

KILOWATT AMPLIFIERS FOR 50 AND 144 MHZ

The amplifiers shown in Fig. 6-38 were designed for versatility. Though capable of running at the maximum legal power for amateur stations, they operate efficiently at much lower levels. They work well as linears, for use with a-m or ssb, or they can be modulated or keyed in high-efficiency Class-C service. Though the tube type shown is expensive when purchased new, an effective substitute is commonly available on the surplus market at much lower cost. Operated as a rack-mounted pair, as pictured, the amplifiers offer convenient band-changing from 50 to 144 MHz, merely by snapping on the appropriate heater voltage switch, and changing the air connection from one to the other.

The external-anode type of transmitting tube has many variations. The family originated with the 4X150A many years ago, and tubes of the early type are still available, and widely used. A later version, with improved cooling, is the 4X250B, capable of higher power but otherwise very similar to the 4X150A. More recently the insulation was changed from glass to ceramic, and the prefix became 4CX. All the general types thus far mentioned were made with variations in basing and heater voltage that will be apparent to any reader of tube catalogs. The 4CX250R used here is a special rugged version, otherwise very similar to the 4CX250B, and interchangeable with it for amateur purposes. Similar types are supplied by other makers as the 7034/4X150A 7203/4CX250B and 7580. There is another version for linear-amplifier service only, called the 4CX350A.

If one then goes to other basing arrangements similar power capabilities may be found in the

4CX300A, 8122 and others, but differences in tube capacitance might require modification of the circuit elements described here. The air-system sockets (required for all external-anode tubes mentioned) may be the same for all types in the second paragraph, but those just above require different sockets.

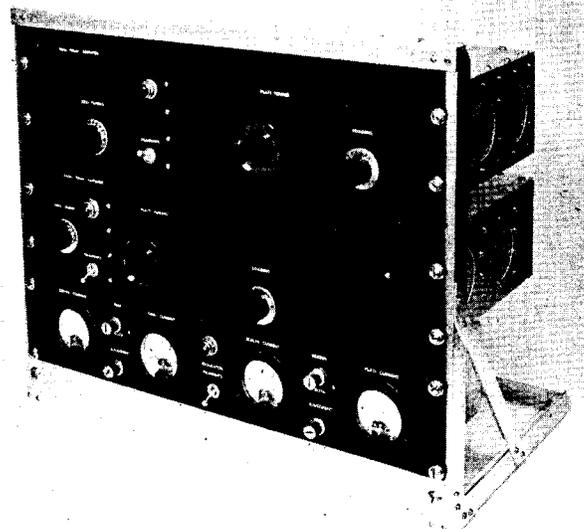
Both amplifiers take a kilowatt on cw or ssb with ease. The 144-MHz model must be held to 600 watts input for plate-modulated service to stay within the manufacturer's ratings. On 50 MHz the three tubes in parallel loaf along at 1000 watts in the low-duty-cycle modes. The permissible input on a-m phone is 900 watts. Class C efficiency is on the order of 75 per cent, over a wide range of plate voltages. It is possible to run all the way from 800 to 2000 volts on the amplifier plates without altering screen voltage or drive levels appreciably.

Mechanical Layout

The amplifiers are similar packages, to mount together harmoniously, though this is of only incidental interest to the fellow concerned with one band or the other. They are built in standard 4 by 10 by 17-inch aluminum chassis, mounted open side up and fitted with shield covers. In the author's station a single blower is used for all transmitters. This explains the air-intake sleeve seen on the back of each amplifier. An air hose from the remote blower is pushed into the amplifier being used.

The transmitters are all hooked up together, to meters, power circuits, audio equipment and power supplies common to all. Changing bands involves

Fig. 6-38 — The kilowatt amplifiers for 50 and 144 MHz in a rack made from aluminum angle stock. At the bottom is a meter panel with controls for meter and mode switching.



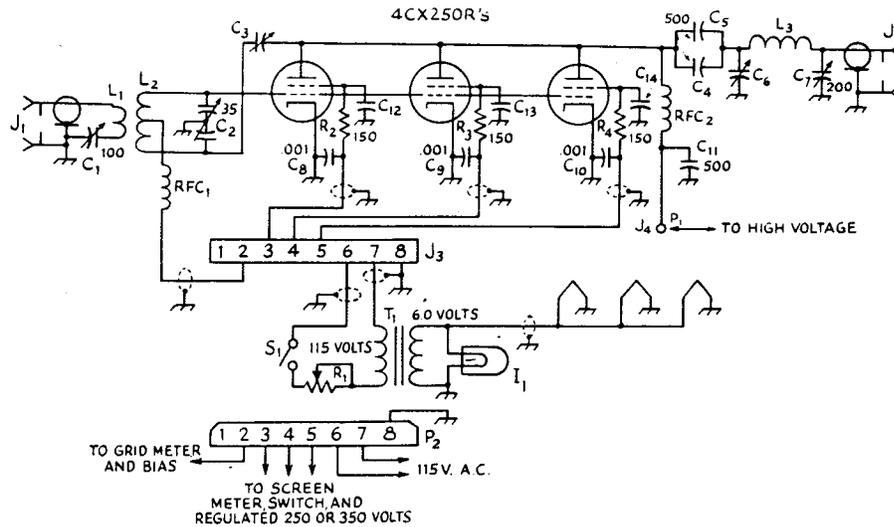


Fig. 6-39 — Schematic diagram and parts information for the 50-MHz amplifier.

- C1 — 100-pF miniature trimmer (Hammarlund MAPC-100).
- C2 — 35-pF per section split-stator (Hammarlund HFD-35X).
- C3 — Neutralizing capacitance — see text.
- C4, C5, C11 — 500-pF 5000-volt transmitting capacitor (Centralab 858S-500).
- C6 — Tuning capacitor made from 3-inch aluminum disks — see text and Fig. 6-40.
- C7 — 200-pF variable, .03-inch spacing (Johnson 167-12 or 200L15).
- C8, C9, C10 — .001-µF disk ceramic.
- C12, C13, C14 — Bypass built into special air-system socket.
- I1 — Green-jewel pilot lamp holder.
- J1, J2 — Coaxial chassis receptacle.
- J3 — 8-pin male power fitting.
- J4 — High-voltage power connector female (half of Millen 37501).
- L1 — 1 turn insulated wire about 1-inch dia. Make from inner conductor of coax running to J1. Strip jacket and braid back about 4 inches. Insert between center turns of L2.
- L2 — 8 turns No. 14, 5/8-inch dia, 1-1/4 inches long, center tapped.
- L3 — 3 turns 2 inches dia, 3 inches long, 1/4-inch copper tubing.
- P1 — High-voltage power connector, male (half of Millen 37501).
- P2 — 8-pin cable connector to match J3, female.
- R1 — 20-ohm 10-watt slider-type resistor. Set so that heater voltage is 6.0 at socket.
- R2, R3, R4 — 150-ohm 1/2-watt resistor. Connect at socket screen terminal.
- RFC1 — No. 32 enamel wire closewound full length of 1-watt resistor, 10,000 ohms or higher.
- RFC2 — No. 28 dsc or enamel, wound 1-3/4 inch on 1/2-inch Teflon rod. Space turns 1 wire dia for 8.3 µH. For winding information see Chapter 16.
- S1 — Spst toggle.
- T1 — 6.3-volt 8-A. Adjust R1 to give 6.0 volts.

mainly the switching on of the desired heater circuits, and the insertion of the air hose in the proper intake sleeve. Separate antenna relays are provided for each final stage, and power switching and plugging and unplugging are largely eliminated. Tube sockets are the air-system type, mounted on 4-inch high partitions with folded-over edges that are drawn up tightly to the top, bottom, front and back of the chassis with self-tapping screws. Air is fed into the grid compartments at the left side, as viewed from the front. Its only path is through the sockets and tube anodes, and out through screened holes in the right side of the chassis. Panels are standard 5 1/2-inch aluminum. Controls for the amplifiers are similar, though their

locations are slightly different. No attempt was made to achieve symmetry through mechanical gadgetry, since the unbalance of the front panels is not displeasing. The rack shown in Fig. 6-38 was made up from aluminum angle stock to fit the job. Several screen and bias control arrangements were tried before the circuit shown in Fig. 6-43 was settled upon. Meters read driver plate current, and amplifier grid, screen and plate currents. Switches enable the operator to check the grid and screen currents to each tube in the 144-MHz amplifier separately, and the screen currents in the 50-MHz amplifier likewise. A mode switch provides proper screen operating conditions for a-m, linear, or cw service.

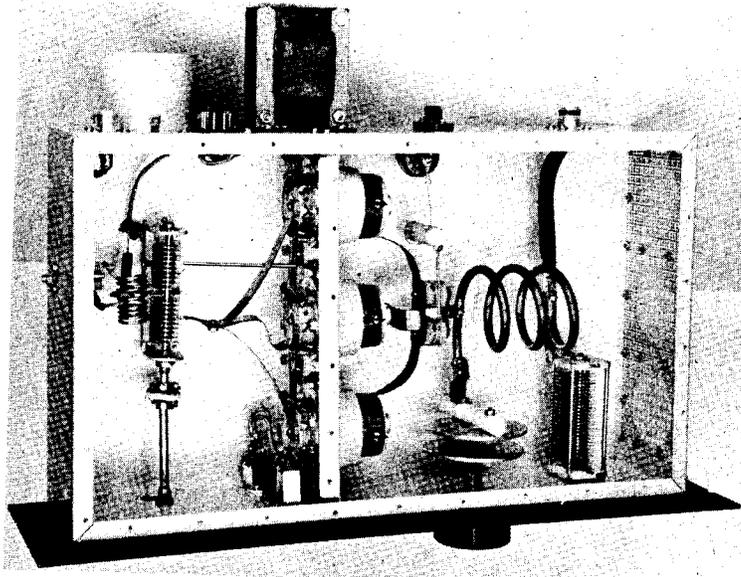


Fig. 6-40 — Interior of the 50-MHz amplifier. Note method of paralleling grid and plate connections.

The 50-MHz Amplifier

The use of three tubes in parallel in the 50-MHz amplifier was an experiment, tried with the expectation that parasitics, unbalance, excessive tank circuit heating and all manner of troubles would develop. These problems never materialized; use of paralleled tubes seemed to introduce no problems on its own, and extensive experience with the amplifier has confirmed the worth of the idea. This happy state of affairs involves a few basic considerations that should be stated here.

1) Paralleling straps in the grid and plate circuits were made "three of a kind." The two going to the outer grids were bent identically, and then the one for the middle tube was bent back on itself as necessary to use the same total length of strap. The same was done in the plate circuit.

2) The grid circuit was split-stator tuned, to get a reasonably-sized grid coil, even with the combined input capacitance of the three tubes plus circuit capacitance — some 60 pF or more. This also provided a means for easy neutralization.

3) The pi-network plate circuit is tuned with a handmade disk capacitor. This has a far lower minimum C than the more conventional tuning capacitor, and it is devoid of the side bars and multiple ground paths that are so often the cause of parasitics in vhf amplifiers. No parasitic resonances were found in this amplifier, other than one around 100 MHz introduced apparently by the rf choke. This caused a blowup when grid-plate feedback developed with a similar choke in the grid circuit. The problem was solved easily by use of a low- Q choke of different inductance in the grid circuit. Do *not* use a high-quality rf choke for RFC1!

4) All power leads except the high-voltage one are in the grid compartment, and made with

shielded wire. Where the high voltage comes into the plate compartment it is bypassed at the feed-through fitting.

5) The plate circuit is made entirely of copper strap and tubing, for highest possible Q and low resistance losses. It may be of interest that the entire tank circuit was silver-plated after the photographs were made. Efficiency measurements made carefully before and after plating showed identical results.

Looking at the interior view, Fig. 6-40, we see the grid compartment at the left. The coaxial input fitting, J1 in Fig. 6-39, is in the upper left corner of the picture. Coax runs from this, out of sight on the left wall, terminating in a loop, L1, made from its inner conductor. This is inserted between turns at the center of the grid coil, L2. The series capacitor, C1, is just visible on the left chassis wall. It is not particularly critical in adjustment, so no inconvenience results from its location away from the front panel.

Screen voltage, bias, and 115 volts ac come through an 8-pin fitting, J3, mounted between the air intake and the heater transformer, T1. On the front panel are the heater switch, S1, and the pilot-lamp holder.

The three air-system sockets (Eimac SK-600, SK-620, SK-630, Johnson 124-110-1 or 124-115-1, with chimneys) are centered on the partition, spaced so that there is about 1/4 inch between their flanges. The small angle brackets that come with the sockets should be tightened down with their inner ends bearing against the ceramic chimneys, to hold them in place. Note that the 150-ohm isolating resistors R2, R3, and R4 are connected right at the screen terminals.

Both grid and plate straps are cut from flashing copper 5/8-inch wide. Lengths are not critical, except that all grid straps should be the same length, and all plate straps identical. The plate

straps are made in two pieces soldered together in T shape, to wrap around the anode and join at the coupling capacitors, C4 and C5. These T-shaped connections could be cut from a sheet of copper in one piece, with a little planning.

The copper-tubing plate coil, L3, is mounted on stand-off insulators not visible in the picture. Connections to the coupling capacitors, the tuning capacitor, C6, and the loading capacitor, C7, are made with copper strap. It will be seen that these various pieces are bolted together, but the straps were also soldered. The connection from C7 to the output fitting, J2, is a single strap of copper, bolted and soldered to L3.

The disk tuning capacitor can be made in several ways. Flashing copper is easy to work, and the 144-MHz capacitor was made of this material. A more sturdy disk can be made from 1/8-inch aluminum. Those shown in Fig. 6-40 were 3-inch meter cutouts from an aluminum panel. Disk-type neutralizing capacitors (if you can find them; they're not common catalog items these days) provide ready-made disks and lead screw for tuning. For the latter we used 3-inch 1/4-20 brass screws from a neighborhood hardware store. A panel bushing with brass nuts soldered to it provided the lead-screw sleeve. The stationary disk is supported on 1/2-inch-diameter Teflon rod, a material also used for the rf choke form. Teflon works easily and is unexcelled for insulating applications where high temperatures are encountered. We found it reasonably priced, in various diameters, at a local plastics house.

The plate rf choke, RFC2, is important. You'll probably have to make it to get one of sufficiently good quality. For more on this see information under Fig. 6-39 and "RF Chokes for the VHF Bands," Chapter 16. Two coupling capacitors were paralleled because we've experienced trouble with exploding capacitors in pi-network plate circuits in

the past. Maybe one would have handled the job, but two do for sure.

Some Possible Variations

It is always risky to suggest variations on a design unless they have been checked out in use, as bugs may develop in unforeseen ways. The following are ideas only, to be used at the builder's risk, since they have not been tested by the designer.

You might not care for three tubes in parallel. Two should work well, handling a kilowatt except in a-m linear or plate-modulated service. Many builders report success with 2 tubes.

For those who can afford it, a vacuum variable capacitor should be ideal for C6. One with about 10 pF maximum capacitance should do nicely.

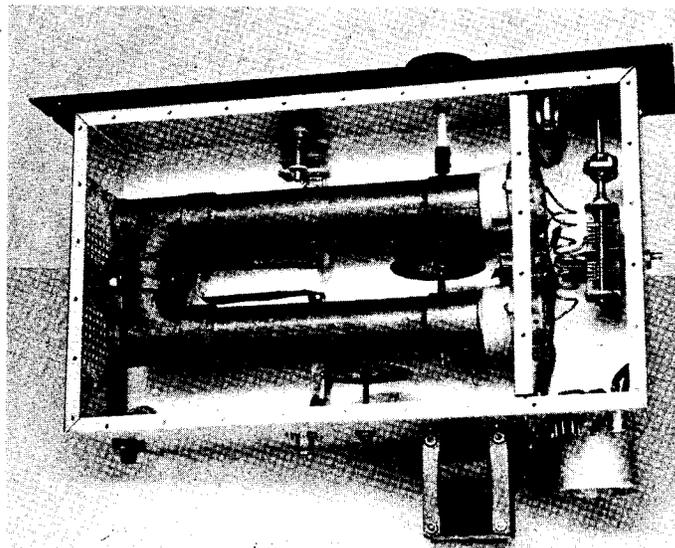
For lower tube cost, 4X150As from surplus should work without mechanical changes. Use plenty of air, if you intend to push the ratings of the 150As. A 100-cfm blower is not too much. The ability of the anode structure to withstand heat is the main difference between the 150A and later versions of this tube, and some people have gotten away with 250 ratings with 150-type tubes. In this connection, the 50-MHz amplifier will take a kilowatt at 1200 to 1500 volts, if your power supply will handle the current. This approach plus plenty of air, is preferable to using plate voltages much in excess of the 4X150A ratings.

The 144-MHz Plumber's Special

Use of 1 5/8-inch copper tubing for a 2-meter tank circuit is by no means new.* We simply went one step further and made the entire circuit from standard plumbing components. All the heavy metal you see in the plate compartment of Fig. 6-41 came from the plumbing counter of the local

* "High-Efficiency 2-Meter Kilowatt," *QST*, Feb., 1960, p. 30. "Top Efficiency at 144 Mc. with 4X250Bs," Breyfogle, *QST*, Dec., 1961, p. 44.

Fig. 6-41 — Interior of the 144-MHz amplifier, showing the plate circuit made from standard plumbing components. Brass pipe junctions make connection to the anodes, and T fittings are modified to form the short at the end of the line.



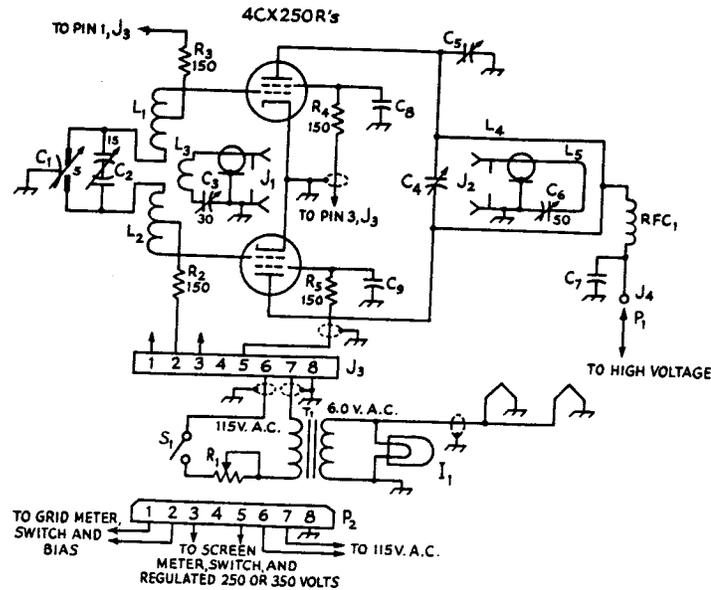


Fig. 6-42 - Schematic diagram and parts information for the 144-MHz amplifier.

- C1 - 5-pF differential trimmer (Johnson 160-303 or 6MA11).
 C2 - 15-pF per section split-stator (Hammarlund HFD-15X). Leave rotor ungrounded.
 C3 - 30-pF miniature trimmer (Hammarlund MAC-30).
 C4 - Tuning capacitor made with 3-inch disks. See text and Fig. 6-41.
 C5 - 3-inch disk movable with respect to L4. See text and Fig. 6-41.
 C6 - 50-pF variable (Hammarlund MC-50).
 C7 - 500-pF 5000-volt (Centralab 858S-500).
 C8, C9 - Bypass capacitor built into air-system socket.
 I1 - Green-jewel pilot lamp holder.
 J1, J2 - Coaxial chassis receptacle.
 J3 - 8-pin male chassis connector.
 J4 - High-voltage power connector, female (half of Millen 37501).
 L1, L2 - 3-1/2 turns No. 14, 5/8-inch dia, turns spaced 1/2-inch. R2 and R3 tap on about 1 turn in from grid end. See text.
 L3 - 1-turn inner conductor of coax from J1, about 3/4-inch dia. Remove jacket and braid about 3 inches. Adjust position with respect to L1, L2 for maximum grid current.
 L4 - Plate line 1-5/8-inch copper pipe, with junctions and T fittings. Exposed portion of pipe is 8 inches long. Cut right end of T fittings to 1/4-inch shoulder, and joined ends to 3/8-inch shoulders.
 L5 - 1/2-inch strap of flashing copper, U portion 4 inches long and 1-1/4 inch wide. Make loop and connections from single piece. Support L4 and L5 on standoffs of ceramic or Teflon.
 P1 - High-voltage connector, male (half of Millen 37501).
 P2 - 8-pin female cable connector to match J3.
 R1 - 20-ohm 10-watt slider-type. Adjust for 6.0 volts at socket.
 R2, R3, R4, R5 - 150-ohm 1/2-watt resistor.
 S1 - Spst toggle.
 T1 - 6.3 volt 8 A. Adjust R1 for 6.0 volts.
 RFC1 - 2.15 μ H rf choke. No. 22 enamel closewound 1-3/16 inch on 1/4-inch Teflon rod.

Sears store. The picture and Fig. 6-41 should be largely self-explanatory.

At the tube end of the plate line, L4 in Fig. 6-42, we have brass castings normally used to join sections of the copper pipe. They make a nice sliding fit over the tube anodes. For tighter fit, cut thin brass shim stock and insert as much as needed between the anode and the sleeve. The end of the fitting can be slotted and then clamped firm on the anode with a hose clamp, as an alternative. The short at the B-plus end of the line is made with two T fittings, with their flanges cut down to 1/2 inch and slipped over a short section of the pipe that is not visible. Joints throughout the assembly were silver-soldered with a torch, but conventional soldering should do equally well. The flanges at the

open ends of the T fittings are cut down to about 1/4-inch in length.

The last instruction and the information about the plate line given under Fig. 6-42 apply only if the fittings are identical to those obtained by the builder. Since there are several types of fittings available from plumbing supply houses, the following overall dimensions should be heeded: tube end of the plate line to center-line of short - 10 3/8 inches; spacing of pipes center to center - 3 1/2 inches.

In using tube types other than those specified, it may be that some change in plate circuit inductance will be needed. A simple check will show if this is needed. Slip the castings and pipe together without soldering, and assemble the plate

circuit temporarily. Check the tuning range by means of a grid-dip meter. No plate or heater voltage is needed for this rough check, but it is well to have the coupling loop in place, and a 50-ohm resistor connected across J2.

The coupling loop, L5, is cut from a single piece of flashing copper 1/2 inch wide. This delivered slightly more output to the load than was obtained with loops of wire of various lengths tried. The loop should be positioned so that the bottom edge is approximately flush with the bottom of the pipes. Optimum coupling to a 50-ohm load is achieved when the closed end of the "U" is about 1/4 inch lower than the open end. Looking down at the plate-line assembly, the coupling loop is centered between the pipes.

The loop and plate line are supported on Teflon rod insulators. The rf choke is also wound on Teflon. Note its position *outside* the U of the plate line. First mounted inside the loop, it went up in a furious burst of smoke when high power was applied to the amplifier.

Our tuning disks are 3-inch sheets of flashing copper. For nicer appearance and better mechanical stability, use 1/8-inch aluminum as in the 50-MHz model. Three-inch brass 1/4-20 screws are threaded through the pipe fittings. The rear one is held in place with a lock nut, and the other is rotated by the tuning knob, a bakelite shaft coupling, and a length of 1/4-inch Teflon rod running in a panel bushing.

A third disk is mounted adjacent to the rear portion of the tank circuit. Its position is adjusted to achieve perfect balance in the tank circuit, but in practice this turned out to have no measurable effect. It is felt that a really good choke at RFC1, and careful adjustment of C1, can practically eliminate the effect of any slight unbalance if the point of connection of RFC1 to the tank circuit is not bypassed to ground.

The 144-MHz grid circuit, L1L2, looks like two coils, but actually is a coiled-up half-wave line. This is somewhat more compact than a half-wave line with its conductors out straight, and it seems equally effective. The grids are connected to the outer ends and the tuning capacitor to the inner. The point of connection of the bias-feed resistors should be determined in the same way as with the usual half-wave line: by coupling in 144-MHz energy and touching a pencil lead along the inductance while watching the grid current. The correct point for final connection of the resistors is that at which no reaction on grid current is observed. Isolating resistors here, and for feeding screen voltage to the sockets, are preferable to rf chokes. The inner conductor of the coaxial line is used to make the coupling loop, L3, which is placed between the inner ends of the grid circuit.

Balanced drive is maintained by adjustment of the differential capacitor, C1, connected in parallel with C2, and mounted on the side of the chassis adjacent to it. The series capacitor, C3, is out of sight under the tuning capacitor, which is mounted on standoff insulators. It is adjusted by inserting a small screwdriver in a hole in the side of the chassis, but if we were doing it again we'd mount

C3 on the side wall, just under C1, to make it more readily adjustable. Note that the rotor of C2 is ungrounded.

About Neutralization

These amplifiers were tested without neutralization and we almost got away with it, but use of all modes, particularly a-m linear and ssb, imposes strict requirements on stability. Conventional cross-over neutralization employed in the 144-MHz amplifier is omitted from Fig. 6-42 in the interests of clarity. The schematic representation, C3 in Fig. 6-39, is not very informative either.

In the 50-MHz amplifier the lead visible in Fig. 6-40, attached to the rear stator terminal of C2, runs to a polystyrene feedthrough bushing (National TPB) mounted in the partition between the rear and middle sockets. Even this bushing's wire stub projecting into the plate compartment turned out to be too much "C3" and it was trimmed off 1/16th inch at a time, until minimum feedthrough was indicated on a wavemeter coupled to L3 and tuned to the driving frequency.

Similar feedthrough bushings are used in the 144-MHz amplifier, but here a small wire had to be added to each one. The wire connected to the grid of the front tube is aimed toward the anode of the rear tube, and vice versa. Small sheets of this brass or copper should be fastened under the adjacent edges of the sockets, and bent up at right angles to the partition. These 3/4-inch high barriers act to shield the screen rings of the tubes from the feedback "capacitors" and assure that the coupling is from grid to opposite plate, and not to the screen.* Length and position of the feedback wires are adjusted for minimum feedthrough of driver energy to the plate circuit, as described above. About a half inch of wire was needed in addition to the terminal stub in this case.

When used as linear amplifiers the tubes must be biased to permit them to draw considerable plate current with no drive, so perfect neutralization is a "must." Properly neutralized, the amplifiers will be stable when run at or near maximum safe plate dissipation with no drive, even when the grid and plate circuits are swung through their entire ranges. If they will not pass this test the amplifiers are not ready to be used for linear service.

Controls and Metering

Almost everyone who builds his own equipment has a favored way of controlling it, so the system shown schematically in Fig. 6-43 may not suit everyone. It is for use in a station where power supplies are actuated by closing the primary circuits to all that the operator wants to have come on for transmitting purposes. They are mounted away from the transmitting position, and a cable carries the various voltages to the rf position. At the left, J1, J3, J4, and J5 are terminals carrying all voltages from the power-supply position. These are distributed through meters, controls and output fittings, J6, J7, and J8, to various transmitters.

* Air-system sockets are now available with built-in shielding of the screen ring. The Eimac numbers are SK-620 and 630.

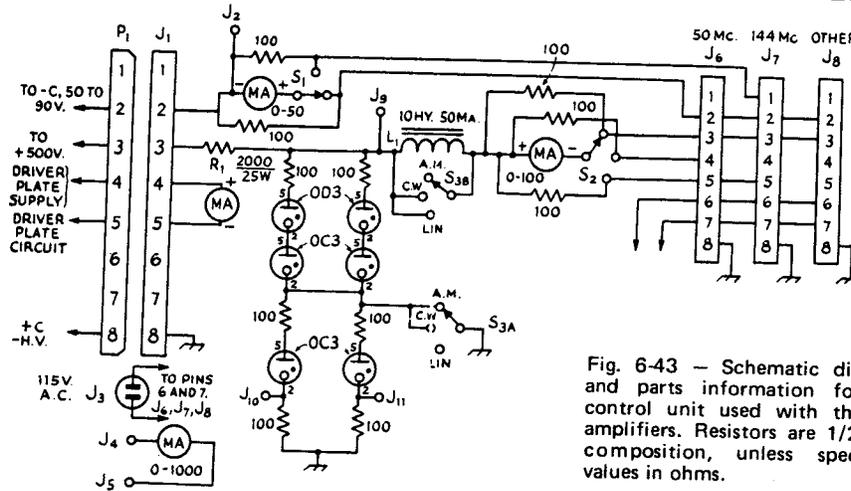


Fig. 6-43 — Schematic diagram and parts information for the control unit used with the vhf amplifiers. Resistors are 1/2-watt composition, unless specified; values in ohms.

- J1 — 8-pin male power connector.
 J2, J9, J10, J11 — Tip jack.
 J3 — Ac connector, male.
 J4, J5 — High-voltage feedthrough connector (Millen 37501).
 J6, J7, J8 — 8-pin female power connector.
 L1 — 10-H 50-mA choke. Must be shorted out for other than plate-modulated service.
 P1 — 8-pin female cable plug.

- R1 — 2000-ohm 25-watt resistor. Value may be reduced to as low as 1000 ohms if regulation at high values of screen current is desired, provided current measured in J10 and J11 does not exceed 40 mA under low-screen-current conditions.

- S1 — Single-pole 2-position switch.
 S2 — Single-pole 3-position switch.
 S3 — Double-pole 3-position switch.

Circuit breakers at the supply position are used to turn everything off when the station is closed down.

Adjustable bias, 50 to 90 volts negative, is brought in through Pin 2 to a 50-mA meter and appropriate shunts that keep the circuit that is not being metered closed. The switch S1 enables the operator to read the grid currents separately in the 144-MHz amplifier. Grid voltage may be read when required, at J2.

Similarly, a 500-volt positive source is connected through Pin 3, a voltage-regulating system, an audio choke, a 100-mA meter and a 3-position switch, to the screens. Currents can be read separately here, too, and this facility is important in determining that all tubes are running within ratings. The VR system is switched by S3A to provide regulated 250 or 350 volts to the screens. Ganged to it is S3B, which shorts the audio choke for all modes except plate-modulated a-m. This must be done, as the choke will cause trouble on the other modes. The series-parallel VR-tube bank is by no means an ideal regulating system, but it prevents soaring of the screen voltage under conditions of low or negative screen current. These occur only in linear operation, and on cw when the key is up. It is not particularly important that screen voltage be held constant for high screen current, as in plate-modulated a-m and key-down cw conditions with low plate voltage. The screen voltage will be kept down by the heavy load on the supply at such times. Actually a single string of three regulator tubes will do the job quite well, and both amplifiers have been worked successfully with this simpler screen arrangement. Current through

the regulator tube strings can be measured between J10 or J11 and ground.

Operation

Because a variety of tubes may be used, with a wide range of conditions as to plate voltage and drive, we're not going to be too specific here. If you follow the tube manufacturer's recommendations for the plate voltage you intend to use you won't be far wrong. All tubes of this class are quite versatile as to drive level and plate voltage; unless you are running close the maximum plate-input ratings the principal factor to watch is screen dissipation, as far as safety of the tubes is concerned. Set up your amplifier with a dummy load and then try the various conditions given in tube data sheets, observing the operation on all meters. In this way you'll soon learn your way around. A few words of preliminary advice may, however, be in order.

First, don't feel that you have to run a kilowatt right off the bat. Put a Variac in your final plate supply primary and run the voltage down for initial testing, or use a lower-voltage supply until you become familiar with the way the rig works. Watch the screen current closely, particularly at low plate voltage or with high grid drive or light loading. The provisions for checking individual screen currents is important, otherwise you may learn too late that one tube has been taking all or most of what you have seen on a meter that reads total screen current only. In the push-pull amplifier it may be advantageous to balance screen currents by C1, rather than grid currents, if balance of both screen and grid currents does not occur at one setting.

Tips on A-M Linear Amplifiers

Tune up for Class C and get the feel of the amplifiers before trying linear operation. Then, if linears are unfamiliar to you, read up on them below, and in chapter 5 before jumping in. Use a scope; there is no sure way to set up and operate a linear without one. The Heath Monitor Scope, HO-10 or SB610, is ideal for this job because of its built-in tone oscillator and in-the-transmission-line features. Running a linear, either sideband or a-m, without a scope check is inviting trouble.

Finally, is you must use an a-m linear, don't expect 70 percent efficiency from it. Don't expect 50. Expect and see that you *get*, no more than 35 percent from a Class AB1 linear, or no more than about half the rated plate dissipation for the tubes used. This means 350 watts out of our 50-MHz amplifier with a kilowatt in, even though you can

get 750 watts out of it in Class C. For the 144-MHz amplifier, 200 watts out with 700 in is about the safe maximum for a-m linear service. These are optimum figures; you may get less, but you can't get more and be *linear*.

For higher plate efficiencies go to ssb, cw, or plate-modulated a-m. In any of these modes these amplifiers will give you the biggest legal signal around, if that's what you want. Or they'll throttle down nicely to 300 watts input or less, merely by lowering the plate voltage. They'll work efficiently at much lower inputs if the screen voltage is dropped appropriately. Chances are that you'll still have a signal that will stand out in most neighborhoods, on either 6 or 2, and you'll have no worries about over heating.

TIPS ON A-M LINEAR AMPLIFIERS

It is no small wonder that the a-m linear amplifier appears attractive to the neophyte looking for his first step up the vhf power ladder. At first glance it seems almost too good to be true. A Class AB1 linear, the type most often used, requires *no driving power at all*. Class AB1 is operation without the amplifier drawing grid current at any time. With the amplifier consuming no power from the driver stage, only a mere handful of exciter is needed. You could use a one-watt transistor rig, and have output to spare.

This applies whether the amplifier runs 100 watts input or 1000, so it can be seen that the linear is most attractive in the high-power bracket. The inevitable price to be paid is low efficiency. Thus, there is hardly any point in building a linear for less than about 200 to 300 watts input; you won't get enough step-up in power to make the project worthwhile. And since any amplifier is a fairly expensive undertaking, it may be well to build it for kilowatt capability, even if you don't expect to push it that far right away. The amplifiers of Fig. 6-38 through 6-43 can be run as low as about 300 watts input if you wish. At this level they deliver about 100 watts to the antenna — no mean signal on a vhf band. There is plenty in reserve when you need it, and the final tubes hardly know they're working.

As its name implies, a linear amplifier is one which reproduces the wave form of its driver stage exactly, but at higher power level. This requires considerable attention to details. Everything has to be *right*, or the signal quality suffers, and it will occupy far more space in the band than a signal should. Grid bias, drive level and antenna loading are all critical. Regular use of an oscilloscope is a must. Meters alone are not enough, if you want to be sure that your signal is above reproach.

About Driver Stages

Obviously the driver stage is important in the linear picture. If we are going to amplify it in exactly its original form, the signal had better be good to start with. A distorted splattering signal

fed to a linear results in more of the same; lots more! The exciter should be stable and its output stage as perfectly modulated as we can make it. Since the driver operates at very low level, this is not hard to do. If an exciter is being built especially to drive a linear, it might be well to go with a neutralized-triode output stage, with no more than about 5 watts input. A Class-A modulator employing inverse feedback and some form of output limiting would be good. Peak limiting is important, to keep the average modulation percentage high and prevent overmodulation.

Most vhf transmitters will have a lot more output than is needed, so the drive applied to the amplifier must be reduced in some way. Detuning the driver output circuit or the amplifier grid circuit will not do, as it may leave the driver without a proper load, and impair its modulation quality. A simple solution is to connect a 50-ohm dummy load parallel with the driver output. A coaxial T fitting is connected to the driver output receptacle. The dummy load is connected to one side of the T, and the amplifier grid input to the other. The amplifier grid circuit still may have to be detuned slightly, if the exciter output is more than 2 or 3 watts, but this will not be harmful for only a small reduction in drive. Driver output may also be reduced by lowering its plate or plate-and-screen voltage, though it is well to check the quality to be sure that linear modulation characteristics are being obtained in the driver.

Checking Signal Quality

The Heath Monitor Scope, Model HO-10 or SB610, is ideal for use with a vhf linear, as it may be left connected to the transmission line for continuous monitoring. Some modification may be necessary for effective use of this scope on 144 MHz, though it works nicely on 50 MHz and lower bands as is. Two coaxial receptacles of the SO-239 type are mounted on the back of the scope, with their inner terminals joined by a wire about 1 1/2 inches long. The transmitter is connected to one receptacle and the antenna coax to the other. The