A 144-MHz Amplifier Using the 3CX800A7

The amplifier described here and pictured in Figs. 111 through 118 is based on the 3CX800A7 triode. This tube has a plate dissipation of 800 W with modest cooling requirements. Requiring only 19-W drive for 700-W output, this amplifier is compatible with some of today's low-power, solid-state multi-mode transceivers.

This amplifier was originally presented in April 1984 *QST* by David D. Meacham, W6EMD. It is based on a design for the 8874 tube presented in January 1972 *QST* by Raymond F. Rinaudo, W6ZO. Most of the changes to the original design are to accommodate the larger size of the 3CX800A7 and its attendant higher capacitances and currents. Fig. 112 is the schematic diagram of the complete 3CX800A7 amplifier. A plate-current meter is not included in this design, but there is room on the front panel if the builder wishes to add one.

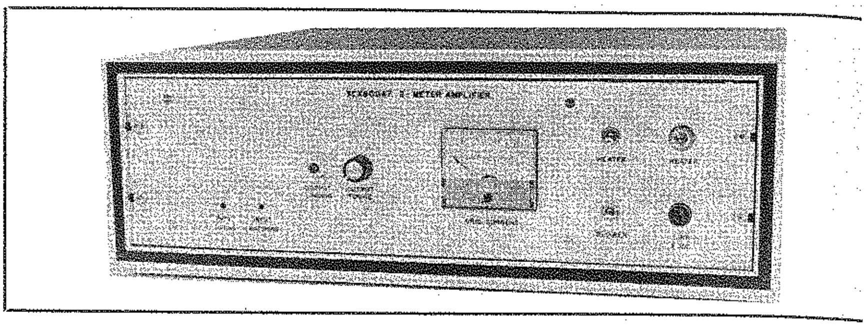


Fig. 111 — Front-panel view of the 3CX800A7 2-meter amplifier.

Construction

The amplifier chassis is mounted in a standard 19-inch-wide, 5¼-inch-h aluminum rack panel (Bud No. SFA-18. A 5 × 13 × 3-inch aluminum chassis (I No. AC-422) is spaced 1¾ inches beh the panel by two aluminum end brack

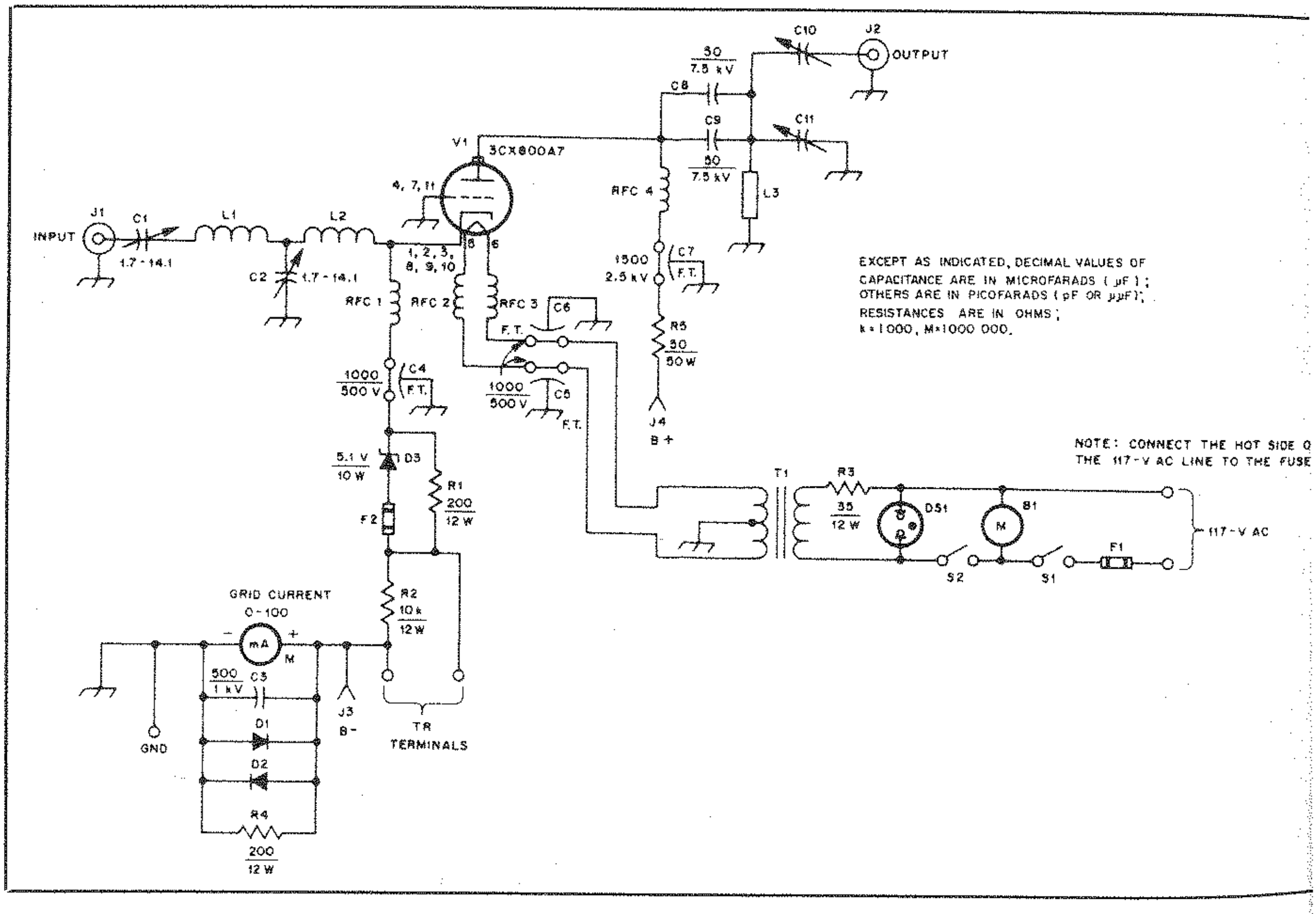


Fig. 112 — Schematic diagram of the 3XC800A7 amplifier.

B1 — Blower (Dayton 4C012 or equiv.); see text.
C1, C2 — 1.7-14.1 pF air variable (E. F. Johnson 189-505-4 or equiv.).
C4, C5, C6 — Ceramic feedthrough, 1000 pF, 500 V (Erie 357- 001).
C7 — EMI feedthrough filter, 1500 pF, 2.5 kV (Erie 1280-060).
C8, C9 — 50 pF, 7.5 kV, NPO (HEC HT-50 852).
C10, C11 — See text.
D1, D2 — 1N4001.
D3 — Zener diode, 5.1 V, 10 W (1N3996A).
DS1 — NE51 in holder with built-in dropping resistor.
F1 — Slow-blow fuse, 2 A (Buss MDL-2 or equiv.).
F2 — 1.5 A fuse (Buss AGC 1½ or equiv.).
J1 — BNC bulkhead feedthrough connector (UG-492 A/U).
J2 — Type N female connector (part of C10 assembly — see text).
J3, J4 — High-voltage connector (Millen 37001 or equiv.).
L1 — 8 turns no. 16 tinned wire, 3/8-in ID, 11/16 in long.
L2 — 6 turns no. 16 tinned wire, 3/8-in ID, 11/16 in long.
L3 — Plate line, 1-5/16 in wide, 8-3/16 in long. See text and Fig. 115.
R1, R4 — 200 ohms, 12 W.
R2 — 10 kΩ, 12 W.
R3 — 35 ohms, 12 W.
R5 — 50 ohms, 50 W.
RFC1 — 1.0 μH choke, 300 mA (Miller 4602).
RFC2, RFC3 — 11 turns no. 20 HF wire on 3/8-in Noryl rod.
RFC4 — 10 turns no. 16 tinned wire, ½-in ID, 1-3/16 in long.
T1 — Filament transformer, 14.0-V, 2-A secondary (Triad F-251X or equiv.).

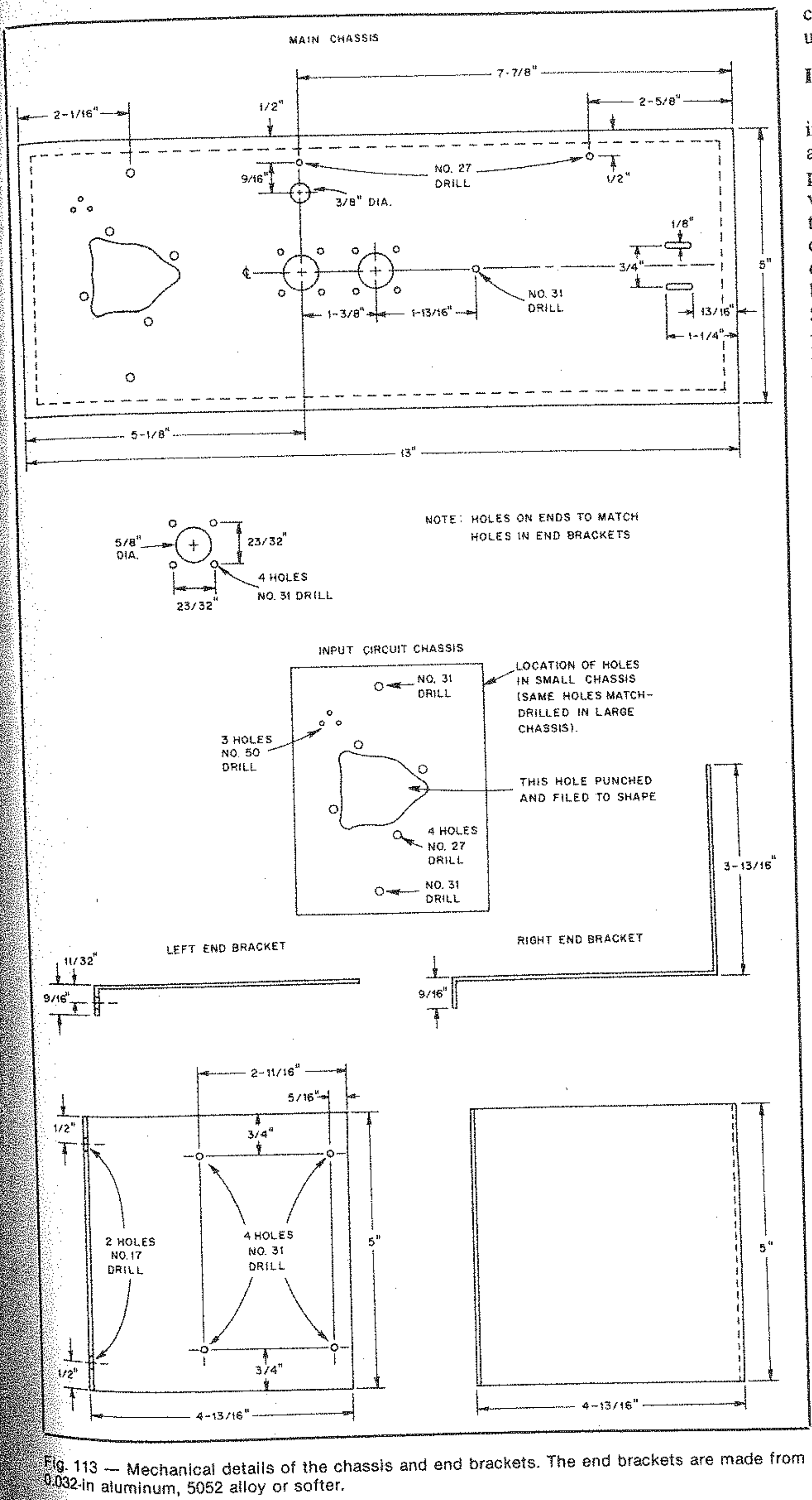


Fig. 113 — Mechanical details of the chassis and end brackets. The end brackets are made from 0.032-in aluminum, 5052 alloy or softer.

A 3½ × 1-inch aluminum chassis (Bud No. AC-1402) houses the input circuitry and is mounted on the larger chassis between it and the front panel. The right-hand end bracket has a large lip on the rear for mounting the heater transformer and connectors. Fig. 113 shows mechanical details of the chassis and end brackets. The cabinet chosen is a lightweight aluminum unit made by Ten-Tec (No. 19-0525).

Input Circuit

In the cathode-driven configuration, the input impedance of the 3CX800A7 appears as a nominal capacitance of 26.5 pF in parallel with a resistive component that varies with operating conditions but is typically about 49 ohms. The computer-designed input circuit of this amplifier operates at a loaded Q of about 2.1. It can be set anywhere in the 2-meter band for an SWR of less than 1.3:1. C1 and C2 are predominantly matching and tuning controls, respectively; there is some interaction between them, however. When the input is tuned at 144.5 MHz, the input SWR will be less than 1.4:1 from 144 to 145 MHz.

The tube socket is an EIMAC SK-1900 or a Johnson part No. 124-311-100. Its center is mounted 2 inches from the end of the input box, adjacent to the mounting bracket. The tube pins and input circuit are cooled by a small amount of air admitted to the input box from the pressurized output box. Three holes, made with a no. 50 drill, provide adequate flow. These holes are spaced in a close triangle and are located diagonally across from the variable capacitors. Air exhausts through the tuning holes. Fig. 114 shows details of the input circuitry.

The heater circuit includes two chokes, feedthrough capacitors, the filament transformer, a voltage-dropping resistor and a switch. The chokes are wound with a turn-to-turn spacing of about one-half the wire diameter. They are self-resonant (parallel resonant) just above the 2-meter band. Nominal heater voltage for the 3CX800A7 is 13.5 V. The closest available commercial transformer has a 14.0-V secondary, so R3 is used in the primary. Switching is set up so the blower must be on before the heater can be activated. Conversely, this arrangement allows the blower to be left on after switching off the heater — a highly recommended practice.

Cathode bias is provided by a 5.1-V Zener diode, D3. R1 prevents the cathode voltage from soaring if the Zener fails. F2 will blow if excessive cathode current is drawn. R2 nearly cuts off plate current on receive. Because the grid is at dc ground, the negative supply lead must be kept above ground for grid-current metering by M1. R4 keeps the negative side of the plate supply from rising if M1, D1 and D2 all open up. D1, D2 and C3 protect the meter from transients and RF voltages.

Output Circuit

The output tank circuit is a silver-plated quarter-wave strip line (Fig. 115) foreshortened by the tube, loading and tuning capacitances at, and near, its open end. It operates at a loaded Q of approximately 20. The silver-plated anode collet (Fig. 115) is made of 0.062-inch-thick brass sheet with Tech-Etch 134B finger stock soldered on

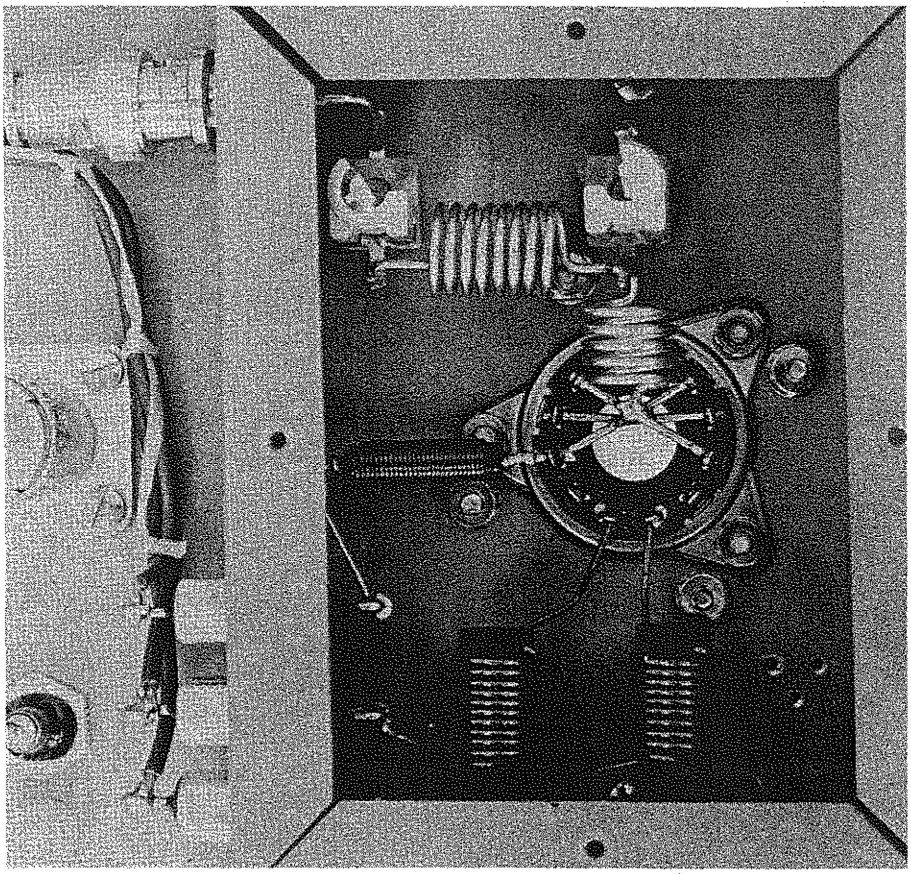
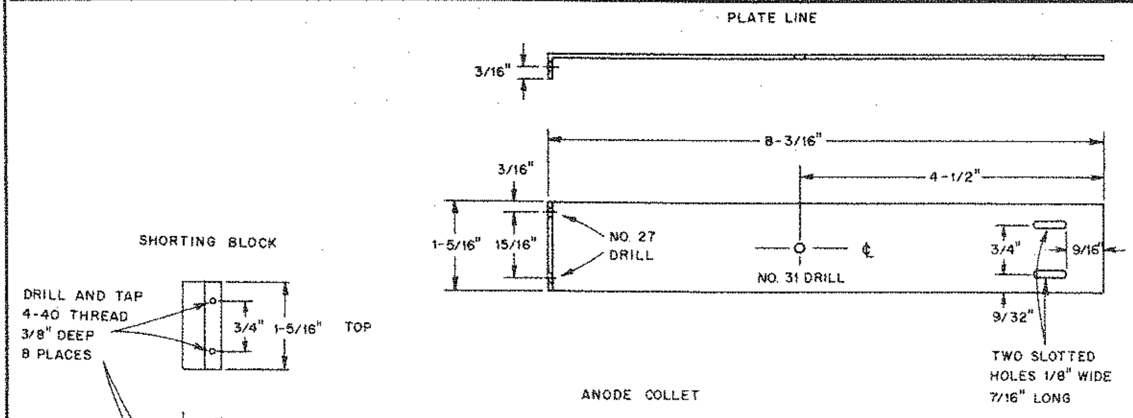


Fig. 114 — Close-up of the input circuitry and tube-socket wiring. Keep all leads as short as possible. Although L2 is shown here with 5 turns, the final version uses 6 turns, as described in the parts list.

the inside. It is supported by two Teflon® standoffs 1½ inch in diameter and 1 inch long. At the far end of the line, a silver-plated shorting block contacts the chassis and the strip line. This block (Fig. 115) is made from 7/16-inch-thick brass 1-5/16 inches wide and 1 inch high. EIMAC CF-800 finger stock is screwed and then soldered on both top and bottom. The chassis and strip line are both slotted to allow 5/16 inch of shorting-block travel to set the tuning range of the capacitive-tuning paddle. A 1-inch-long Teflon standoff supports the center of the line. Construction details may be seen in Fig. 117.

The tuning (C11) and loading (C10) paddles are 1-3/16-inch-diameter discs made from silver-plated, 1/16-inch-thick brass. They are spaced 1-3/8 inches center-to-center. The output loading paddle is nearest the tube, and its center is 1-13/16 inches from the tube cooler surface. Spacing between the paddle and line during operation is about 0.135 inch. The output tuning boss, EIMAC part no. 720362, is tapped



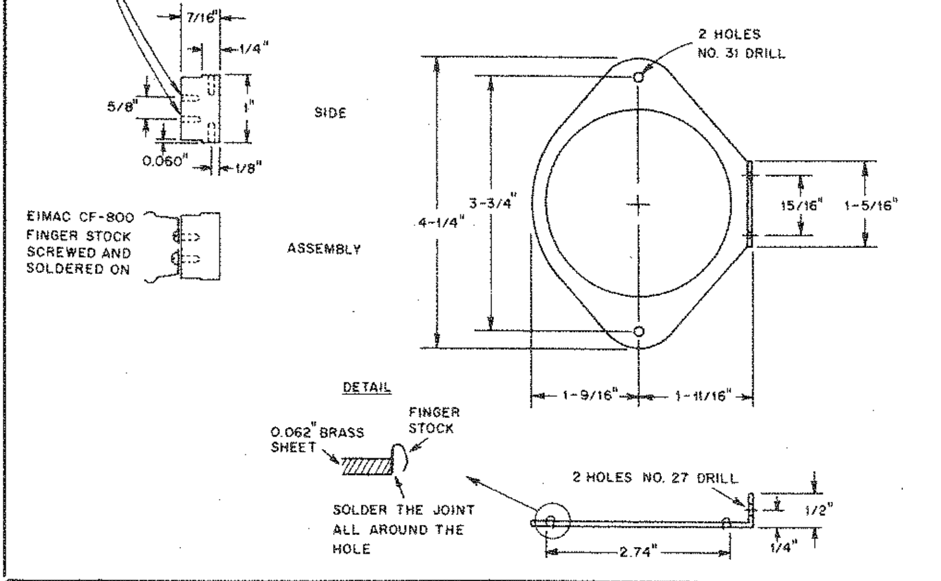


Fig. 115 — Mechanical details of the plate line, anode collet and shorting block. The plate line is made from 0.032-in-thick silver-plated brass, although copper or aluminum (5052 alloy or softer) of the same thickness may be used. The lip on the plate line is screwed to the one end of the blocking capacitors. The anode collet, which is made from 0.062-in-thick silver-plated brass, is screwed to the other ends of the blocking capacitors. Tech-Etch no. 134B finger stock soldered around the inside of the anode collet grips the 3CX800A7. Finger stock on the silver-plated brass shorting block ensures good contact between the chassis and plate line.

for a ¼-28 threaded rod. The output loading control and output connector are two separate EIMAC assemblies combined into one unit. They are available from EIMAC as Support Assembly No. 720361 and Sliding Probe Assembly No. 720407. For this amplifier, the outer conductor was lengthened to reach the front panel. The grid collet is also available from EIMAC as part No 720359.

In addition to RFC4 and feedthrough capacitor C7, an energy-absorbing resistor (R5) is wired in series with the dc plate supply. This resistor will protect the tube and power supply in the event of a high-voltage arc. It provides necessary protection while dissipating only 12.5 W at 500-mA dc plate current.

Cooling

The blower specified provides a measured 25 CFM airflow through the output box and tube cooler at 0.42 inch of water-column static pressure. This amount of cooling is sufficient for 800 W of plate dissipation at sea level with inlet air temperatures up to 35° C. It is adequate for the same dissipation at 5000 feet of altitude with inlet-air temperatures up to 25° C.

Not evident from the photographs is the care taken to separate outgoing hot air from incoming cool air. This is accomplished by the addition of a simple dividing wall inside the cabinet running from the rear chassis cover of the output box to the rear of the cabinet. The material used is rigid fiberglass insulation — the kind you

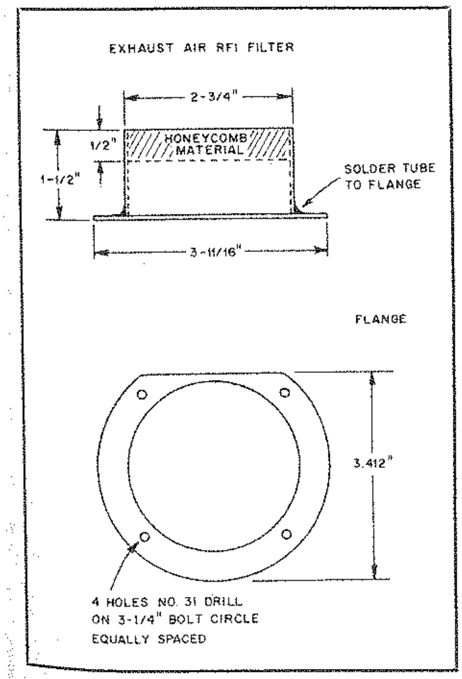


Fig. 116 — Mechanical details of the exhaust air RFI filter. The honeycomb material is soldered inside a 2¾-in OD, 0.065- in wall brass tube. The flange, which bolts to the chassis, is made from 0.125-in-thick brass sheet.

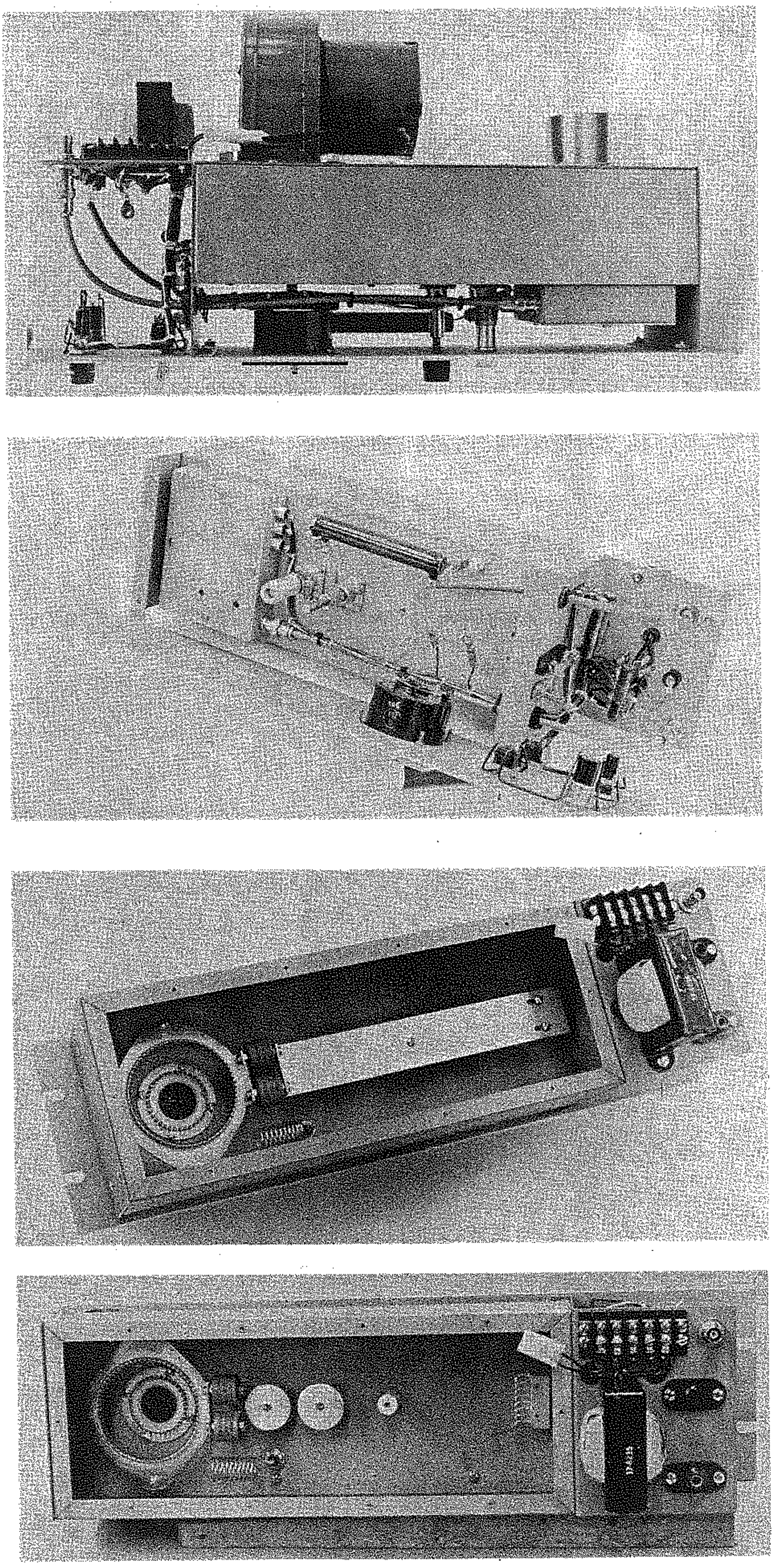


Fig. 117 — Various views of the completed 3CX800A7 amplifier.

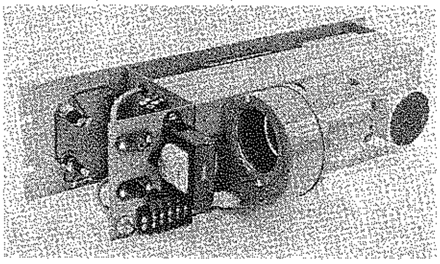


Fig. 118 — Rear view of the amplifier with the plate-compartment cover in place. Note the honeycomb RFI filter at the hot-air exhaust.

cut with a saw. It provides a measure of blower-noise suppression in addition to assuring cool inlet air.

Hot air leaving the anode cooler is directed to a homemade "honeycomb" RFI filter through a chimney made from rolled-up Teflon sheet. The filter is made of brass tubing and sheet with the honeycomb material soldered in place. See Figs. 116 and 118 for construction details. This filter acts as a waveguide-beyond-cutoff having high attenuation at 144 MHz.

The equation for calculating attenuation by this type of filter is

$$A_a = 32 \frac{D}{d}$$

where

A_a = aperture attenuation (dB)
D = length of pipe
d = inside diameter of pipe.

In this case, the "pipe" is each cell of the honeycomb. The basic material for the honeycomb is cadmium-plated brass heat-radiator core.[1] Each hexagonal-shaped cell has a width between flat sides (diameter) of 0.100 inch. The material is ½ inch thick.

[1]One source for the honeycomb radiator core material is G-O-Metric, c/o Marty Manion, 909 Norwich Ave., Delran, NJ 08075.

Plugging these values into the equation yields an A_a of 160 dB — more than enough! From a practical stand-point, it is usually sufficient to make cell length at least three times the nominal cell diameter.

Tune-up

Initial work may be done with a dip meter, particularly on the output circuit. With the tube in place, but with no voltages applied, the shorting block on the end of the plate line should be set to give a paddle-tuning range that straddles the desired operating frequency. Bear in mind that when the tube is "hot," the resonant frequency will be somewhat lower than it is without electron flow.

The input-tuning capacitor can be dip-meter resonated with the matching capacitor set at one-half mesh for a start. Further work here must be done "hot" with an SWR measuring device on the input.

Set the initial spacing between the output paddle and the plate line to 1/8 inch. Connect the output to a 50-ohm dummy load capable of handling at least 700 W at 144 MHz through an accurate VHF wattmeter, such as a Bird model 43. Connect a driver capable of delivering about 20 W to the input through an SWR-measuring device.

The heater of the 3CX800A7 should be run for at least three minutes before applying plate voltage. After the warm-up, short the TR terminals and apply about 1000 V to the plate. This should result in a small amount of idling plate current. Next, apply enough drive to produce a rise in plate current, and adjust the plate tuning for a peak in output power. Now tune and match the input circuit for minimum input SWR. Next, adjust the output loading paddle for maximum power output while keeping the plate current dipped with the plate tuning paddle. Apply full plate voltage and higher drive power, and then repeak the output tuning and loading controls. Touch up the input tuning and matching, and the amplifier is ready for service.

A few words of caution are in order. Remember that the heater voltage must never be applied without the blower running, and that the heater must warm up at least three minutes before applying plate voltage. Never exceed 60-mA dc grid current, even during tune-up. Also, because of the relatively low grid dissipation of the 3CX800A7, RF drive must *never* be applied unless plate voltage is applied to the tube and a suitable load is connected to the output. Following these simple rules will substantially increase tube life and amplifier reliability.

Table 7

Operating Conditions for the 3CX800A7 Amplifier

Plate supply voltage	2200 V
Zero-signal plate current †	65 mA
Single-tone plate current	500 mA
Grid bias (Zener bias)	−5.1 V
Single-tone grid current †	40 mA
Driving power	18.5 W
Output power	707 W
Gain	15.8 dB
Efficiency ††	64%

†Values may vary considerably from tube to tube.
††Actual tube efficiency is about one percent higher because of power loss in the 50-ohm series resistor in the plate lead (R5).

Typical Operating Conditions

With Zener-diode bias, the 3CX800A7 is best operated in Class AB_2 for linear service. The data in Table 7 represent measured performance in linear service at 144 MHz. Complete data sheets are available from EIMAC. This amplifier is easily capable of conservative operation at 700-W output. Two of these tubes will run at the 1500-W output legal limit.