tubes indicate that somewhere around 10 c.f.m. of air is delivered. This is entirely ample for the pair of 4X250Bs. Since the only major source of heat is the tubes, and since this heat is quickly removed by the air, the whole amplifier runs at a satisfactorily low temperature.

Operation

For Class AB_2 operation, the screen voltage is set at 300 volts, and the grid bias at a point (about −40 volts) where the tubes draw 150 ma. without drive. When operating and fully loaded, full output from an HT-30 or similar exciter should swing the plate current to approximately 400 ma.

The various links are of approximately the right inductance to couple to a 50-ohm load. They must be quite tightly coupled to their plate coils. When properly positioned with a 50-ohm load connected, the plate current dips 10 or 15 ma. as the plate capacitor is tuned through resonance with r.f. drive applied. Once adjusted, these links are left alone. The antenna is tuned with the aid of an s.w.r. bridge to present a 50-ohm load to the amplifier. The amplifier should not be operated without a suitable load

Operation is now very simple. The heaters are warmed up for at least 30 seconds. With the plate power switch *off*, the band switch is set to the proper range. The exciter is tuned up to give c.w. output. (Not more than 40 volts r.m.s.) The plate power is turned on and the plate capacitor tuned to the plate current dip, or to maximum indicated output if a Micromatch is being used. The exciter is then set to give the type of output desired.

(Originally described in *QST* for Sept. 1958.)