HAM TIPS

A PUBLICATION OF THE RCA ELECTRON TUBE DIVISION

VOL. 19, NO. 3

© 1959, RADIO CORPORATION OF AMERICA
AUGUST, 1959

FOR SSB SERVICE:

Cathode-Driven Linear Amplifier Using RCA-7094 Beam Power Tube

By Claude E. Doner, W3FAL

RCA Electron Tube Division, Lancaster, Pa.

This article features an extremely stable, five-band, cathode-driven linear amplifier for single-sideband service. Employing a single RCA-7094 beam power tube, the amplifier provides bandswitched operation on 80-, 40-, 20-, 15-, and 10-meter bands and is easily constructed and adjusted. Under the conditions described by W3FAL, it delivers a peak envelope power of approximately 200 watts.

The high power gain, high efficiency, and low distortion necessary in a linear amplifier for single-sideband service can be provided most economically by a high-mu triode in a cathode-drive circuit. Because of its low input impedance, a cathode-driven amplifier does not require a tuned input circuit. And, because of the plate-cathode shielding provided by the grid, it usually does not require neutralization. Its low input impedance also makes it unnecessary to use "swamping" resistors to provide the constant driver loading required for good linearity. Although a cathode-driven amplifier requires more driving power than a grid-driven amplifier, most of the driving power appears as useful power in the output circuit, so that high overall efficiencies can be achieved. Additional economies can be achieved by the use of a triode which can be operated as a zero-bias class B amplifier.

Beam power tubes or tetrodes which can be operated as high-mu triodes make excellent linear amplifiers. They are especially useful in cathode-drive circuits, because of the excellent shielding provided by the two grids.

The RCA-7094 beam power tube has extremely good triode characteristics. It is particularly useful in cathode-drive service (1) because of its low plate-cathode capacitance and high perveance and (2) because it has an indirectly heated cathode and, therefore, does not require the use of filament chokes. As a class B linear amplifier in single-sideband service, a triode-connected 7094 with forced-air cooling can handle a peak-envelope-power input of 350 watts with only 1750 volts on the plate and zero bias on grids No. 1 and No. 2.

The circuit of the amplifier and power supply is shown in Figure 1. For illustrations of the layout and mechanical construction, see the photographs on pages 1, 3, and 4.

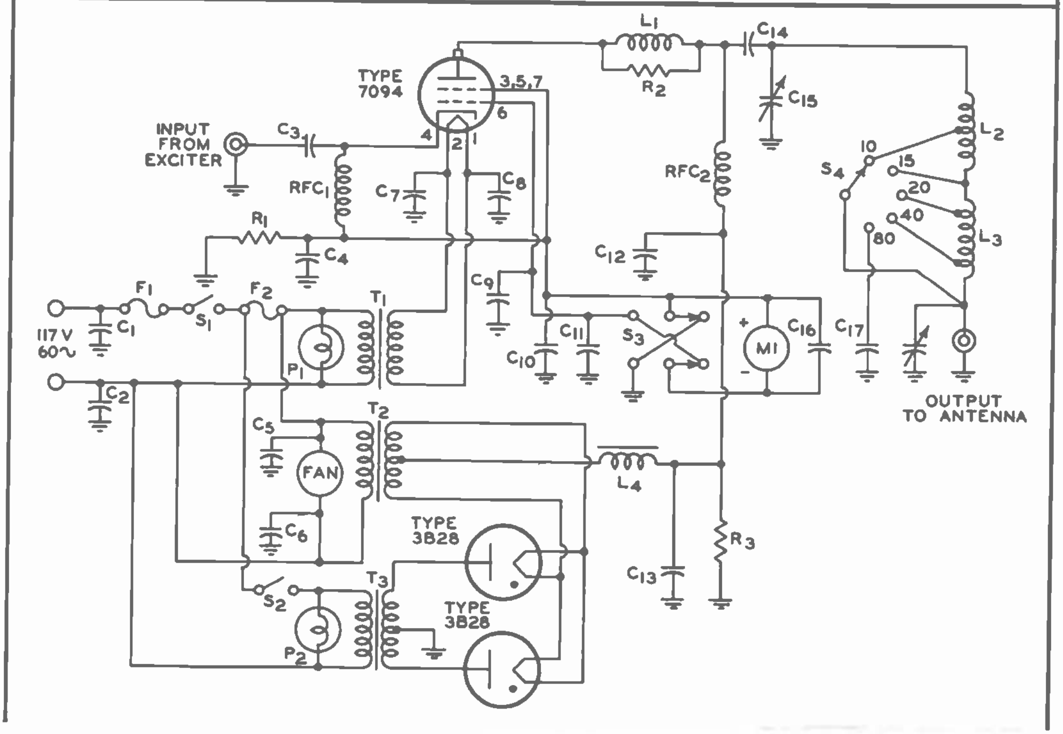
Note that although grids No. 1 and No. 2 of the 7094 are connected in parallel for rf through C_4, C_9, C_{10}, and C_{11}, the dc return for the input circuit is connected to grid No. 2. The grids are not connected in parallel for dc except when the meter switch (S_3) is in the plate-current position. This arrangement permits a single milliammeter connected in the ground side of the circuit to be used to measure either grid current or plate current without the hazard involved in switching the meter in and out of the high-voltage lead. It also minimizes the possibility of improper adjustments which would exist if the meter were used to measure only total cathode current.

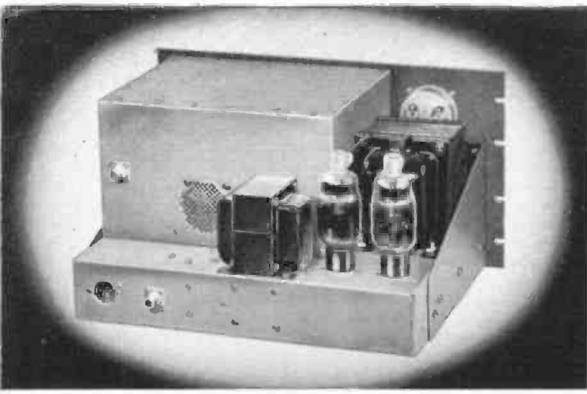
A pi-network type, the output tank uses two tapped coils and a shorting-type bandswitching arrangement. L_2, the coil for the 10- and 15-meter bands, is wound of 3/16-inch copper tubing and has 9 turns spaced 1/4 inch apart and an inside diameter of two inches. L_3, the loading inductance for the 20-, 40-, and 80-meter bands, consists of 23 turns of B & W type 3095-1 coil stock.

The positions of the taps were chosen to provide an operating Q of approximately 12 on all bands for a 50-ohm load. The 10-meter tap is approximately four turns from the tube end of L_2 and should be adjusted so that the plate-tuning capacitor (C_{15}) is almost fully open when the circuit is resonant at the high-frequency end of the 10-meter band. The 15-meter tap is connected to the junction between the two coils. The 20- and 40-meter taps are

Figure 1: Schematic diagram and parts list of W3FAL's linear amplifier and power supply.

C_1, C_2, C_3, C_4, C_7, C_8, C_9, C_{16}—0.01 μf, 600 v, disc ceramic
C_5, C_6, C_{10}, C_{11}—1000 μμf, 500 v, ceramic feedthrough
C_{12}—.0047 μf, 3000 v, disc ceramic
C_{13}—8 μf, 2000 v, oil filled
C_{14}—1000 μμf, 5000 v, ceramic standoff
C_{15}—11 to 100 μμf, variable (E. F. Johnson 100E30 or equiv.)
C_{17}—500 μμf, 5000 v, ceramic standoff
C_{18}—19 to 488 μμf, variable (E. F. Johnson 500E20 or equiv.)
F_1—5 amp fuse, 3AG type
F_2—1 amp "slo blo" fuse, 3AG type
L_1—1 turn, ½" ID (see text)
L_2—9 turns, 2" ID (see text)
L_3—23 turns from a Barker & Williamson 3905-1 coil or equiv.
L_4—8 henry, 250 ma filter choke (Thordarson 20C56 or equiv.)
M_1—0 to 300 ma meter (Triplett 327-PL or equiv.)
P_1, P_2—115 v pilot lamp assemblies
RFC_1—2.5 mh, 300 ma (National R300U or equiv.)
RFC_2—.225 mh, 800 ma (National R175A or equiv.)
R_1—1000 ohms, 2 watts, carbon
R_2—(3) 100 ohms, 2 watts, carbon (see text)
R_3—(2) 100,000 ohms, 50 watts, wire wound (connected in parallel)
S_1, S_2—SPST toggle switch
S_3—DPDT toggle switch
S_4—5 tap rotary switch, ceramic (Ohmite 111 or equiv.)
T_1—6.3 v, 4 amp filament transformer (Stancor P4019 or equiv.)
T_2—2.5 v, 10 amp filament transformer (Thordarson 21F02 or equiv.)
T_3—2065-0-2065 v ac, 1750 v dc at 200 ma plate transformer (Stancor PT8315 or equiv.)
Fan—small tube cooling motor and fan, 115 v ac





Rear view of the cathode-driven linear amplifier shows the rf enclosure and power supply components.

19 and 10 turns, respectively, from the output end of L_3. In the 80-meter position of the bandswitch, a 500-$\mu\mu$f fixed capacitor (C_{17}) is connected in parallel with the loading capacitor (C_{18}).

The meter is a single-scale, 0-300-milliampere type. A lower range meter and external shunt were not considered necessary because the normal grid current (80 milliamperes) and plate current (200 milliamperes) can easily be read on the same scale. The 1000-ohm resistor (R_1), connected between the positive side of the meter and ground, prevents high voltage from appearing at the cathode in the event of switch failure.

The power supply is a conventional full-wave type with choke-input filter. Type 3B28 gas rectifier tubes were used instead of 866-A's to eliminate the "hash" produced by the mercury-vapor types and to permit the amplifier to be operated on its side during tests and initial measurements. However, if you prefer, 866-A's may be used in place of the 3B28's without any changes in circuit values—provided the amplifier is always kept in a position such that the tubes are vertical.

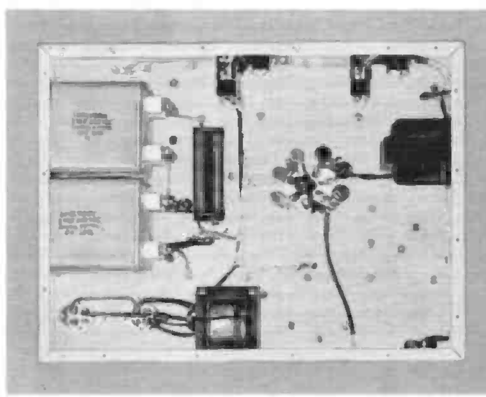
The plate-power switch (S_2) is connected in series with the heater/filament-power switch (S_1) in such a manner that power cannot be applied to the rectifier plates until the filaments of the 3B28's and the heater of the 7094 have been energized. If 866-A mercury-vapor rectifiers are used, it will be necessary to delay application of plate power for at least 30 seconds after filament power has been turned on.

Construction

Because of the simplicity of the circuit, it was possible to construct the amplifier and power supply on a 12- by 17- by 3-inch chassis and a 10½- by 19-inch rack panel. The chassis is bolted directly to the panel and reinforced with 6½- by 11-inch chassis mounting brackets. The 7094 and plate-tank components are enclosed in a 7- by 12- by 9½-inch shield made of 18-gauge sheet aluminum. The front of this shield is mounted flush against the rack panel, and both are drilled for the shafts of the plate-tuning and loading capacitors and the bandswitch. Half-inch-wide flanges on the top and bottom of the shield provide good rf contact to the chassis and the perforated aluminum cover plate.

The small fan mounted on the back wall of the enclosure provides forced-air cooling for the 7094. Serving as the air inlet is a circular area of closely-spaced ⅛-inch holes, 3 inches in diameter. The holes are drilled in the wall behind the fan.

To minimize rf losses, all connections between the plate-tank circuit components, the bandswitch, and the 7094 are made of ¼-inch-wide copper strap. A 4-inch length of RG/8U coaxial cable is used for the connection between the loading capacitor and the output coaxial connector.



Looking at the underside of the amplifier chassis.

The parasitic suppressor in the plate lead (L_1) is a single turn of ⅜-inch-wide copper strap, ½ inch in diameter, shunted by three 100-ohm, 2-watt composition resistors connected in parallel.

The bypass capacitors for the meter (C_{10}, C_{11}, and C_{16}) and fan (C_5 and C_6) are feed-through types. They are installed at the points where the leads to these components pass through the chassis.

Because a single 8-μf capacitor (C_{13}) small enough to fit underneath the chassis was not available, four 2-μf capacitors were used (see the photograph of the chassis underside).

Tuning and Operating Adjustments

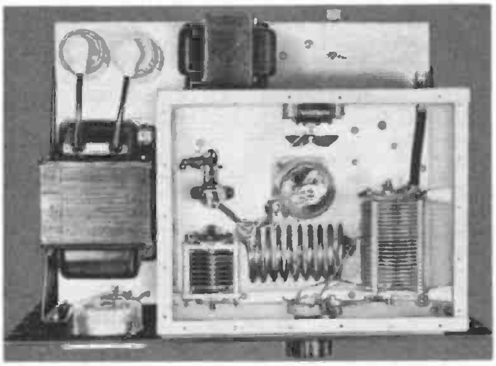
The amplifier requires a single-sideband exciter that can deliver a peak envelope power of approximately 15 watts. To tune the amplifier, connect it to the exciter and to a 50-ohm antenna-feed line or 200-watt, 50-ohm dummy load. Mesh the plates of the loading capacitor (C_{18}) to unload the tube, throw the meter switch to the "PLATE CURRENT" position, and then apply heater and plate voltage to the 7094. With no excitation applied, the plate current should be 35 to 40 milliamperes.

Switch the meter to read grid current, apply a single-tone modulating signal to the exciter, and quickly adjust the drive to the amplifier until the grid current of the 7094 is approximately 50 milliamperes. Then immediately switch the meter to read plate current and tune the plate tank for minimum current.

Reduce the loading capacitance, keeping the plate tank tuned, until the plate current is approximately 100 milliamperes. Increase the drive to obtain 80 milliamperes of grid current.

Adjust the loading and plate-tank tuning to obtain a resonant plate current of 200 milliamperes, keeping the grid current at 80 milliamperes.

When supplied with 15 watts of driving power and adjusted as described above, the amplifier delivers a peak envelope power of approximately 200 watts to the antenna. Third-order distortion products under these conditions are 35 db below the two-tone signal level. An exciter delivering less than 15 watts P.E.P. may be used, provided the loading for the 7094 is reduced sufficiently to maintain a 2.5-to-1 ratio between plate current and grid current.



Here is a top view of the linear amplifier, with the rf enclosure cover removed.

Information furnished by the Radio Corporation of America is believed to be accurate and reliable. However, no responsibility is assumed by RCA for its use; nor for any infringements of patents or other rights of third parties which may result from its use. No license is granted by implication or otherwise under any patent or patent rights of RCA.

From your local RCA distributor, headquarters for RCA receiving and power tubes.

RCA HAM TIPS is published by the RCA Electron Tube Division, Harrison, N. J. It is available free of charge from RCA distributors.

Harvey Slovik, Editor

DISTRIBUTED BY
CAMERADIO CO.
1121 PENN AVE.
PITTSBURGH 22, PA.

WHEN MAILING
PLACE POSTAGE HERE

FORM 3547 REQUESTED