Low-Cost 770W Linear Amplifier With 572Bs in Grounded Grid

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Availability:

A Low-Cost 700-Watt Linear Amplifier

572Bs in Grounded Grid

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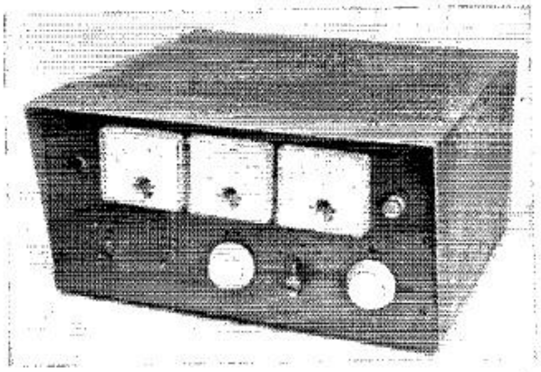


The enclosure around the completed amplifier is made from perforated aluminum stock and reinforced at the top with aluminum angle material. Across the bottom from the left are the a.c. and standby switches, plate tuning, band switch, and loading control. The knob at the upper right corner is the sensitivity control for the output meter.

In this day of low-priced kits it gets to be a real challenge to design a piece of gear for the home builder that will be attractive from a cost standpoint. This article describes a linear amplifier that meets this requirement. In fact, it does so by quite an appreciable margin when compared to any wired or kit amplifier with comparable power.

The amplifier shown in the photographs and Fig. 1 is capable of about 700 watts p.e.p. input on sideband or a like amount of power on c.w. What will probably come as a shock to the reader is the power supply (figuratively speaking!). Whenever high power is contemplated the usual stumbling block in cost is the power supply, particularly the power transformer. This power supply gets around that problem by using a power transformer that usually can be obtained for nothing. We say "nothing" because, after writing earlier articles describing equipment using this type of transformer, we know this is the general rule.

In the 1956 to 1959 era millions of TV sets were produced, and most of them used extremely husky power transformers. These sets have been reaching the obsolete stage, and they usually can be had for the asking from TV shops. Most of the transformers in these sets have high-voltage windings of about 700 volts, center-tapped, with current ratings of 300 to 400 ma. These transformers are built for continuous duty so they are real husky units, and in amateur service, which can be considered intermittent use, they will furnish high power. Such a transformer is used in this amplifier and provides an *easy* 700 watts input! (Rather than get into a long discussion about how much power can be taken from a given transformer, it is recommended that you read an article by W1DF that first introduced the "Economy Power Supply."[1])

In addition to keeping the power-transformer cost down, a careful check of the surplus market turned up several other items of standard values that were or could be used in the amplifier. More about this in a moment.

The Circuit

The amplifier uses a pair of 572Bs in grounded-grid operation. Drive is coupled to the filaments via C_1 and the filaments are isolated from ground by RFC_1, a homemade choke. One problem in using a TV transformer is that the 6.3-volt winding rarely is center-tapped. An artificial center tap is created by using R_1 and R_2 across the filament winding. S_1, between the junction of R_1R_2 and ground, can then be used as a standby switch. A pair of terminals, E_1 and E_2, are connected in parallel with S_1, and if desired, the standby function can be controlled by an external relay such as is provided in the VOX circuits of most exciters.

The grids of V_1 and V_2 are bypassed to ground for r.f., and the grid current is measured by M_1. The tank circuit is a pi network designed to cover 80 through 10 meters and designed to work into 50-ohm loads. A very necessary item in a grounded-grid amplifier is an output indicator. M_2 is connected into an r.f. voltmeter circuit and serves as an output indicator. The plate current is measured by M_3 which is connected in the negative side of the high-voltage line.

The power supply is a voltage doubler that provides a no-load voltage of about 2100 volts. This drops to about 1900 volts under a load of 400 ma. Power-supply filtering is taken care of

[1] Grammer, "More Effective Use of Small Power Transformers," *QST*, Nov. 1952.

If you're good at smoking out useful parts in the surplus outlets, you can build this 700-watt grounded-grid amplifier for well under $100 — and that's hard to beat in the present market!

* Technical Staff.

by a series string of high-capacitance electrolytics. Six 325-µf. 400-volt capacitors provide approximately 50 µf. at 2400 volts. This large amount of output capacitance provides excellent dynamic regulation.

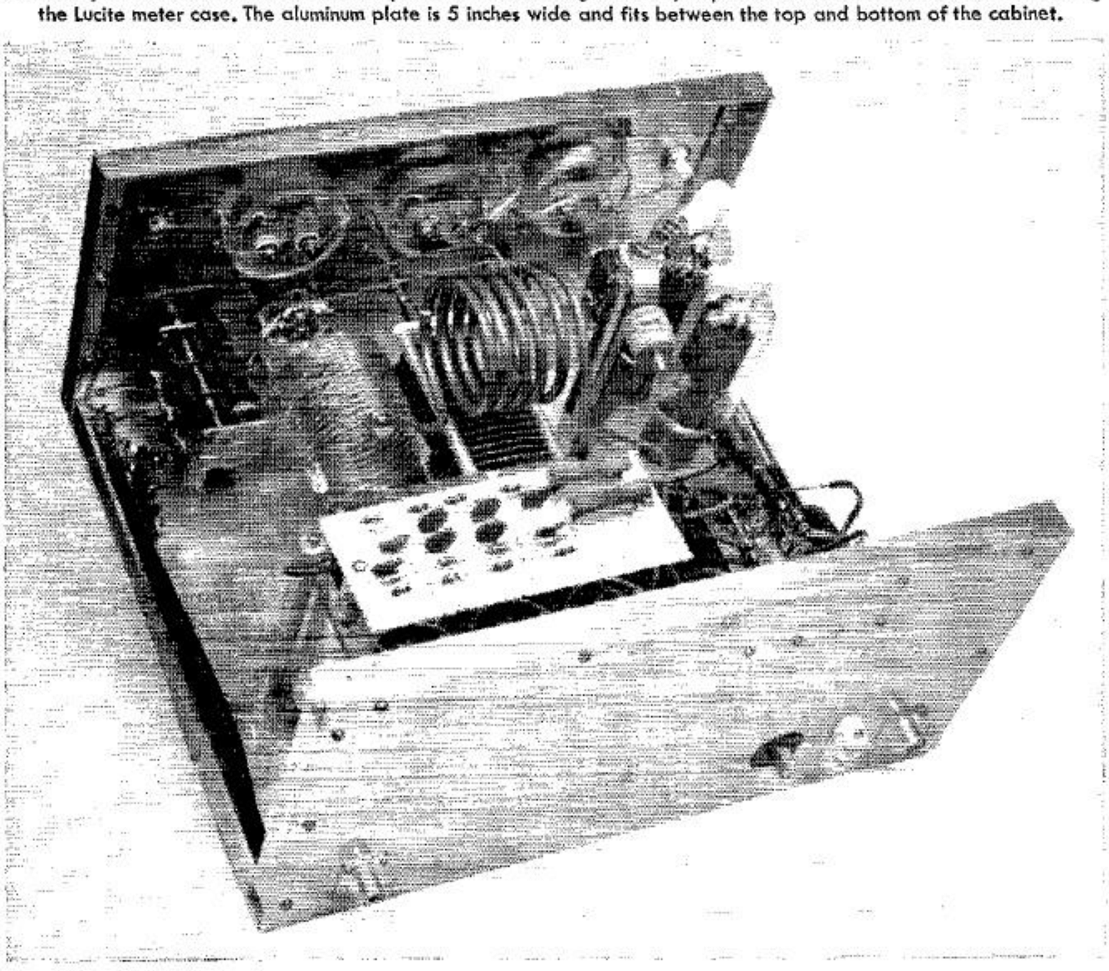
Getting the Parts

The power transformer used in this amplifier came from a 1951 17-inch RCA set. In searching through replacement catalogs it was found that nearly all makes of early sets had power transformers similar to this one. What you want to look for is one that will give 700 to 750 a.c. volts from the high-voltage secondary. Most 17-inch or larger TV sets used transformers having 300-ma.-plus ratings. Alternatively, if you are in an area where surplus stores are handy it is possible to pick up suitable power transformers quite reasonably (see Fig. 1, T_1). Look for transformers in the 700- to 800-volt range, with current ratings of 300 ma. or more. The maximum safe voltage with the rectifier-filter circuit given in Fig. 1 would be 800 volts. In a voltage-doubler circuit you can figure your no-load d.c. output voltage at 2.8 times the total a.c. secondary voltage, and 800 volts a.c. would give you about 2400 volts no-load d.c. output. This approaches the maximum rating on the electrolytic capacitor string.

While a particular type of plate tuning capacitor, C_4, was specified in Fig. 1, it is possible to substitute any similar capacitor as long as the maximum capacitance is 150 pf. and the plate spacing is at least 0.075 inch. Likewise, C_5, the output loading capacitor, is approximately 1200 pf. maximum, made up by connecting the three stators of a t.r.f.-type capacitor in parallel. Some surplus stores occasionally have high-capacitance variables on sale, and any value over 1200 pf. is suitable.

The chassis and enclosure in our unit are home-built from angle, sheet and perforated aluminum stock. Heavy-duty sheet material can be found in sheet-metal shops and the perforated and angle stock in almost any large hardware store. The layout of the amplifier is not particularly critical, so any cabinet large enough to house the unit could be used. Good buys in cabinets

This view shows the component arrangement toward the front of the chassis. At the far left, between the loading capacitor and the coax output lead, are the components for the r.f. voltmeter circuit, mounted on a terminal strip. The large copper-tubing tank-coil section is supported by its own leads. Not shown in this photograph is an aluminum baffle plate that is normally mounted between the front amplifier tube and the grid meter, to prevent heat from the tube from distorting the Lucite meter case. The aluminum plate is 5 inches wide and fits between the top and bottom of the cabinet.



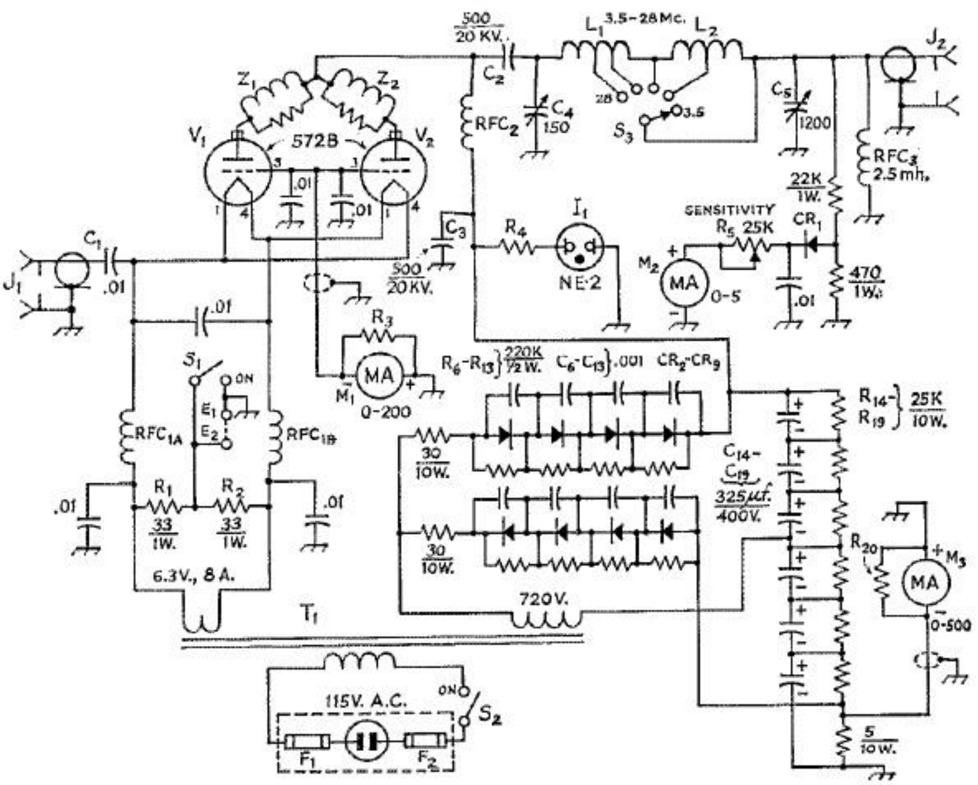


Fig. 1—Circuit diagram of the 572B amplifier. Resistances are in ohms; K = 1000. All 0.01 µf. capacitors not listed below are disk ceramic.

C_1, C_6–C_{13}—0.01-µf. disk ceramic.
C_2, C_3—500-pf. 20-kv. TV-type high-voltage.
C_4—150-pf. variable, minimum 0.070-inch spacing (E. F. Johnson 154-8, Millen 12515).
C_5—1200-pf. variable, t.r.f.-type, 3-gang, 400-pf.-per-section, stators connected in parallel.
C_{14}–C_{19}, inc.—325-µf. 400-volt electrolytic (Mallory CG3250T400D1).
CR_1—1N34A germanium diode.
CR_2–CR_9, inc.—600-volt p.i.v., 750-ma. silicon rectifier (Barry Electronics 600/750).
F_1, F_2—10-amp. fuse, fuse-in-plug assembly.
I_1—NE-2 panel mount neon lamp.
J_1, J_2—Coax fitting, SO-239.
L_1—6 turns ¼-inch diam. copper tubing, 3-inch dia. turns spaced ¼-inch apart, 20-meter tap, junction of L_1 and L_2; 15-meter tap, 3¼ turns from junction of L_1 and L_2; 10-meter tap 4¼ turns from junction of L_1 and L_2.
L_2—See text; 40-meter tap 7 turns from C_5 end of coil.
M_1, M_3—0–50 ma. (Barry Electronics Model 350P).
M_2—0–5 milliammeter (Barry Electronics Model 350P modified as per text).
R_1, R_2—33 ohms, 1 watt.
R_3, R_{20}—Meter shunts; see text.
R_4—1.88 megohms (four 0.47-megohm 1-watt resistors in series).
R_5—25,000-ohm control.
R_6–R_{13} inc.—0.22 megohm, ½ watt.
R_{14}–R_{19}, inc.—25,000 ohms, 10 watts.
RFC_1—28 bifilar turns No. 12 Formvar or Nylclad close-wound on ½-inch diam., 7½-inch long ferrite rod (Lafayette Radio 32R6103, formerly MS-333).
RFC_2—90 µh. 500-ma. r.f. choke (B & W 800).
RFC_3—2.5-mh. r.f. choke.
S_1, S_2—Single pole, single-throw toggle.
S_3—Single-pole, 6-pos. ceramic rotary (Centralab 2501).
T_1—Power transformer; see text (Barry Electronics 970960-1-1).
Z_1, Z_2—Parasitic suppressor; 3 turns No. 16, ½-inch diam., ½-inch long, wound over three 150-ohm 1-watt resistors in parallel.

can occasionally be found in surplus and radio stores. In other words, it pays to shop around to keep the construction costs down.

Also, 811As could be used in place of the 572Bs. 811As are cheaper, but you cannot run as much input as with 572Bs. Maximum input for a pair of 811As is approximately 500 watts. Both types of tubes take the same socket connections but other changes are needed to run 811As. Maximum plate voltage should not exceed 1500 volts with the tubes fully loaded to about 300 ma.

When 811As are run at their maximum plate voltage, 4.5 volts of negative grid bias is required. This could easily be obtained from three 1.5-volt flashlight cells connected in series. The plate voltage supply would require a different transformer. In a voltage doubler, the maximum secondary voltage of the transformer should not exceed 600 volts, which will provide about 1750 volts d.c. unloaded, dropping to about 1500 volts with the 811As fully loaded. The capacitor rectifier string would be cheaper because not as many components would be needed for the lower voltage. Only four of the high-capacitance units would be required. Mallory lists a 180-µf. 450-volt capacitor (CG181T450K1) for $2.50. Four of these would provide 45 µf. at 1800 volts, which would be ample. The silicon rectifiers are rated at 600 volts p.i.v. so only six would be required.

A cost breakdown on the amplifier, excluding the metal work, resulted in a figure of about $75.00 for the 572Bs and about $50.00 for the 811As. This includes the three panel meters at $5.50 each. An additional saving could be effected here by using a single meter, switching it to read currents in the various stages. The 572Bs can be obtained for about $10.00 each[2] and the 811As for $3.85. The other expensive item is the bank of capacitors. The units specified in Fig. 1 sell for $3.00 each. From time to time, similar capacitors show up on the surplus market. The remaining components are standard catalog items.

Construction Details

To make the cabinet, a sheet of aluminum, 31 by 16 inches, was bent into the form of a U, the front and back being 8½ inches high. The U was stiffened by using 1 × 1-inch aluminum angle stock completely around the inside edge of the cabinet. The overhang effect is achieved by another U-shaped piece of aluminum formed around the front panel. This piece of aluminum also helps to hold down the wrap-around perforated aluminum. The inside and outside photographs show these details.

The amplifier tube sockets and RFC_2 are mounted on a 4 × 4-inch platform, 1¼ inches high. Check the height of the platform with the tubes in the sockets to make sure you have enough clearance between the tops of the tubes and the cabinet.

There are probably several ways that T_1 can be mounted. We made up a U-shaped clamp that fitted over the core, and the transformer was clamped to the bottom of the cabinet. Electrolytic capacitors of the type specified in Fig. 1 come with screw terminals. A piece of ¼-inch thick Lucite sheet, 7¼ by 4½ inches, was drilled to take the screw terminals of the capacitors and the assembly was then supported by corner pillars above the chassis base. Keep in mind that while there is only about 400 volts across each capacitor, there is about 2000 volts between the top of the string and chassis ground.

[2] Scientific Instrument Research and Development Co., 525 Lehigh Ave., Union, N. J.

The silicon diode rectifiers and their associated components are mounted on a strip of perforated phenolic board. If this is hard to find, it is possible to use Lucite or poly sheet stock. The strip measures 2 by 7 inches and it is mounted directly above the capacitor string.

While any meters of appropriate values can be used, we used the 0-50-ma. units (surplus) specified in Fig. 1. If you should use these meters, they will need to be shunted to get the appropriate ranges. M_1 should have a full scale of 200 ma., or a multiplying factor of 4. The shunt is made from 40 inches of No. 32 enamel-covered wire wound on a 1000-ohm 1-watt resistor. The resistor is used only as a form so any value over 1000 ohms can be used. The plate meter, full scale, is 500 ma., or a multiplying factor of 10. Seventeen inches of No. 32 enamel wire will make the proper value shunt.[3]

Upon close examination of this type of meter, an internal shunt across the terminals can be seen through the Lucite case. By applying the tip of a hot soldering iron near the negative terminal we made a hole large enough to reach one end of the shunt and cut it. Upon checking after the shunt was removed, it was found that the meter movement is basically 0–5 ma., which is sensitive enough for use as the output indicator, M_2.

We used modified Air Dux 2008B5 Pi Dux assembly for L_2. The coil was modified by removing all but 8 of the close-spaced turns and all but 8 of the wide-spaced turns. For 20, 15 and 10, a huskier coil is required. The 6 turns are spaced over a 3-inch length and the coil is 3 inches in diameter. In the case of L_2, there are some ceramic surplus forms, 3 inches in diameter, that can occasionally be found in surplus (the BC-375 transmitter used them). If you can find such a form, or a suitable substitute, you can make your own L_2 coil. The inductance of L_2 is 11 μh. and you can get this inductance by winding 16 turns of No. 14 solid wire at a pitch 4 turns per inch, the coil being 4 inches long. The 40-meter tap would be 10 turns from the C_5 end of the coil.

Although it doesn't show too well in the photographs, we painted the panel to give the unit a more professional look. The lacquers and

[3] For other types of meters a different shunt may be required. Details for making shunts are given in *The Radio Amateur's Handbook*, Measurements Chapter.

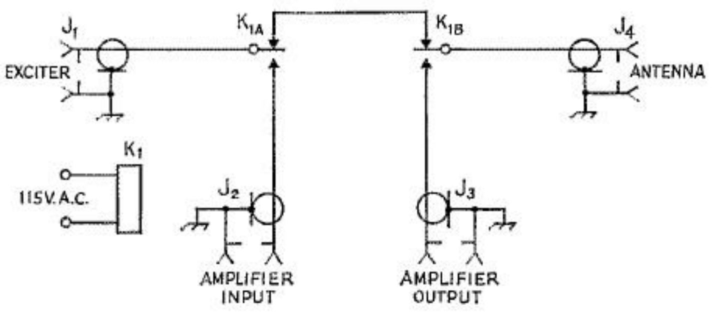
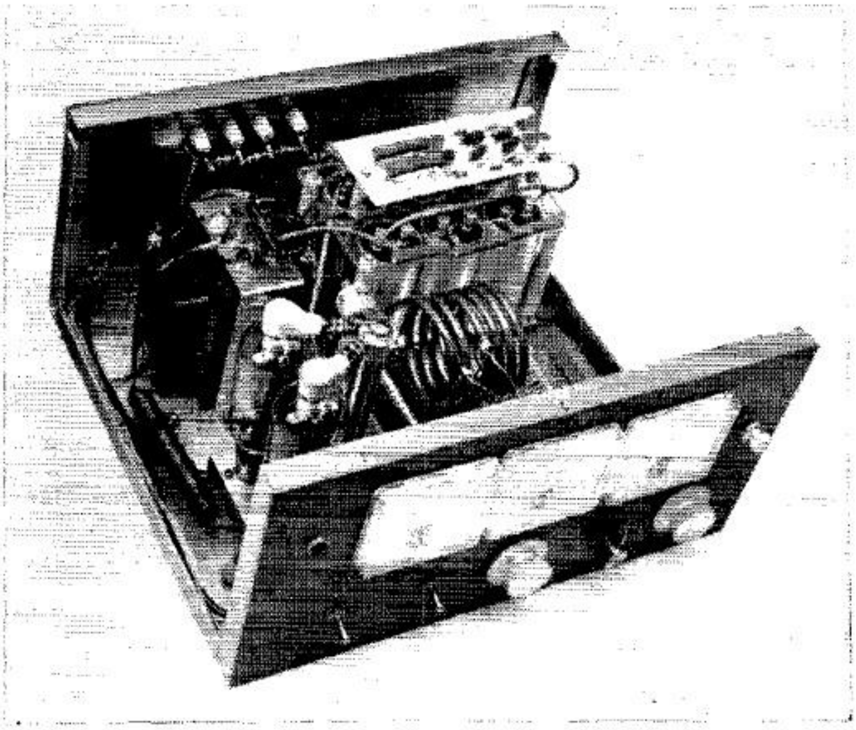


Fig. 2—Circuit for relay for transceive operation. K_1 can be any type antenna relay capable of handling the power used. The a.c. for the relay can be controlled by circuits in transceiver or by separate switch. J_1–J_4 are coax chassis connectors.



At the right rear is the rectifier and capacitor assembly. To the left is the power transformer. Standard terminal tie points are mounted on top of the aluminum bracket that secures the transformer to the cabinet base. The standoffs mounted on the rear wall support the dropping resistors for the neon panel lamp, the high-voltage indicator. At the left-hand side is the filament choke, RFC_1.

enamels that come in spray cans are excellent for this purpose. However, before you paint, make sure the panel is completely clean. Vinegar is an excellent material for removing finger and grease marks. Don't rush the job when applying the spray paints. It takes many light coats of spray to come up with a satisfactory job.

Tune-Up Procedure

If you've never tuned up a grounded-grid amplifier you are likely to find it differs considerably from other types. It is practically impossible to use the conventional plate-current dip in tuning this type of amplifier. The plate-current and grid-current meters are primarily used to check the operating conditions. What is required is an output indicator, and although an output meter of the type used here is only a relative indicator, it does show when you are getting the most output.

Tuning any linear amplifier is best accomplished with a scope. Details for using one have been covered many times in past articles, and information can be found in the ARRL *Handbook*. However, it is possible to tune up without a scope and be reasonably assured that the amplifier is linear, with no flat topping. With a pair of 572Bs as used here, the object is to adjust the driving power, tuning and loading controls to reach maximum output with a plate current of 360 ma. and a grid current of 40 ma., using a c.w. driving signal. Simultaneously, when you have arrived at the stated conditions, reducing the drive slightly should cause the output (and input) to start to drop. Under these conditions, the amplifier should be working linearly. Arriving at these conditions requires careful adjustment of the controls and the drive from the exciter. These conditions are, of course, for sideband or a.m. linear work. On c.w., you can drive the tubes harder and there is no real concern about linear operation.

Any of the exciters in the 30- to 150-watt range will provide more than adequate drive, as the tubes require only a driving power of about 30 watts. Of the 30 watts, about 20 watts will be fed through to the output.

There is no switching provision built into this amplifier for use with transceivers. However, it would be quite simple to add an antenna-type changeover relay for such operation. Such a circuit is shown in Fig. 2. The relay could be mounted in a small box which in turn could be mounted on the back of the amplifier.

However, an interesting thing was noted in using this amplifier with a transceiver. We connected the amplifier to an antenna system and used a transceiver to drive it, but a separate receiver was used. After using this setup for a few contacts, and noting no "hash" from the amplifier with the filament center tap grounded, we connected a speaker to the transceiver. The transceiver, of course, had closer coupling to the amplifier than the separate receiver and we certainly expected some hash or noise from the amplifier. There was none, but what was more surprising was the fact that there was enough signal coupling from the antenna, through the amplifier, to make it quite easy to copy signals with the transceiver. There was a very slight reduction in signal strength as compared with connecting the receiver directly to the antenna but not enough to really be concerned about. In any case, we would suggest that you try the system before adding a separate relay. It may well suit your needs. QST