A 160- to 10-Meter Amplifier Using the 3CX1200A7

Billed as a replacement for the glass 3-1000Z, the EIMAC 3CX1200A7 metal/-ceramic triode is the basis of the 160- to 10-meter amplifier described here and shown in Figs 69 through 78. The amplifier will produce 1500 W output for about 100 W drive, making it a natural companion for today's solid-state transceivers. Dick Stevens, W1QWJ, designed and built this project.

The 3CX1200A7 requires a higher plate voltage than other ceramic transmitting tubes. In this case, the design is for 3500 V at full load. The amplifier will, however, still produce 1000 W output with 2500 V on the plate. A high-voltage power supply design is not included with this writeup. This amplifier was used with the power supply described earlier in this chapter along with a 160- to 10-meter 8877 amplifier. The high-voltage supply was modified slightly for use with this amplifier: C1 is increased to 200 μF, and R1 is changed to 1.5 kΩ to allow a longer charging time for C2. Another suitable high-voltage power supply design appears in Chapter 27.

A large volume of air is required to adequately cool the 3CX1200A7. Use of

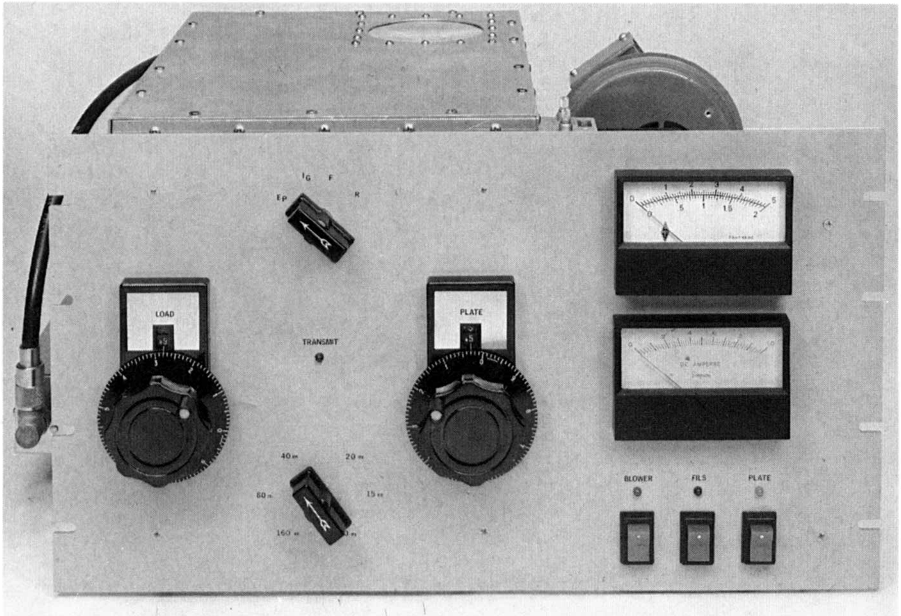


Fig 69—The 3CX1200A7 160- to 10-meter amplifier is built behind a standard 19 × 10½-inch rack panel. Vernier drives are used to control the loading and tuning capacitors. The top meter can be switched to read plate voltage, grid current, forward power and reflected power. (The meter switch is above the LOAD and PLATE dial drives.) The bottom meter is dedicated to plate current. An external low-pass filter is mounted on the left side of the chassis.

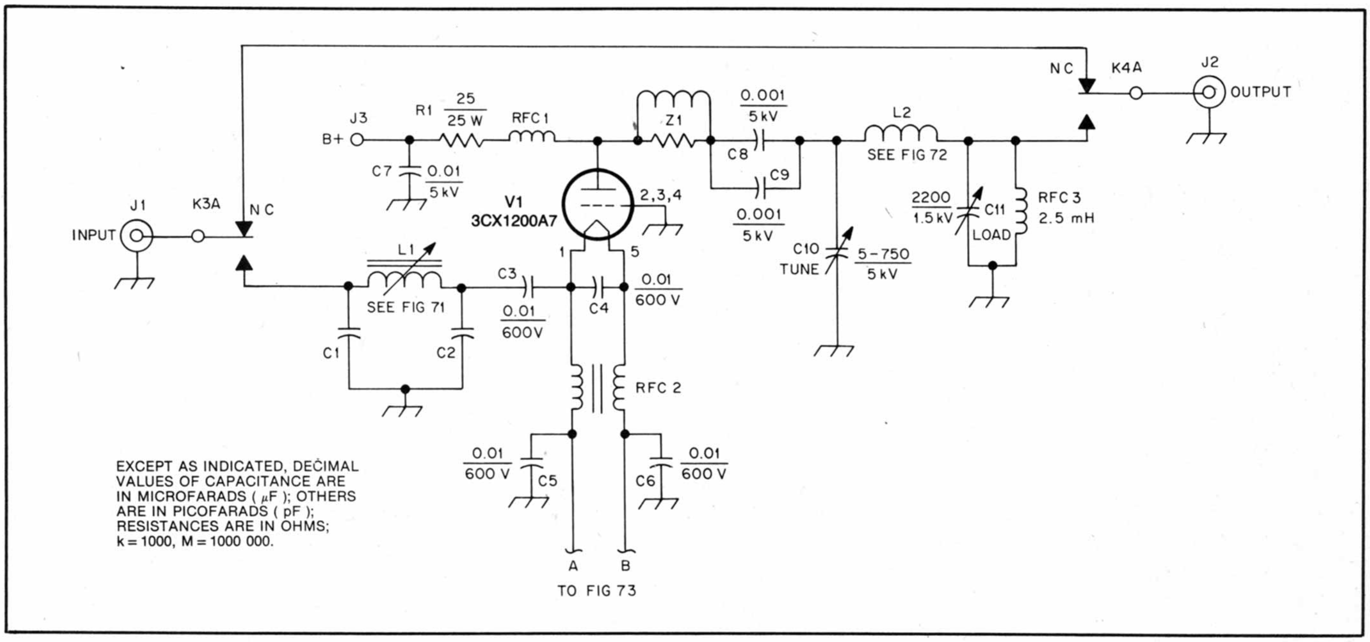
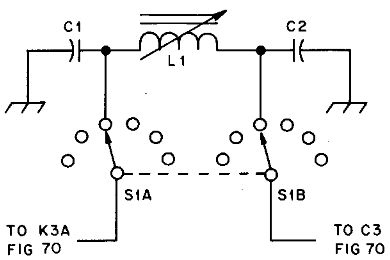


Fig 70—Schematic diagram of the 3CX1200A7 amplifier RF deck. Details of the input and plate-tank circuits are shown in Figs 71 and 72.

C1, C2—See Fig 71.
C3, C4—0.01-μF, 600-V mica capacitor.
C5, C6—0.01-μF, 600-V disc-ceramic capacitor.
C7—0.01-μF, 6-kV disc-ceramic capacitor.
C8, C9—0.001-μF, 10-kV RF-type doorknob capacitor.
C10—5 to 750-pF, 5-kV vacuum-variable capacitor.
C11—2200-pF, 1.5-kV air-variable capacitor.
J1, J2—UHF female chassis-mount connector.
J3—High-voltage connector (Millen 37001 or equiv).
K3, K4—See Fig 73.
L1—Input pi-network tunable coil. See Fig 71 for details.
L2—Plate-tank coil. See Fig 72 for details.
RFC1—90-μH, 1-A RF choke (Hammond 1521 or equiv).
RFC2—Bifilar wound 30-A filament choke, 28 bifilar turns no. 10 enam wire on a ½-in. diam × 7½-in. long ferrite core (Peter W. Dahl Co).
RFC3—2.5 mH RF choke (Millen 4537 or equiv).
Z1—Parasitic suppresser, four 220-Ω, 2-W metal-film resistors in parallel, mounted on a 5-inch long, ½-inch wide copper strap bent in a U shape.



Q = 4

Band	C1 (pF)	C2 (pF)	L1 (μH)
160	3300	3100	3.53
80	1700	1670	1.90
40	900	840	0.96
20	440	417	0.47
15	300	275	0.32
10	220	205	0.23

Q = 2

Band	C1 (pF)	C2 (pF)	L1 (μH)
160	1608	1608	4.9
80	782	782	2.4
40	402	402	1.2
20	204	204	0.62
15	135	135	0.41
10	101	101	0.30

Fig 71—Details of the 3CX1200A7 amplifier input circuit. Component values are shown for Q = 4 and Q = 2. The amplifier was built using the values for Q = 4 (see text).

C1, C2—500-V silver-mica capacitors. See table for values.
L1—The coils for each band are wound on JW Miller 42A000CBI tunable ceramic coil forms (3/8-inch diam with red core). The number of turns required for each band:
10 meters—4 turns no. 22 wire spaced to occupy 3/8 in.
15 meters—6 turns no. 22 wire spaced to occupy ½ in.
20 meters—7 turns no. 22 wire spaced to occupy ½ in.
40 meters—9 turns no. 22 wire spaced to occupy ½ in.
80 meters—11 turns no. 22 wire close wound.
160 meters—20 turns no. 24 wire close wound.
S1—Double wafer, 6-position ceramic rotary switch with 60° indexing to match plate-tank bandswitch S2 (Centralab 2551 or equiv).

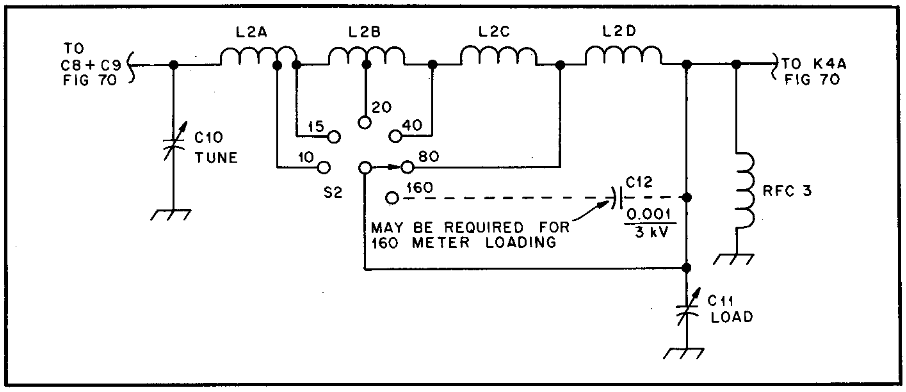


Fig 72—Details of the plate-tank circuit for the 3CX1200A7 amplifier. See Fig 70 for the rest of the circuit.

C10, C11—See Fig 70.
L2A—5 turns of ¼-inch diam copper tubing, 2¼ inches ID, 2½ inches long. See text. Tap at 4 turns for 10 meters. Tap at junction of L2A and L2B for 15 meters.
L2B—6¼ turns of B&W 2404T coil stock. Tap at 3 turns for 20 meters. Tap at junction of L2B and L2C for 40 meters.
L2C—6½ turns of B&W 2406T coil stock. Tap at junction of L2C and L2D for 80 meters.
L2D—10 turns of B&W 2408T coil stock. For 160 meters, use L2A, L2B, L2C and L2D.
RFC3—See Fig 70.
S2—Six position, one section, high-power ceramic RF rotary switch with nonshorting contacts and 60° indexing (Radio Switch Corp Model 86 or equiv).

the proper EIMAC air system socket (part no. SK410) and chimney (part no. SK436) is essential. The blower is a Dayton 4C440, rated at 60 CFM.

This project makes extensive use of parts purchased at flea markets and from surplus dealers. Although most components could be purchased new (at considerable expense), there are many good parts available surplus. The builder is encouraged to modify the design shown here when possible to make use of whatever surplus parts are available.

RF Circuits

Fig 70 is a schematic of the amplifier RF circuitry. For clarity, some details of the input and output circuits are omitted—these details are shown in Figs 71 and 72.

Details of the tuned input circuit are shown in Fig 71. Individual pi networks are used for each band. A tunable coil and two fixed capacitors are used for each band. These circuits are designed for a Q of 4, based on EIMAC's recommendation. Tubes requiring high values of grid drive require a higher Q than the usual 2 to prevent flattopping. Tuning of the input circuits is sharp, but if they are adjusted for an SWR of 1:1 at the center of each band, the SWR at the band edges is less than 1.5:1.

Unfortunately, you won't be able to "fudge" the 10-meter input circuit to reach 12 meters—the Q is too high. Component values are given for input networks with a Q of 2 for those builders wishing to reach 12 meters.

The amplifier plate tank circuit is a standard pi network with a calculated Q of 10. Details are shown in Fig 72. Use of a vacuum variable (C10) for the tuning capacitor makes it easy to get a reasonable Q at 160 and 10 meters. The 3CX1200A7 has a high internal capacitance: tube capacitance and stray circuit capacitance are almost enough to resonate the plate circuit at 10 meters. The minimum capacitance of an air variable suitable for tuning on 160 meters is too great to allow a reasonable Q on 10 meters. So, the vacuum variable, with its low minimum capacitance, is ideal for this application. An air-variable capacitor (C11) is used for loading. As shown in Fig 72, an additional 1000-pF fixed capacitor (C12) may be switched in if more loading range is needed for 160 meters.

The location of RFC1 differs from many other designs. Normally, the plate RF choke is connected to the junction of the parasitic suppressor (Z1) and plate blocking capacitor (C8 and C9). In this case, a low-frequency parasitic was noticed during testing, and moving RFC1 to the position shown corrected this problem.

Switches for the input (S1) and output (S2) circuits are connected by a chain drive so only one front-panel bandswitch control is needed. S1 and S2 *must* have the same indexing. All of the parts necessary for making the chain drive arrangement are available from Small Parts, Inc (see Chapter 35).

Metering and Control Circuits

Control and metering circuits are shown in Figs 73 through 75. Circuitry is included to prevent amplifier operation without plate voltage, and filament inrush protection is also provided. No ALC arrangement is used because modern transceivers will not overdrive the amplifier. Metering includes grid current, plate current, plate voltage and forward and reverse power.

Refer to Fig 73. Closing S1 starts the blower and lights DS1. Closing S2 applies 120 V to T2 through R3, the inrush-current-limiting resistor. Simultaneously, C1 charges through R2, and after a second or so K1 operates and contacts K1A short out R3, applying full primary voltage to T2. K1B contacts cause DS2 to light, showing that the filament inrush protection has functioned. Closing S2 also applies 120 V

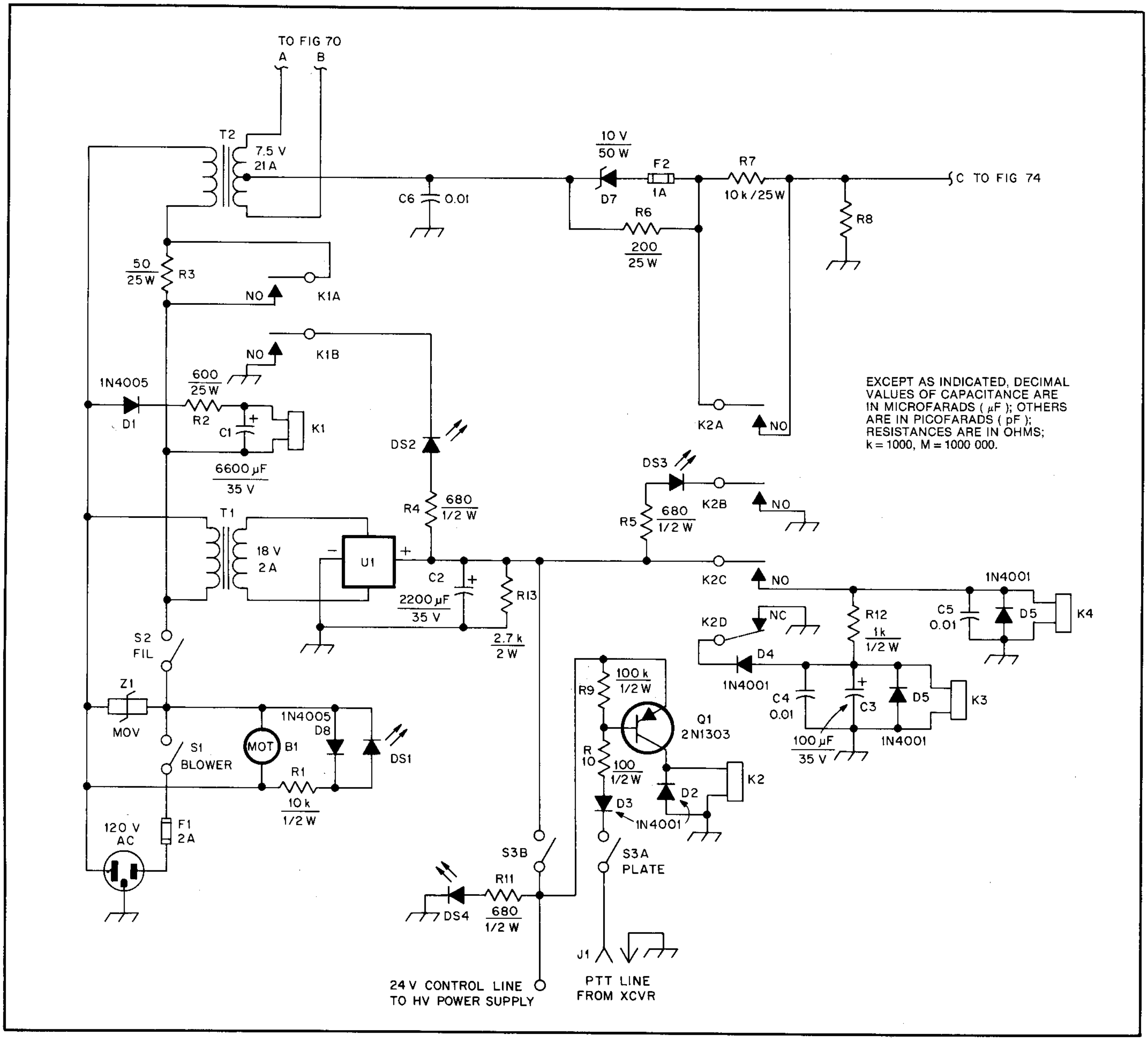


Fig 73—Details of the control circuitry for the 3CX1200A7 amplifier. Capacitors are disc-ceramic, 50-V types unless noted. Capacitors marked with polarity are electrolytic.

B1—60 CFM blower (Dayton 4C440 or equiv).
C1—6600-µF, 35-V electrolytic made from two 3300-µF, 35-V capacitors in parallel.
D1, D8—600-PIV, 1-A diode (1N4005).
D2-D6—50-PIV, 1-A diode (1N4001).
D7—10-V, 50-W Zener diode (1N2808 or equiv).
DS1-DS4—LED.
J1—Phono jack.
K1—DPDT relay with 10-A contacts and 12-V dc coil.
K2—4PDT relay with 3-A contacts and 24-V dc coil.
K3—RF input relay (see Fig 70). SPST relay with 3-A contacts and 24-V dc coil.
K4—Antenna relay (see Fig 70). SPST relay with 10-A contacts and 24-V dc coil. Dow-Key antenna relay preferred; must be able to handle 1.5 kW of RF.
R8—Grid-current meter shunt. Value depends on meter movement used. See text.
S1, S2—SPST switch.
S3—DPDT switch.
T1—Control circuit transformer. Primary, 120 V; secondary, 18 V at 2 A.
T2—Filament transformer. Primary, 120 V; secondary, 7.5 V at 21 A (Peter W. Dahl Co).
U1—100-PIV, 1.5-A bridge rectifier.
Z1—130-V metal-oxide varistor.

to T1. T1 and related components supply 24 V dc for other control circuits.

Closing S3 sends 24 V dc to the high-voltage power supply. The high-voltage supply is activated by a 24-V dc relay in the primary. DS3 lights when S3 is closed. You may choose a different method of activating the high-voltage supply, depending on your individual needs.

Q1 is the amplifier keying transistor. Many modern transceivers have amplifier keying circuits with insufficient current and/or voltage ratings to close a relay coil. They can, however, key Q1 which in turn keys the relays in the amplifier. When Q1 conducts, K2 operates and completes several functions. K2A shorts out R7, which changes the tube bias from cutoff to operating bias. DS3 lights to show that the tube is ready to operate. K2C activates K3 and K4, the antenna relays. K4, the output relay, closes immediately. There is a slight delay in the closure of K3, caused by R12 and C3, to prevent hot switching K4. When the amplifier is unkeyed to return to receive, K2D discharges C3 so that there is no additional delay as K3 returns to the receive position.

Operating bias is provided by D7. F2 protects the grid from excessive current. R8 is a grid milliammeter shunt. Its exact value depends on the meter used.

This amplifier includes metering for plate current, grid current, plate voltage, forward power and reverse power. See Fig 74. M2 is a dedicated plate-current meter. M1

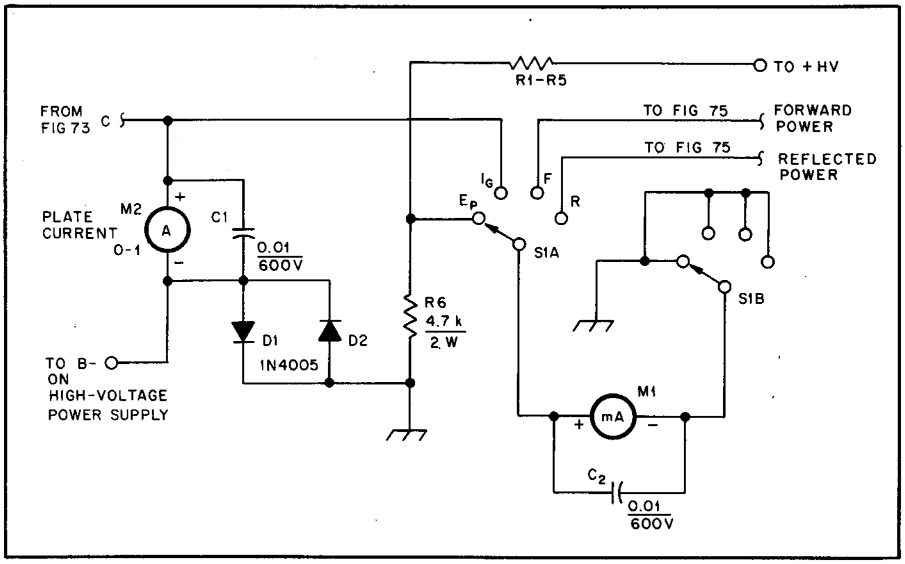


Fig 74—Schematic of the metering circuitry for the 3CX1200A7 amplifier. Note that S1B may be left out and the negative lead from M1 may be returned directly to ground.

M1—0 to 1-mA meter movement with scales to read 0-2 and 0-5. See text.
M2—0 to 1 A meter.
R1-R5—HV meter multiplier, 5 MΩ at 10 W. Made from five 1-MΩ, 2-W (2% tolerance) resistors in series.
S1—2-pole, 4-position rotary switch.

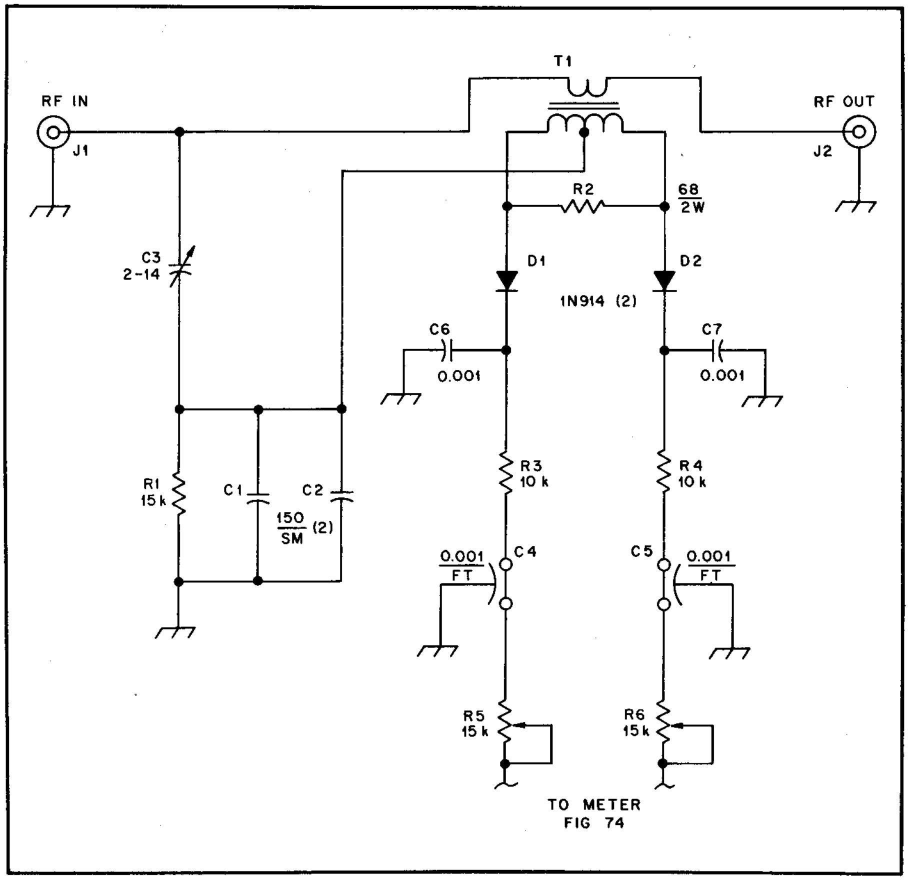


Fig 75—Schematic of the wattmeter circuitry for the 3CX1200A7 amplifier.

C1, C2—150-pF silver-mica capacitor.
C3—Miniature ceramic or air trimmer, approx 2-14 pF.
J1, J2—SO-239 chassis-mount connector.
T1—Secondary: 20 turns no. 22 enam on Amidon T-50-2 core, center tapped. Primary: Section of RG-8 through center of secondary core; connect the RG-8 center conductor between the center pins of J1 and J2. Ground the shield.

is a 0-1 mA movement with scales that read 0-2 and 0-5. S1 is used to switch in the appropriate shunt or meter multiplier resistor. Depending on switch position, M1 reads 0-500 mA grid current, 0-5 kV plate voltage, 0-2000 W forward power and 0-200 W reflected power. R6 prevents the voltage at the end of multiplier string R1-R5 from going to supply voltage when S1 is set to positions other than plate voltage. Note that S1 can be a single-wafer switch. S1B is not needed—the negative end of M1 may be grounded and S1B eliminated. Fig 75 shows the wattmeter. This circuit is similar to many others that have appeared over the years.

Construction

Figs 76 and 77 show the amplifier with the covers removed. Detailed dimensions are not given because many of the parts used are surplus. It would be difficult to duplicate this amplifier exactly, so you should consider the information presented here as guidelines, rather than as "cookbook" directions.

The input circuit is built on a 3 × 17 × 4-inch (HWD) chassis (Bud AC-432) that runs along the back of the amplifier chassis assembly. The 3CX1200A7 socket is mounted to this chassis, and underneath are the filament choke, input bandswitch, individual pi-network input circuits for each band, coupling and bypass capacitors, and the input relay and associated circuitry. Originally, the filament transformer was mounted on this chassis as well, but it was moved to cure an instability problem. (The metal case of the filament transformer did not provide a good shield). B1 blows air into the sealed input-circuit compartment, and air is exhausted into the output-circuit compartment.

The filament transformer, control circuits and bias components are built in a 3 × 9.25 × 7-inch (HWD) chassis that is bolted to the input chassis. (This is a standard Bud AC-408 chassis shortened to 9.25 inches.)

Output-circuit components, including the tuning and loading capacitors, tank coil and bandswitch, are mounted on a piece of 1/8-inch aluminum sheet. A heavy copper strap is used for grounding the tuning and loading capacitors. Use of this strap is necessary to prevent ground-loop currents.

Four separate pieces make up the plate-tank coil. See Figs 72 and 76 for details. A length of ¼-inch diameter soft-drawn copper tubing is the basis for the 10-meter coil. Clean the tubing well and wind 6 turns on a 1¾-inch diameter form. (This is one more turn than needed, but gives some extra material to work with.) Flatten one end of the tubing and drill it to clear a no. 6-32 screw. Remove the excess turn, flatten the other end and drill it to pass a no. 6-32 screw. Spread or compress the coil so that there are 2½ inches between the centers of the holes drilled in the ends of

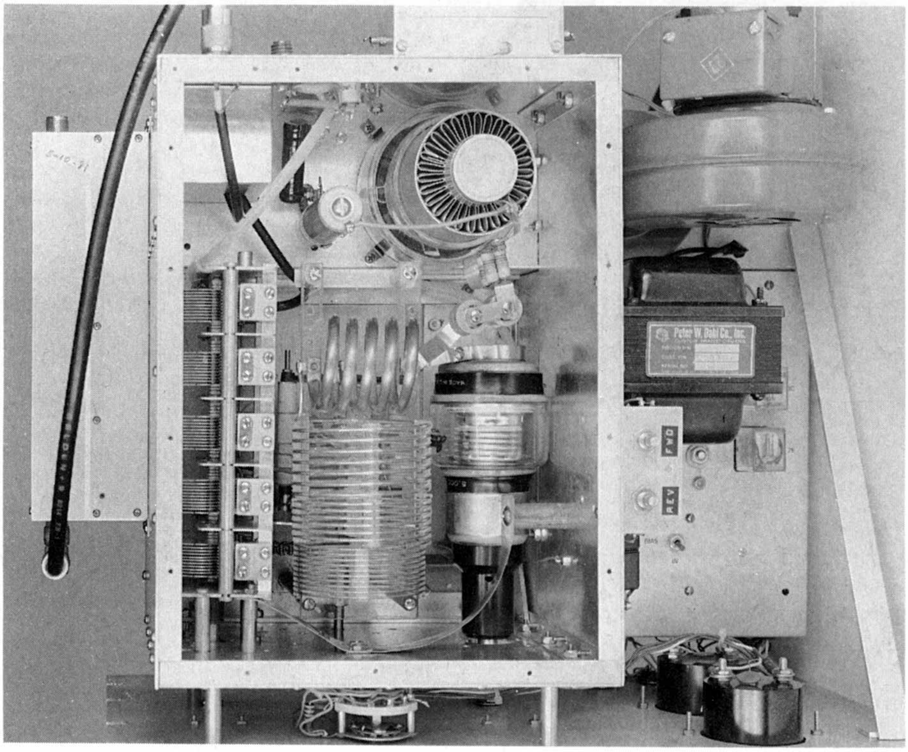


Fig 76—Top view of the 3CX1200A7 amplifier with the cover removed. The blower, at the right rear, is bolted to the input chassis that runs along the rear of the amplifier assembly. The filament transformer is mounted in front of the blower, on the chassis that holds the control circuits. K1 and K2 are mounted in sockets to the right of the filament transformer. The wattmeter adjustment potentiometers (R5 and R6, Fig 75) are mounted on a bracket on the side of the plate-circuit enclosure near the filament transformer. The plate-current meter and multimeter are mounted on the front panel (lower right corner of photo), and the multimeter rotary switch is mounted to the front panel in front of the plate-circuit enclosure. The 3CX1200A7 is mounted on the input-circuit chassis at the right rear of the plate circuit enclosure. High-voltage wiring and bypass capacitors, and the RF choke, are to the left of the tube. The Minibox in the left rear corner of the plate-circuit compartment houses K4, the output relay. The vacuum-variable tuning capacitor is mounted at the right front of the plate compartment, and the loading capacitor is at the left front. The plate-coil assembly and plate-circuit bandswitch (under the plate coil) are mounted between the two capacitors.

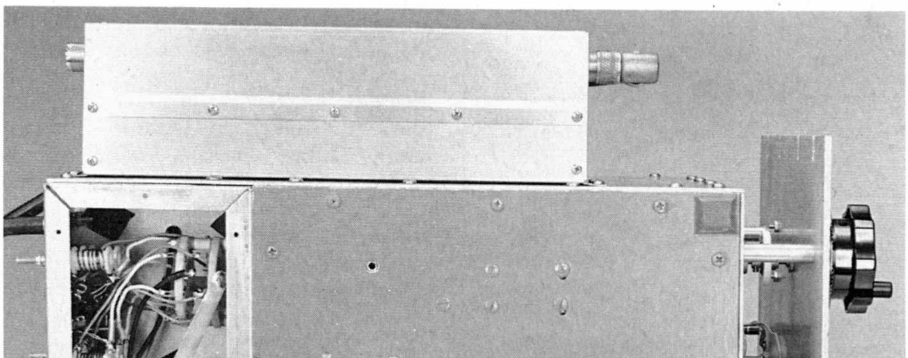


Fig 77—Bottom view of the 3CX1200A7 amplifier with the covers removed. The amplifier chassis assembly consists of three parts: (1) the input chassis (left side of photo) runs the entire width of the amplifier; (2) the control circuit chassis (lower right); and (3) the plate compartment (upper right) built on an aluminum sheet. The tuned input circuits are visible in the input chassis, above the tube socket. The pi networks are built on an unetched piece of circuit board material, with the coil adjustment shafts protruding through the rear panel. The input bandswitch is mounted to the opposite chassis wall, with its shaft protruding into the plate-circuit compartment. Below the tube socket is the filament choke. A small circuit board bolted to the rear wall to the left of the tube socket holds the input relay and associated components. In the control-circuit chassis, most components are mounted on terminal strips. K1 and K2 are mounted in sockets in the lower center of the chassis. Q1 and associated parts are mounted on a small circuit board in the lower right corner.

the coil. The finished coil is 5 turns, spaced 2½ inches.

A 2-7/8 × 8¼-inch piece of ¼-inch-thick Plexiglas® serves as the main plate-tank coil support. Drill a mounting hole in each corner of the Plexiglas sheet, ¼ inch in from the ends. Drill two holes for the 10-meter coil 1-5/8 inch in from one end. Mount the 10-meter coil above the Plexiglas sheet on 3/8-inch spacers.

Next, cut three pieces of B&W coil stock. You'll need 6¼ turns of 2404T, 6½ turns of 2406T and 10 turns of 2408T. Slide the 2404T onto the Plexiglas support, followed by the 2406T and then the 2408T. Using a thin piece of brass shim stock, connect one end of the 2404T to one of the mounting screws for the 10-meter coil. Using more shim stock to make a good mechanical bond, splice the other end of the 2404T to the 2406T, and the 2406T to the 2408T. Solder all connections. The free end of the 2408T goes to the loading capacitor.

The output-circuit shield is made of sheet aluminum and angle stock. The top has a screened hole for hot air exhaust.

K4, the output antenna relay, is in the Minibox mounted to the inside rear wall of the output compartment, directly behind the loading capacitor. The wattmeter RF-sensing circuitry is inside the Minibox mounted on the outside of the back panel, near the tube.

Problem Areas

During original tests, the amplifier operated very poorly above 20 meters. It had severe LF and VHF parasitics, and none of the common cures worked. By accident, it was found that the case of the filament transformer was hot with RF energy, and in fact an arc could be drawn from the transformer mounting bolts. An NE2 neon lamp, mounted on an insulated rod and placed near the tube or filament transformer, glowed bright purple. (Normally, the neon lamp glows orange in the presence of HF energy. If it glows purple, VHF energy is present.) Removing the filament transformer from the shielded plate compartment cured the VHF parasitic problem, but there was still a trace of a low-frequency parasitic. Moving the plate RF choke (RFC1) to the position shown in Fig 70 cured this problem.

Table 1
Typical Operating Conditions for the 3CX1200A7 Amplifier

Plate Voltage	3500 V
Plate Current	800 mA
Grid Current	180 mA
Power Output	1500 W
Drive Power	100 W
Input SWR	<1.5:1

Tune-Up

Check the high-voltage supply for proper operation before connecting it to the RF deck. Check all circuit paths in the power supply and RF deck for possible short circuits. Verify the operation of all control circuits with the high-voltage off and with the tube removed from the socket. When everything works, place the tube in the circuit and apply power to the blower, filament transformer and control circuitry. Measure the filament voltage at the tube socket; it should be 7.5 V. If all is well, remove power from the RF deck and install the covers. Connect the high-voltage supply. Connect an exciter capable of delivering about 100 W to the input through a wattmeter and connect the amplifier output to a suitable dummy load through a second wattmeter.

Close the the BLOWER and FILS switches. The blower will start and filament power will be applied. The BLOWER and FILS lamps will light. Close the PLATE switch, and the high-voltage will come on. Plate voltage should register with M1 in the E_P position. Press the transceiver PTT switch. M2 should indicate about 150 mA resting plate current.

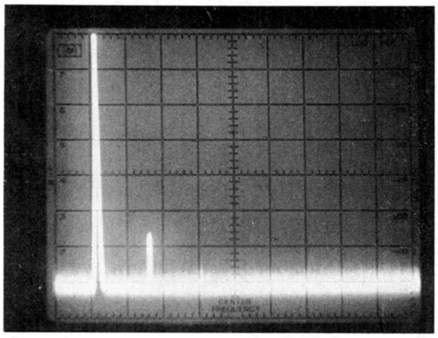


Fig 78—Spectral photograph of the 3CX1200A7 amplifier operating through the low-pass filter. Power output is 1500 W at 14 MHz. Each horizontal division is 10 MHz; each vertical division is 10 dB. All harmonics and spurious emissions are at least 56 dB below peak output.

Apply about 10-W drive and adjust the slugs of the coils in the input pi networks for lowest SWR at the center of each band. Adjust the TUNE and LOAD controls for maximum output. Gradually increase drive until the power output reaches 1500 W. With 3500 V on the plate, grid current should be about 200 mA, and plate current should be about 800 mA. Recheck the input SWR on each band with the amplifier running at full output.

Table 1 shows the operating parameters for this amplifier. Although it has no problem meeting FCC specifications for spectral purity, a B&W low-pass filter is bolted to the side of the plate-tank compartment for added harmonic suppression. Fig 78 shows the spectral output of the amplifier with the low-pass filter.