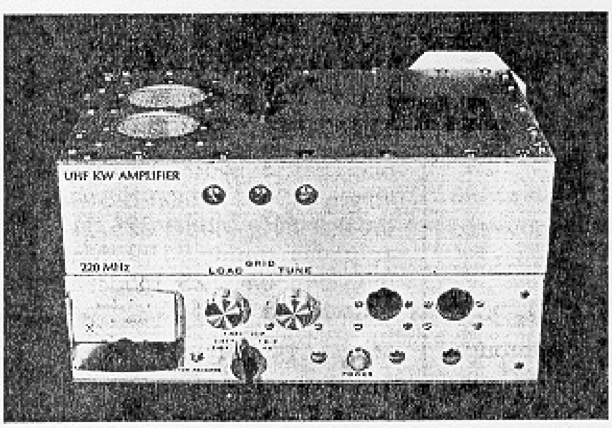
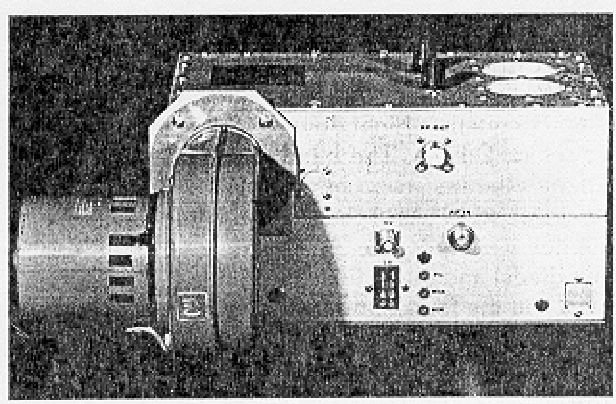
stripline kilowatt amplifier for 220 MHz

Updated version of a design published previously in *ham radio*

The **144-MHz stripline kilowatt** amplifier described in the October, 1977, issue of *ham radio*[1] has been constructed and operated by a number of Amateurs, both from the information in the article and from parts kits available from ARCOS.* A 220-MHz version of this amplifier was built and tested during 1977 and has been reproduced several times. One of these models has been in service on a 220-MHz repeater for over two years. This same amplifier was borrowed from the repeater and used during VHF/UHF tests over the past two years by the W2SZ/1 (Mount

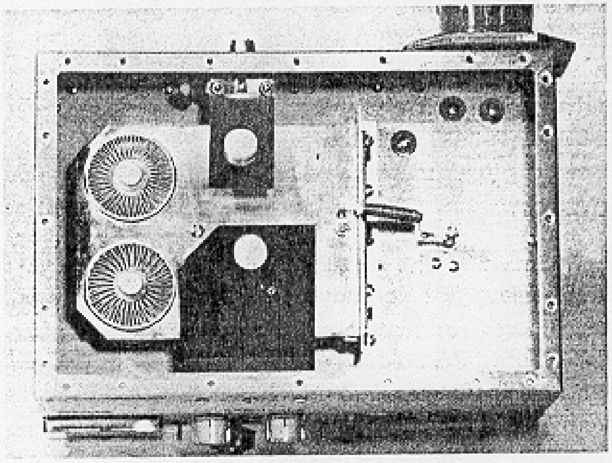
*ARCOS, Amateur Radio Component Service, Box 546, East Greenbush, New York 12061. All parts for the 220 amplifier and power supply are available.



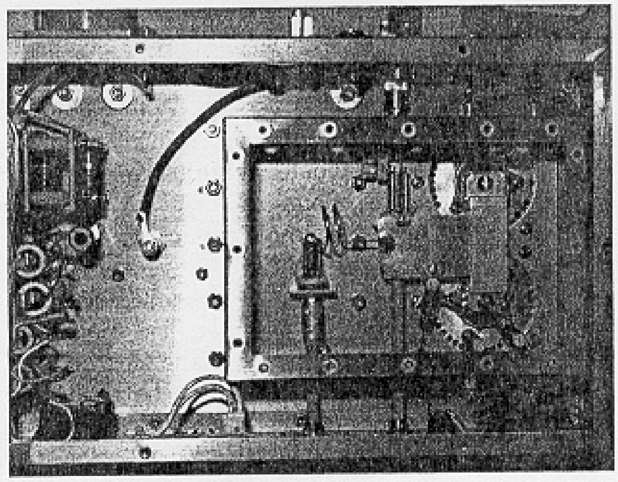


Front and rear views of the 220-MHz stripline kilowatt amplifier, which is enclosed in two mated chassis. Two optional designs are available, one for triode and one for tetrode tubes.

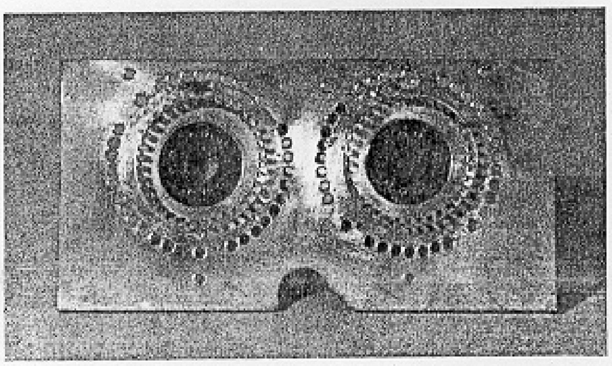
By F. J. Merry, W2GN, 35 Highland Drive, East Greenbush, New York 12061



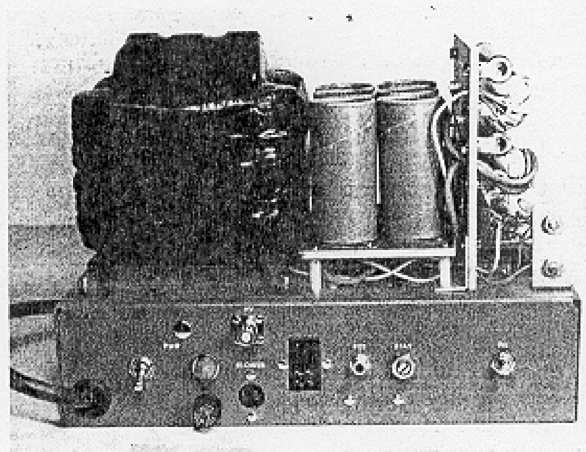
Top view of the stripline amplifier with cover removed showing the load and tuning flappers.



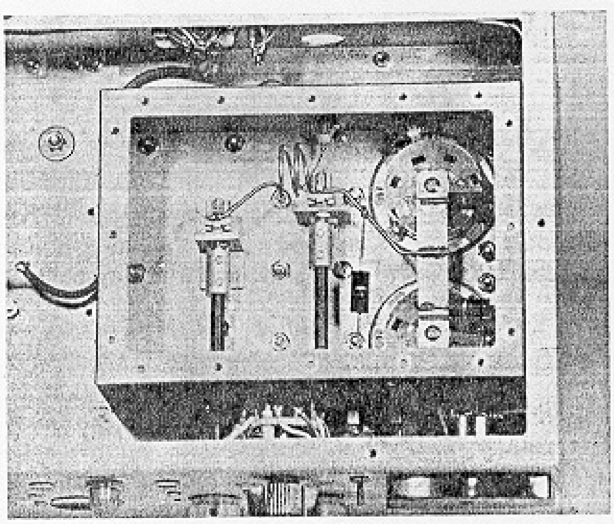
Bottom view of the triode amplifier with cover removed.



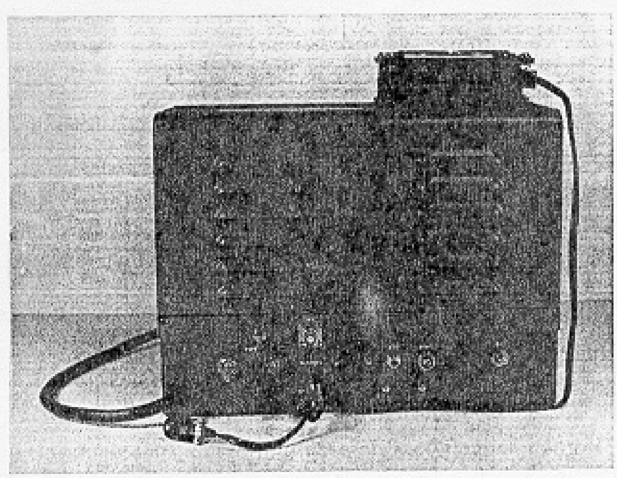
Socket assembly for the 8874 triodes, which may be installed onto the amplifier chassis in place of the tetrode sockets.



Front view of the power supply with cover removed.



Bottom view of the tetrode amplifier with cover removed.



Front view of the power supply for the stripline amplifier with cover installed.

Greylock) group. Experience has been favorable in all respects.

The experienced builder, especially if he has built the 144-MHz model, will find no difficulty in building and operating the 220-MHz version. With EME and tropo activity on 220 MHz on the increase, this amplifier is a good candidate where there is a need for reliable high-power operation.

Similar to the 144-MHz amplifier in chassis dimensions and other respects, the 220-MHz version uses a quarter-wave plate line and a coil-simulated half-wave grid line. Except for the plate-line mounting screws, the location of the high-voltage feedthrough capacitor and a hole for a bushing for the plate tuning flapper drive string, chassis punching is identical to the drawings for the 144-MHz amplifier as described in reference 1. Originally described by K2RIW (reference 2) for a 432-MHz stripline amplifier, this type of chassis construction has proven adaptable to not only 432, 220, and 144 MHz but also to an equally successful 50-MHz version using a pi-network output circuit with inductive tuning. The 50-MHz model will be described in a subsequent article.

The amplifiers mentioned above can use any of the ceramic tetrodes such as the 4CX250R, 4CX250B, or 8930, further illustrating the flexibility of this type of chassis construction. The 8874 triodes can also be used in a grounded-grid application by installing a mounting plate for the 8874 sockets in place of the individual EIMAC 630A sockets. The triode amplifiers have the advantage of not requiring the critical screen supply voltage and the disadvantages of higher tube cost and higher drive power requirement.

design

Referring to the schematic, (**fig. 1**), the quarter-wave plate line is tuned and loaded by flapper capacitors. The plate blocking capacitor is a Teflon sandwich at the cold (rf) end of the line. The grids are connected by a strap to which is connected the grid coil. A 1k, 2-watt resistor is used for a grid choke (class AB1 operation — no grid current). A 1k, 2-watt resistor in series with a 1000-pF capacitor is connected to ground from each grid. These two loading resistors increase the stability margin of the amplifier and desensitize it so that it can be driven to 500 watts output with about 10 watts of drive. Additional resistors may be added depending on the drive power available. If the grid load resistors are omitted, the amplifier is stable but it becomes extremely power sensitive.

A further examination of the schematic reveals an optional rf output indicator circuit and 660-MHz and

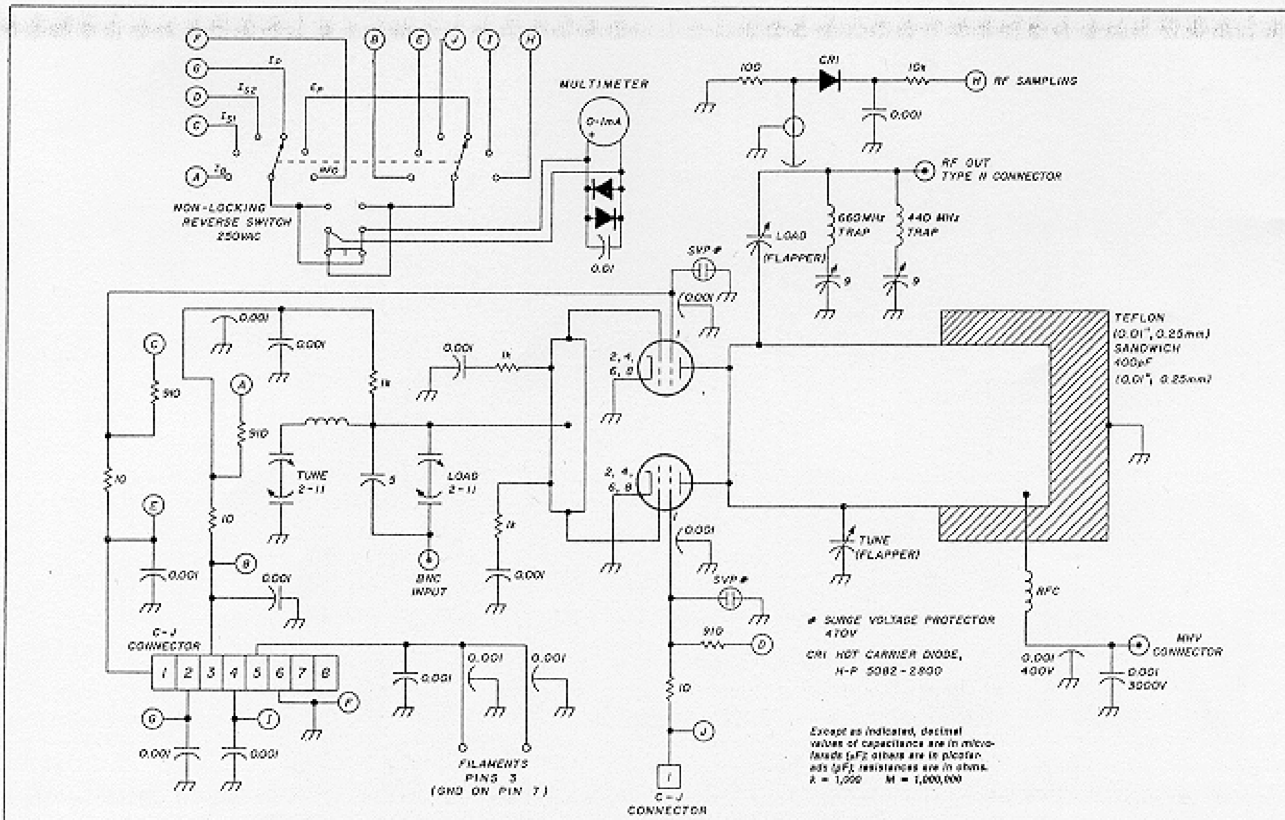


fig. 1. Schematic diagram of the tetrode stripline kilowatt amplifier.

440-MHz harmonic traps in the rf output, surge voltage protectors (SVPs) on the screen leads, and the usual lead filtering to keep the rf locked into the grid box and plate compartment. Metering is with a single 0-1 mA meter and a six-position switch with appropriate metering resistors for plate current, plate voltage, individual screen currents, grid current, and relative rf output. Thus, all important operating parameters are monitored.

A nonlocking reversing switch facilitates reading negative values of screen and grid currents, which are normally experienced with tetrode amplifiers. I recommend that an rf output wattmeter be used instead of the relative rf output indicator circuit. Proper adjustment of the plate tuning controls is difficult unless both plate current and the rf power output can be observed simultaneously. Other dc metering arrangements may, of course, be employed, including enclosing the meter circuit in a separate box at the operating position with the amplifier remotely located or by locating the metering circuit in the power-supply chassis.

The surge-voltage protectors in the screen circuit will ground the screens if the screen voltage rises above 470 volts. This protection is important and should be provided on all tetrode amplifiers. Emission effects in ceramic tetrodes will cause the screen to go negative under certain operating conditions. When this condition occurs, the screen voltage rises, causing higher plate current. The tubes can go into a runaway condition unless the amplifier is shut down. The surge voltage protectors prevent the runaway condition by automatically reducing the screen voltage to a very low value. Once one of the SVPs has fired, it's usually necessary to shut off the power. Power may be restored after a pause to let the capacitors discharge to a point below the sustaining voltage of the SVP that fired. A small saving can be realized by using only one SVP connected to the screen-supply lead.

Two other factors are involved in foolproof operation of the screen circuit:

1. The screen power supply must be provided with a current-limiting resistor so that the current doesn't exceed about 100 mA when one of the SVPs fires.

2. The power supply must have a resistor, from screens to negative, which is of a value low enough to provide a sink current of at least 40 mA. This feature provides a path for the negative screen current so that the screen voltage will hold at the regulated value.

With the above features provided in the screen circuit, the tetrode amplifier will perform as reliably and smoothly as a triode amplifier.

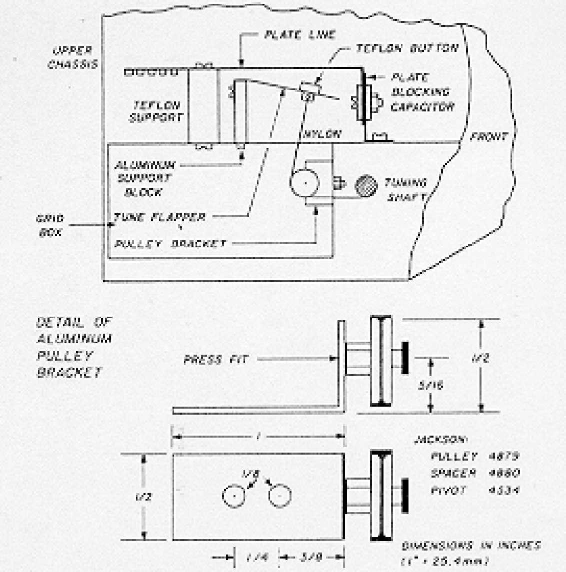


fig. 2. Cross-sectional diagram illustrating operation of plate-tuning flapper. The diagram is for front-panel control. Alternatively, the plate-tuning flapper may be located above the plate line and adjusted with a screw and knob (like the load flapper).

construction*

Chassis punching and drilling follows the same pattern shown by the drawings and as discussed in the 2-meter amplifier article.[1] Variations are listed below.

Plate-line mounting holes. The five holes in the right end (facing front) of the upper chassis (used to mount the 2-meter plate line) are not required. The 3/16 inch (5 mm) holes that fasten the 1-1/4 meter plate line to the chassis are located by setting the line in place with the tubes installed.

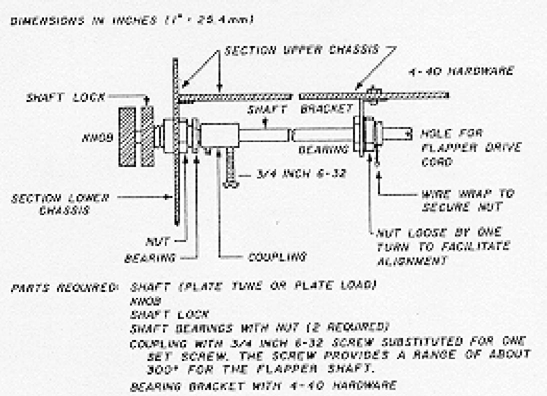


fig. 3. Sketch illustrating assembly of flapper control shaft with shaft lock. This assembly is used in place of planetary drives. It provides a greater range of adjustment and more positive operation.

*See the appendix before proceeding further.

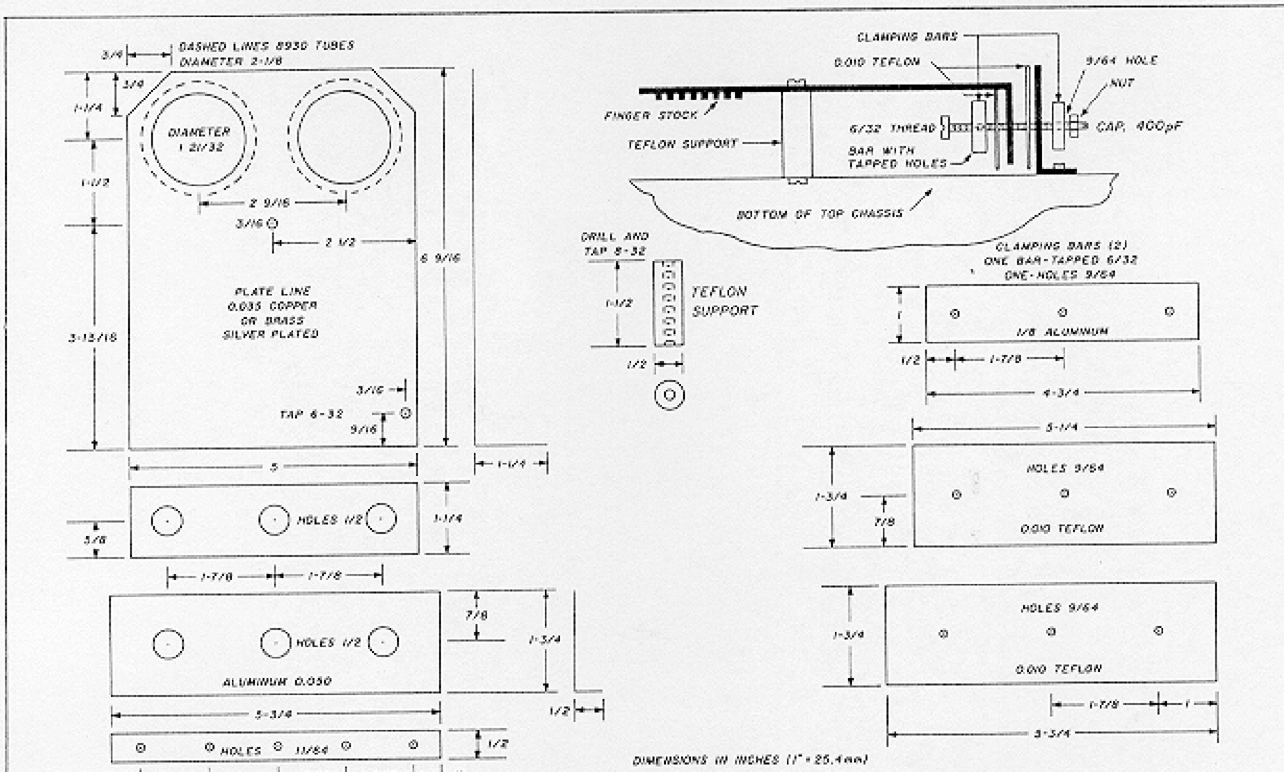


fig 4. Plate-line details of the 220-MHz stripline kilowatt.

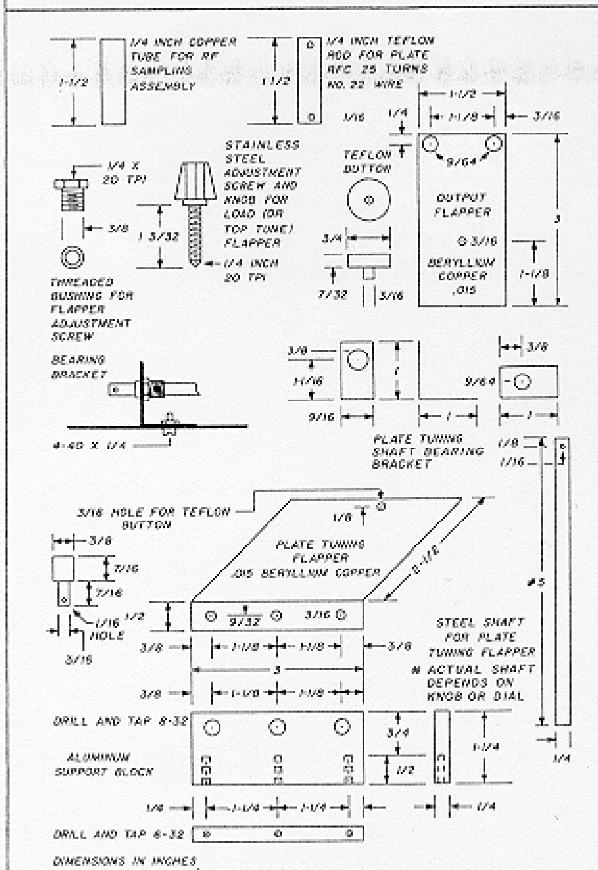


fig. 5. Plate-line tuning and output flappers.

Mounting the high-voltage feedthrough capacitor. The 7/16 inch (11 mm) hole for the high-voltage feedthrough capacitors is located 2 inches (5 cm) to the right (facing the front of the amplifier) of the cold end of the plate line and in line with the rear edge of the plate line. The rf choke is mounted between a lug on the plate line and another lug on the high-voltage feedthrough capacitor.

Plate-tuning flapper. The plate-tuning flapper is mounted on an aluminum block as in the 2-meter amplifier. It is shorter than the 2-meter flapper. The drive cord is connected to the tuning control through a pulley inside the grid box, **fig. 2**. A knob shaft lock and a steel shaft provide the plate tuning adjustment, **fig. 3**.

An alternative method of installing and controlling the plate tuning flapper is to secure it to the front of the upper chassis wall and adjust it with a 1/4 inch (6.4 mm) threaded rod from the top of the chassis — a simple and positive method of control, the same as that used to control the plate load flapper.

Plate line. The construction of the plate line is shown in **figs. 4** and **5**. The parts of the line must be free of burrs to avoid puncturing the Teflon insulation. Assembly of the line must be accurate so that the screws holding the clamping bars are centered in the holes in the plate line and the underside of the plate line is 1-1/2 inches (38 mm) from the floor of the upper chassis.

Grid circuit. Details of the grid circuit are shown in **fig. 6**. Miniature capacitors (20-pF) may be substituted for the butterfly caps. The advantage of the costly butterfly cap is that no bearings are included in the rf path. The 2-11 pF butterfly caps will require a10-pF padder mounted across the two stators.

triode amplifier

If the 8874 triodes are the tube choice, the sockets can be mounted on a brass plate, which is then installed onto the amplifier chassis in place of the EIMAC 630A sockets used for the tetrodes, **fig. 7**. There's no need to change dimensions of the plate line provided it's for the 4CX250 tubes. The grid line becomes the cathode line, and an rf choke is substituted for the 1k, 2-watt grid resistor. The grid load resistors are also omitted. See the schematic of the triode version, **fig. 8**.

Note that the triode amplifier has two meters mounted on the chassis. The right-hand meter reads plate current; the left-hand meter reads grid current. By operating a nonlocking meter switch, plate voltage is read on the grid-current meter. (I assume that an rf wattmeter will be used to monitor power output.)

Metering and cathode resistors are mounted on the right-hand end of the lower chassis. The zener bias diode and the control connector are mounted on the rear of the lower chassis. An ungrounded contact closure on the control connector is required to establish operating bias.

harmonic traps and rf indicator pickup

The harmonic traps (440 MHz and 660 MHz) in the rf output are installed in a small box (Pomona 2428) mounted on the rear of the amplifier, **fig. 9**. Alternatively, these traps can be installed in a box with coaxial connectors on each end (Pomona 2411). This box can be inserted in the output line at the rf output connector or immediately following the output wattmeter. The adjustment of these traps is best done

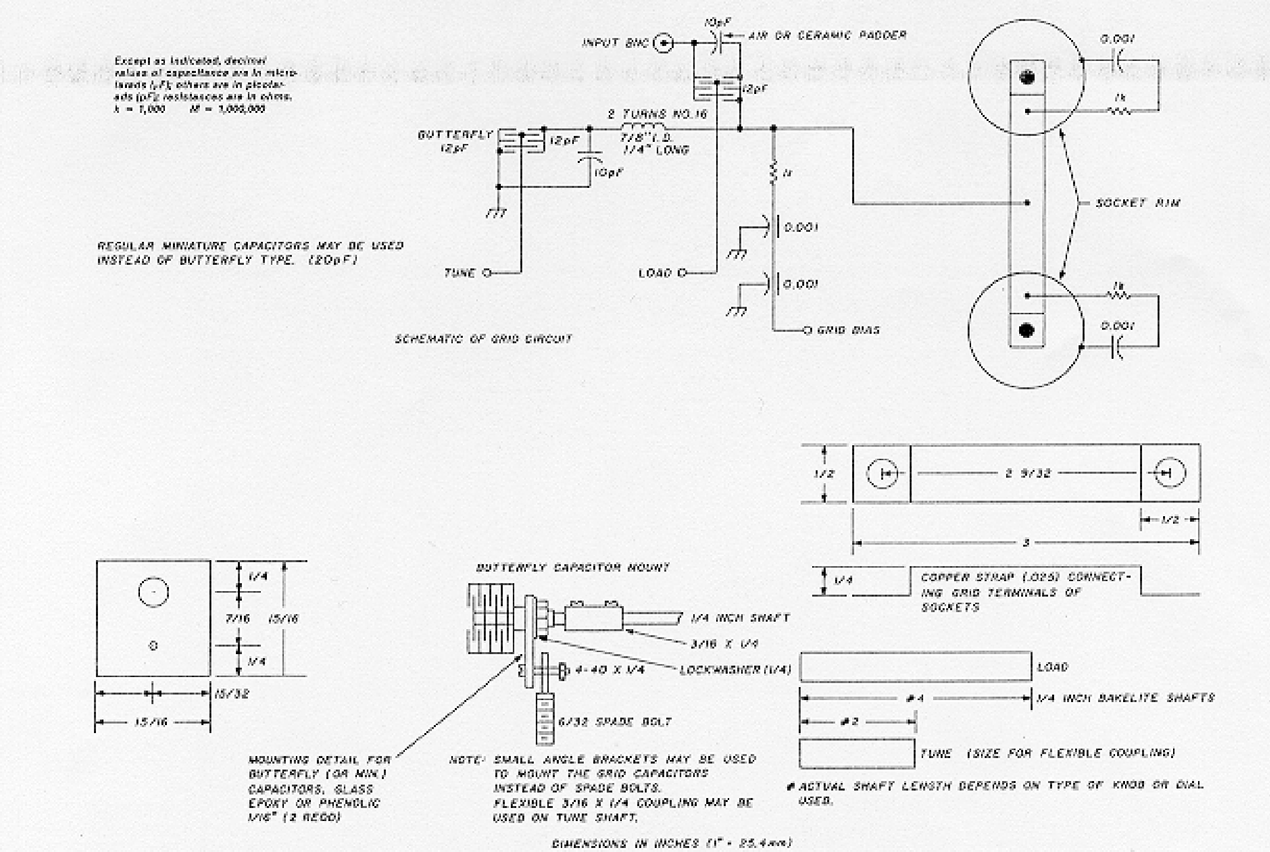


fig. 6. Grid-circuit details. The butterfly caps will require a 10-pF padder mounted across the two stators.

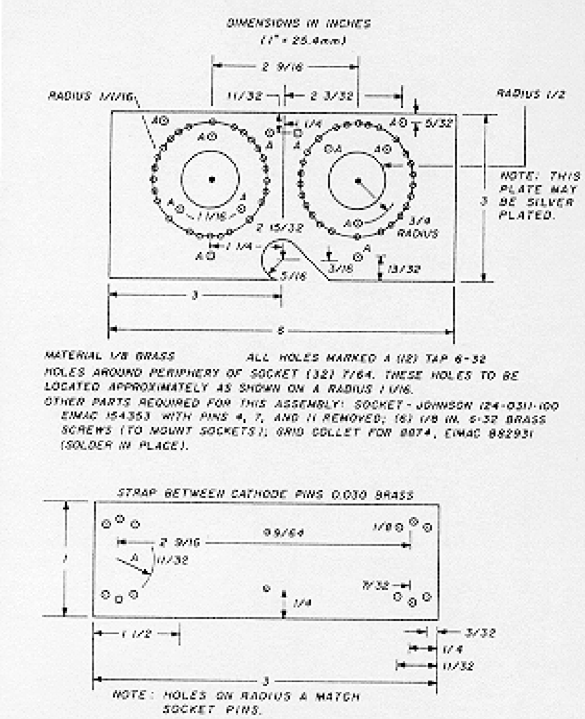


fig. 7. Socket plate for the 8874 amplifier.

while observing the level of the harmonic output on a spectrum analyzer.

The rf pickup assembly is also illustrated in **fig. 9**. The amount of rf pickup is obtained by adjusting the position of the lug, which is mounted on top of the output flapper, with respect to the lug on the standoff insulator.

The rf pickup assembly may be omitted if you plan to have an rf wattmeter in the output circuit. As I mentioned previously, it's desirable to have an rf wattmeter to monitor output and to achieve the best adjustment of plate tune and load controls for maximum efficiency.

assembly

The following sequence is suggested for assembly:

1. Mount and wire all parts on the lower chassis.

2. Fasten the grid box to the upper chassis and install the sockets, feedthrough capacitors, SVPs and BNC input connector. For the tetrode amplifier, orient the sockets so that terminals 1 and 3 are opposite their respective feedthrough caps. The sockets for the triode amplifier are mounted so that the heater terminals are positioned between their respective feedthrough capacitors on the cathode box.

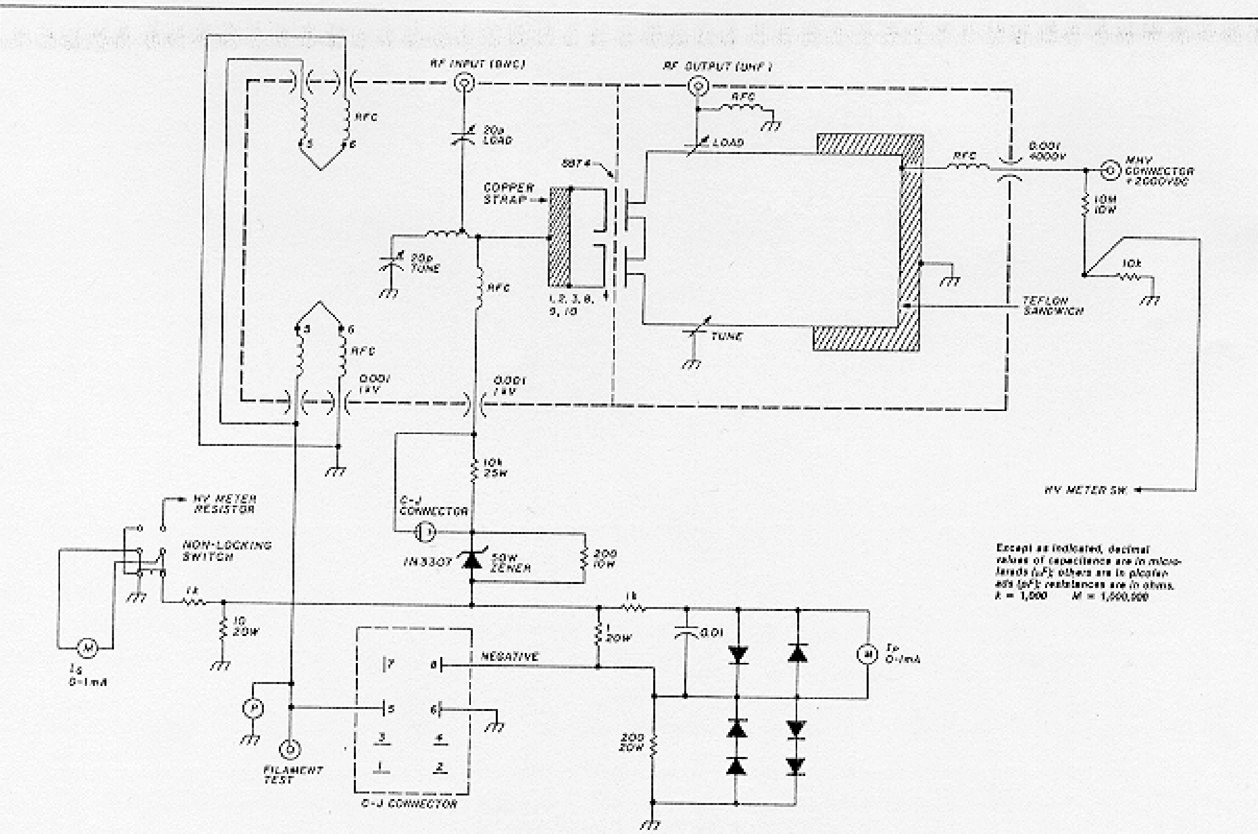


fig. 8. Schematic diagram of rf section, triode amplifier.

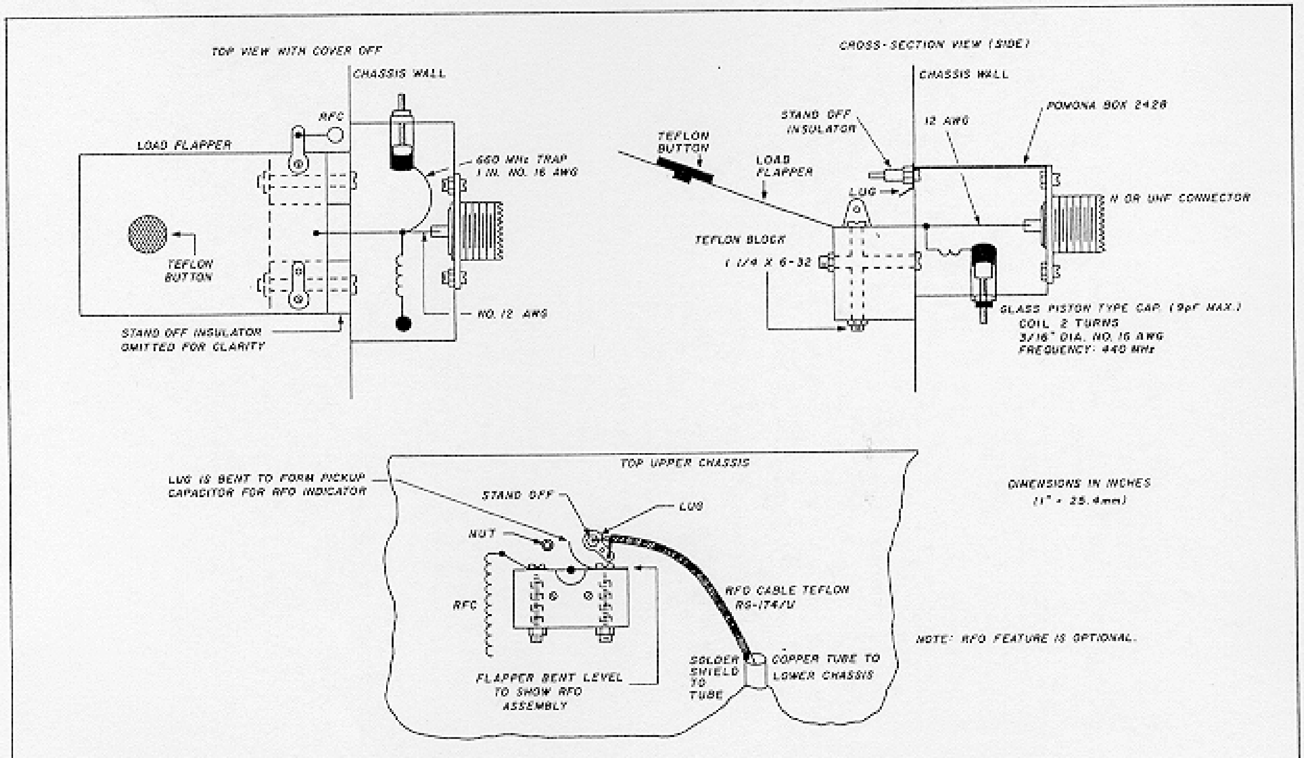


fig. 9. Harmonic traps and rf indicator pickup assembly.

3. Install the high-voltage feedthrough capacitor and the rf output pickup assembly.

4. Fasten the upper and lower chassis together and complete the wiring interconnections.

5. Mount the butterfly caps in the grid box (**fig. 6**) and install the tune and load controls.

6. Install the grid line, grid coil and resistors as in **fig. 6**.

7. Install the plate-tuning flapper, pulley, dial, shaft and bearing. Tie the nylon line to the flapper before mounting the flapper.

8. Install the tubes temporarily and put the plate line (previously assembled) in place. Work the finger stock over the tubes *very carefully*. Make sure everything lines up. Mark the mounting holes at the end of the plate line, then remove the plate line and tubes and drill the mounting holes for the plate line. Reinstall tubes and plate line.

9. Connect the plate rf choke.

10. Install the output flapper, rf grounding choke and RFO assembly.

11. Assemble the top plate screen and vent plate and the threaded bushing for flapper adjustment. Put the tubes in place and put the Teflon chimneys in position in the vent plate. Fasten the top plate in place.

12. Recheck wiring and fasten the bottom plate.

The amplifier is now ready for test.

blower

The blower may be mounted onto the air-intake plate on the rear of the amplifier or it may be hose connected. The Dayton model 4C012A specified in the 2-meter construction article[2] is satisfactory for normal operation. **Figs. 10** and **11** give the dimensions for air-intake plates for higher-power blowers;

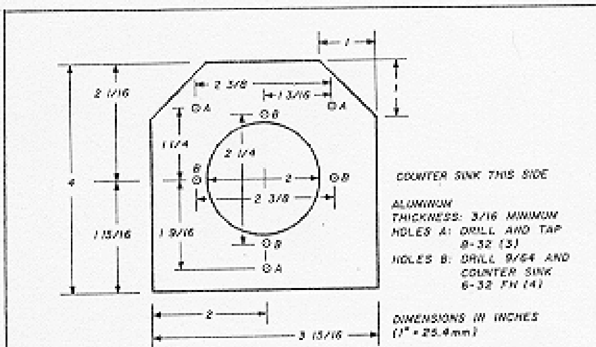


fig. 10. Air intake cover-plate details, Dayton 4C443 blower mount.

that is, the Dayton 4C443 (100 CFM) and the Rotron V537A2R4 (160 CFM). Generally speaking, the more air flow the better, so the choice of blowers is usually a compromise based on noise level and price. The noise can be reduced appreciably by control circuits that reduce blower speed during standby periods. To make the blower operation foolproof (the amplifier will fail in less than a minute without air), an air switch can be mounted in the output air stream of the blower, or a pressure switch can be mounted on the upper chassis. These switches can be connected to shut down the power supply or bias the amplifier to cutoff (see next section).

power supply

The power supply was given a rather brief treatment in the previous article.[1] There's a tendency to consider the power-supply design and construction as less significant than the amplifier. This can be a mistake, especially for the tetrode screen supply which, as discussed previously, has critical requirements for successful operation of tetrodes. This time, to provide background on its operation, the power supply is described in some detail (see the schematic, **fig. 12**).

Features of modern high-voltage power supply

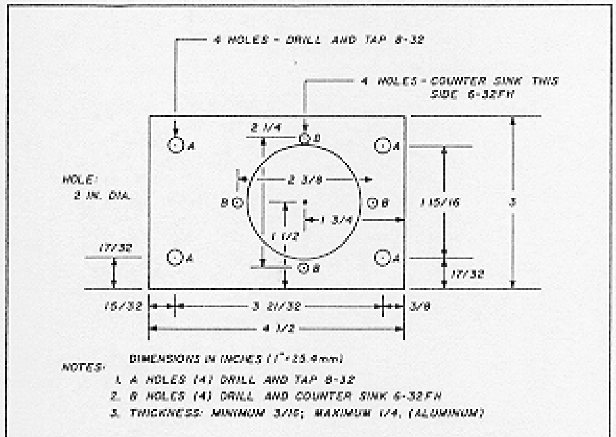


fig. 11. Air intake cover-plate (Rotron V537A2R4).

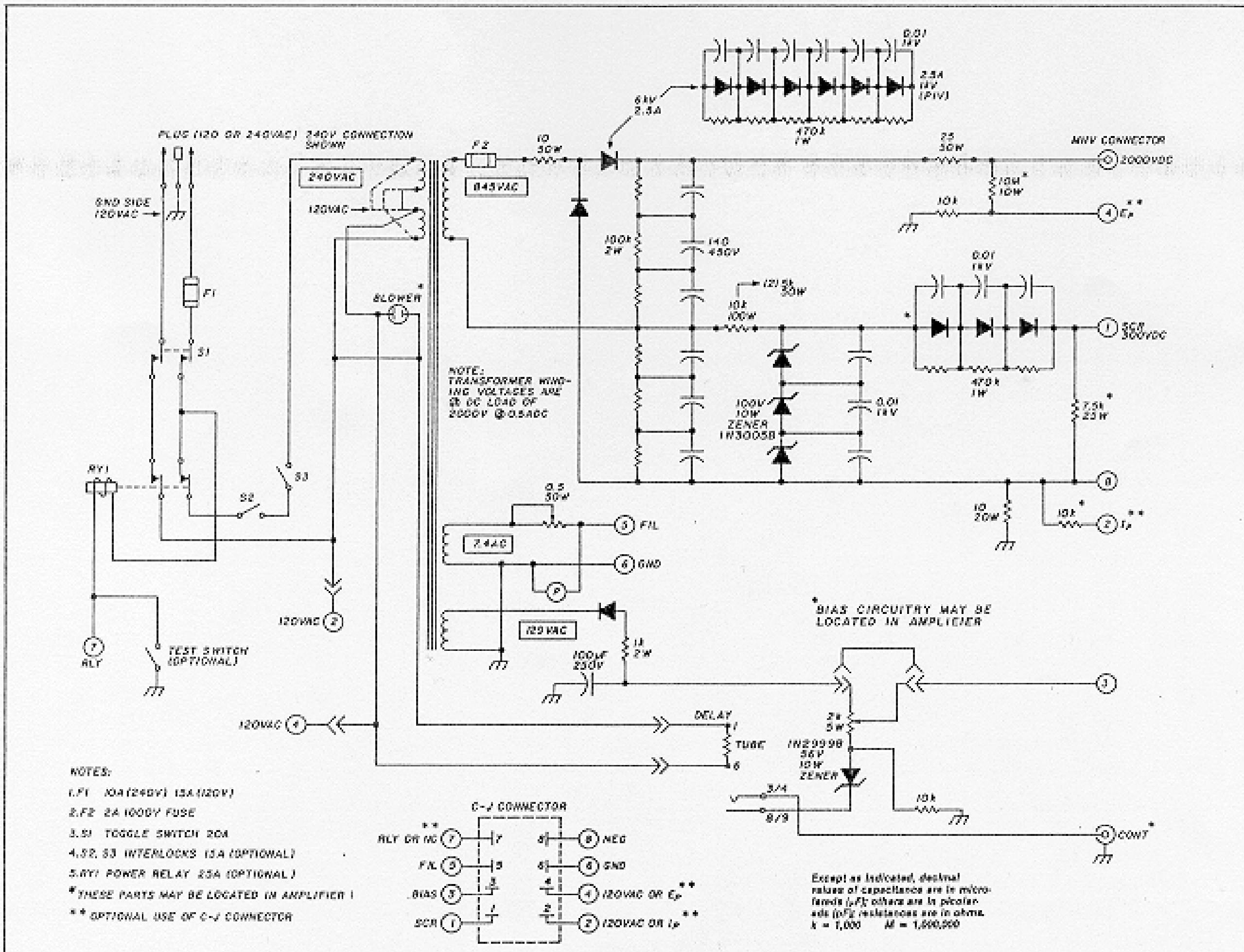


fig. 12. Power-supply schematic for the tetrode stripline kilowatt amplifier.

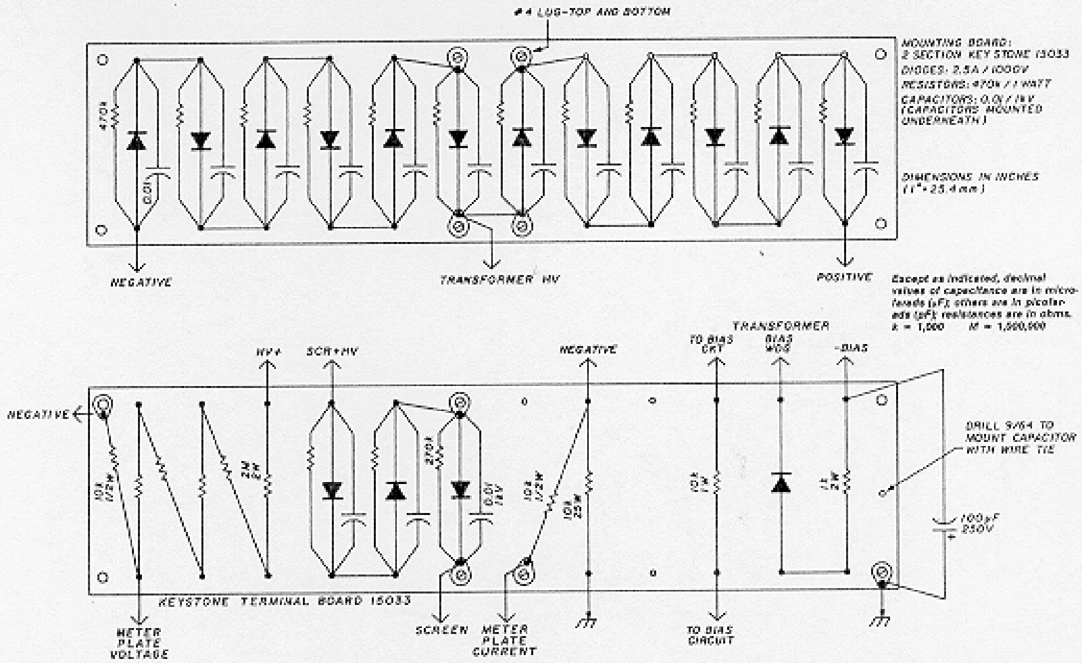


fig. 13. Details of the power-supply terminal strips. These two strips are mounted one over the other with 1-inch 6-32 spacers, with the high-voltage rectifier board toward the chassis.

design include compactness: 12 inches wide by 7 inches deep by 10 inches high (30.5 by 17.8 by 25.4 cm) and light weight (37 pounds, or 17 kg). All output voltages and other features to operate the amplifiers discussed above are provided. No-load output is 2300 volts dc. Outputs under loads of 1 ampere, 500 mA, and 100 mA are respectively 1850, 2000, and 2200 volts dc. Screen voltage is 300 volts dc regulated to 40 mA sink current. Cutoff and operating bias voltages are respectively −120 volts dc and −56 to −90 volts. (Operating bias is regulated at −56 volts dc.) Also provided are 7.6 volts ac, which is adjustable from 5.5 volts to 6 volts ac at 6 amperes. One-hundred-and-twenty volts ac are provided at the blower receptacle.

The transformer (custom manufactured by H. E. Johnson and Associates, Clearwater, Florida for ARCOS) has input provisions for either 120 Vac or 240 Vac, 50 to 400 Hz. Assembled around a 1540-watt hipersil core, the transformer is vacuum impregnated with insulating varnish then coated with a single-part thermosetting epoxy for mechanical protection. In ambient air of 25 degrees C with convection-radiation cooling only, continuous operation at 1000 watts dc results in a temperature rise of less than 30 degrees C.

The primary power circuit consists of a three-wire power cord, double-pole power switch, power relay (optional) and top and bottom cover interlock switches (optional). A test switch (also optional) simulates the ground for operating the power relay, which comes from the associated amplifier over pin 7 of the low-voltage connector. The power cord must be sensed correctly for this feature to work with the 120-Vac connection.

A blower receptacle is provided. The power cord from the power supply blower, which is mounted on top of the power supply, plugs into the blower receptacle. The blower cord has a bridged receptacle to which the amplifier blower can be connected. Alternatively, 120 Vac may be connected to pins 2 and 4 of the power supply's low-voltage connector for operating the amplifier from a receptacle on the amplifier chassis. If this option is chosen, metering resistors for plate current and plate voltage must be located in the amplifier instead of in the power supply.

A review of the schematic will show that a voltage-doubling circuit is used with over 30 μF of electrolytic capacitors in each leg of the rectifier circuit. Six 1000-volt PIV/2.5-amp diodes are used in series in each rectifier leg. The diodes are protected by a secondary fuse (2 amps/1000 Vdc) and a 10-ohm, 50-watt series resistor. The short-circuit current is limited in the high voltage lead by a 25-ohm, 50-watt resistor.

The voltage doubling circuit provides a 1000-Vdc output for developing regulated 300-Vdc screen voltage (pin 1 of the low-voltage power connector) by using a series resistor and zener diodes. The zeners are protected from high-voltage transients on the screen leads from the amplifier by series diodes in the screen lead. The screen terminating resistor may be located either in the power supply or in the amplifier.

The screen series resistor and screen terminating resistor values were chosen to maintain regulation with a 40-mA sink current in the screen terminating resistor. Adequate sink current for the screen circuit is essential to the proper operation of tetrode amplifiers. The sink current path through the terminating resistor provides a bleed path for the reverse screen current, which is normal for tetrodes. As I mentioned previously, if an adequate bleed path is not provided, the screen voltage will attempt to rise to the plate voltage and the tube will go into a runaway condition unless protected by surge voltage protectors at the screen-socket terminals. The 40 mA sink current provided for the screen terminating resistor in this power supply meets the tube manufacturer's recommendation for at least 15 mA per tube.

The series diodes in the screen lead block any high-voltage transients, which can occur in the time interval it takes for the surge voltage protection to operate, from destroying the zeners used for regulation.

The blower, mounted on top of the power supply over the vent slots near the screen-series resistors, provides cooling for approximately 100 watts of heat dissipation from the screen circuit components.

The grid-bias voltage (pin 3 of the low voltage connector) is regulated by a zener and is adjustable by a potentiometer. A delay tube is used to delay operating bias on the amplifier during warm-up. The bias changes from cutoff (– 120 Vdc) to operate (– 56 to – 90 Vdc) when ground is placed on the control jack. Provision is made for metering plate voltage and plate current over pins 2 and 4 of the low-voltage connector (when these pins are not used, as described above, for 120 Vac to the amplifier chassis). Pin 5 of the low-voltage connector provides adjustable filament voltage to the amplifier. Pin 6 provides ground and pin 8 connects to the negative lead of the power supply. The high voltage is connected to the amplifier by RG-59/U coaxial cable using Amphenol MHV connectors.

The conductors between the amplifier and the power supply, other than the high voltage, are connected over an eight-conductor cable (Belden 8448) having one pair of No. 16 AWG conductors used for the filament voltage and ground. The other six conductors are No. 22 AWG.

Construction of the power supply is shown in the photos. The amplifier was assembled on a prepunched foundation chassis available from ARCOS. Diagrams of the terminal strips used to mount the high-voltage diodes, screen and bias circuitry, and so forth, are shown in **fig. 13**. Other construction details are included in **fig. 14**. There's nothing critical about parts location, so any convenient chassis arrangement may be used. Be sure to provide adequate ventilation for the screen resistors and zeners.

For use with the triode amplifier, the screen regulation and grid bias components are omitted (**fig. 15**). Note that the metering resistors for the triode amplifier are located in the amplifier.

test and operation

Connect the amplifier to the power supply and make the usual checks of blower operation, filament voltage, bias voltage, screen voltage and plate voltage. Set the bias for an idling current of about 100 mA for initial tests. Apply a watt or so of excitation and adjust the grid controls for maximum plate

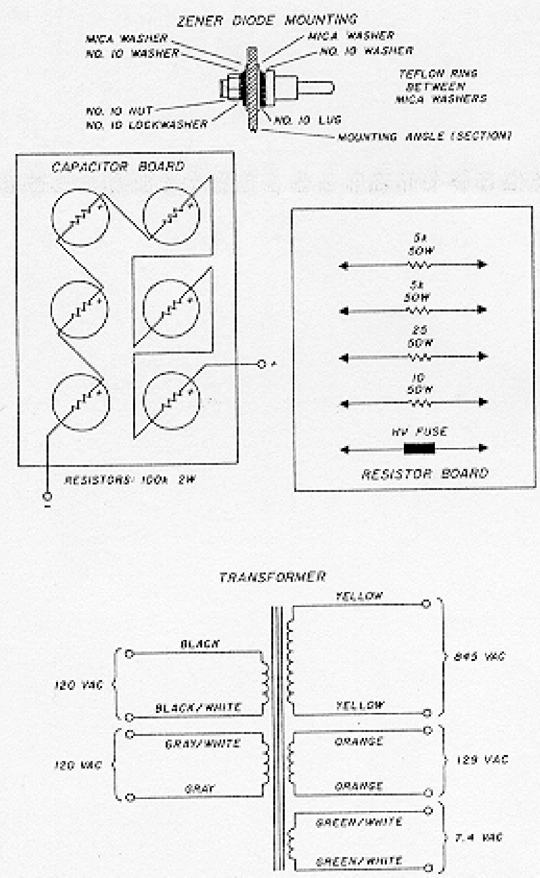


fig. 14. Construction details for the zener mounting, capacitor board, and resistor board in the power supply. The transformer is custom made for ARCOS by H.E. Johnson and Associates, Clearwater, Florida. Secondary ac voltages shown at a dc load of 2000 volts at 0.5 amp.

current. Then resonate the plate circuit by observing power output. If the plate circuit will not resonate, change the range of the plate-tuning flapper controls.

Increase drive until the output is at about 400 watts with the loading control about 1/8 inch (3 mm) above the top plate. Now set the grid controls for minimum SWR toward the driving source. Next, adjust the plate load and tune controls for a compromise between maximum output and minimum plate current at an output level of 500 to 600 watts. See **table 1** for a typical set of readings taken during the test of one of these amplifiers.

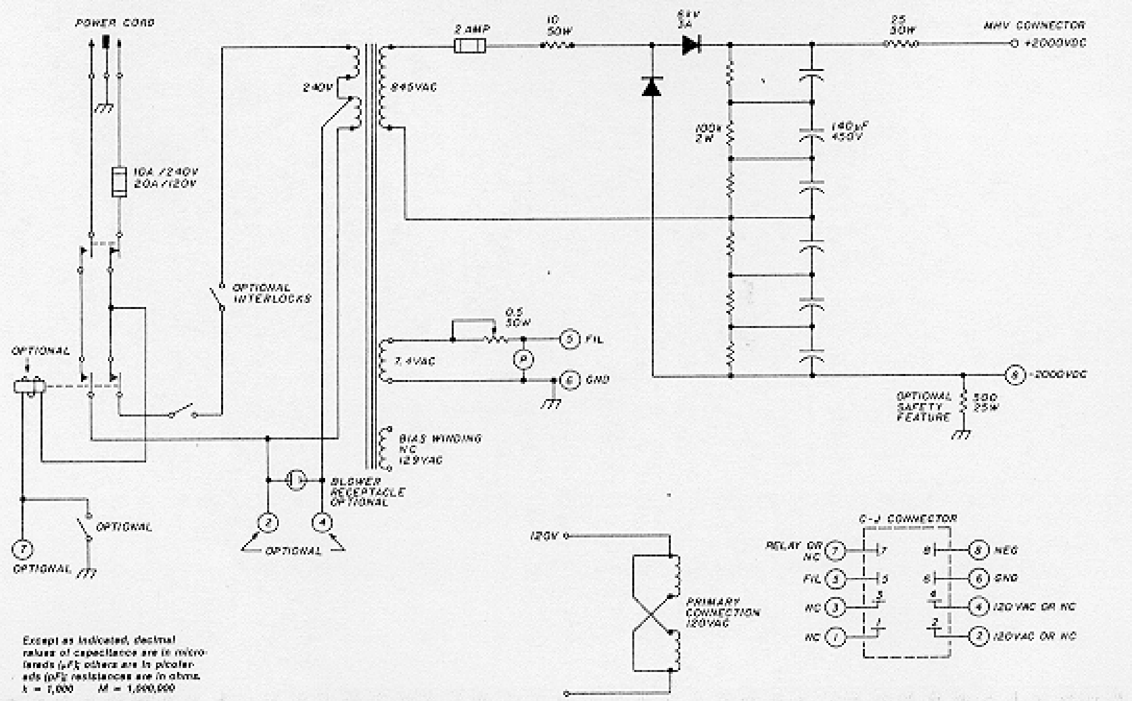


fig. 15. Schematic of the power supply for the triode stripline kilowatt amplifier.

table 1. Typical test results for the 220-MHz amplifier.

E_{fil} (volts)	E_{grid} (volts)	E_{scr} (volts)	E_{plate} (volts)	I_{grid} (mA)	$I_{scr\,1}$ (mA)	$I_{scr\,2}$ (mA)	I_{plate} (amp)	RFO	drive (watts)	output (watts)	input (watts)	temperature 1 (F)	temperature 2 (F)
5.9	−92	380	2350	—	—	—	.100	—	idling	—	235	128	128
5.9	−92	379	2200	0	−6	−2	.280	4	6	280	616	180	180
5.9	−87	378	2100	−1	−5	−1	.540	6	12	600	1134	170	170

tubes: 4CX250R
dummy load: 150 ft (46 meters) of RG-8/U terminated by a Heath Cantenna.™
operation: Class AB1

Notes:
1. Temperature 1 and temperature 2 refer to the temperatures at the two exhaust ports.
2. Efficiencies are 45 percent on line 2 and 53 percent on line 3.
3. RFO readings are the relative power output on the multimeter of the amplifier.
4. The negative grid and screen currents are normal for this type operation.
5. Observe the excellent screen voltage regulation.
6. Plate voltage regulation is 11 percent.
7. At 1-kW input the power output would be about 540 watts on CW for this operation condition.
8. SSB inputs can exceed the above figures somewhat if desired.
9. Key down on CW at 1 kW input, the tubes are within their dissipation rating (500 watts).
10. Power readings were taken with Bird 43 wattmeters in both drive and output.

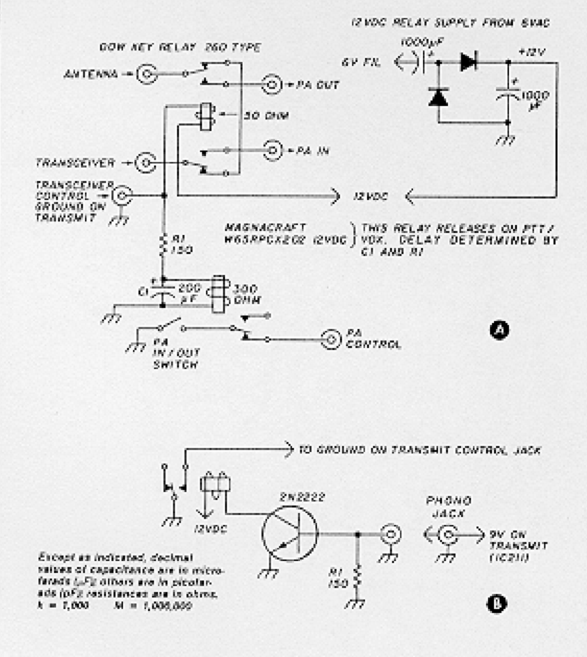


fig. 16. Antenna relay control schematic, A. Circuit prevents "hot" switching and also provides power-amplifier input-output control. Place a tab of cellophane tape on the pole piece of the Dow-Key 260 relay. B shows a circuit to adapt the ICOM or similar transceivers to furnish ground during transmit. The base circuit (R1) must be adapted to the application used.

A relative indication of the effectiveness of cooling, as well as the relative dissipation shared by the two tubes, can be obtained, as suggested by K2R1W[2] by mounting a candy thermometer over the air outlets. Temperatures read in this manner should not exceed 200 degrees F (93.5 C) under any condition. The thermometer is equipped with a pair of stiff wire legs, which faciliate setting it on top of the amplifier over the exhaust holes.

A failure of the air supply, if undetected, will result in a very rapid and disastrous temperature rise inside the plate compartment. Usually the solder on the plate line melts and the finger stock springs out to touch the chassis — grounding the high voltage and operating the high-voltage fuse. In cases observed so far, the tubes have survived. To prevent damage, an air switch in the blower or a pressure switch for the plate compartment may be used to shut down the power supply or bias the amplifier to cutoff when air pressure fails.

A suggested setup for switching the antenna when using a transceiver for drive power is shown in **fig. 16**. Some transceivers don't furnish ground on transmit, providing either 12 Vdc or some other voltage. There's not enough current available in some cases to operate a relay. A transistor and relay may be connected as shown in **fig. 16** to accept a voltage on transmit and produce a ground to operate the antenna-switching circuit. Note that a 12-Vdc supply is required for the above circuit. This may be obtained from the 6 Vac on the filament line as indicated.

references

1. Fred Merry, W2GN, "Stripline Kilowatt for 2 Meters," *ham radio*, October, 1977, page 10.
2. Richard T. Knadle, Jr., W2RIW, "A Stripline Kilowatt for 432 MHz," *QST*, April, 1972, page 48; May, 1972, page 59.

appendix

Errata in the October, 1977, article[1] on the two meter amplifier should be considered during construction.

Page 11 — **fig. 1**: "B" lead to meter switch is not shown. It is a direct lead from the opposite side of the 10-ohm metering resistor. (Opposite from the "A" lead.)

Page 12 — Caption on **fig. 3** should read 8930.

Page 13 — The caption of **fig. 5** is correct, but the drawing should be interchanged with that of **fig. 10**.

Page 13 — (**fig. 4**): The 3/8-inch dimension shown on the right side view should be 3/4 inches. The Dayton blower referred to in the text is model 4C012A. (The blower now recommended is Dayton 4C443. A different blower mounting plate is required.)

Page 15 — The dimension 1-7/8 inches (upper left) for the center line of the socket holes should read 1-5/8 inches.

Page 17 — (**fig. 10**): See note concerning page 13, **fig. 5** above.

Page 19 — (**fig. 13**): (upper right) — the dimension not shown for the self-crimping nuts on the lower piece of the plate line is 1/4 inch.

Page 20 — (**fig. 14**): Aluminum support block — the vertical holes in the block should be 1-1/4 inches apart (not 1-1/8). The width of the fixed plate-line capacitor plate is 1-1/8 inches, not 1-1/2 inches.

Page 21 — (**fig. 15**): The grid coil is three turns, 5/8 inches diameter, 3/4 inches long, No. 16 AWG.

Page 21 — (**fig. 15**): The butterfly capacitor mounts are made of G-10 glass epoxy laminate having a thickness of 0.06 inch.

Page 21 — The dimension between the holes in the copper strap is 2-9/16 inches not 2-9/32.

Improvements developed since the October, 1977, article was published:

1. Surge-voltage protectors were added to the screen terminals of each socket.

2. The output (load) flapper assembly has been strengthened by mounting it on a Teflon block. A large Teflon button is mounted in a hole in the load flapper on which the adjustment screw bears. The adjustment screw was changed to a 1/4-inch thread cap screw. With this arrangement, there is no strain on the center conductor of the output connector, and mechanical stability is achieved. The Teflon piece underneath the load flapper is not required.

3. In the original design, the plate-tuning flapper was quite close to the plate line at resonance, which resulted in a tendency for it to flash over when loading was too light. To provide additional clearance and smoother tuning control, a padder capacitor of the flapper type was added above the plate line opposite the plate loading capacitor.

4. The zener regulators in the power supply are protected from high-voltage transients on the screen lead by a string of diodes.

ham radio