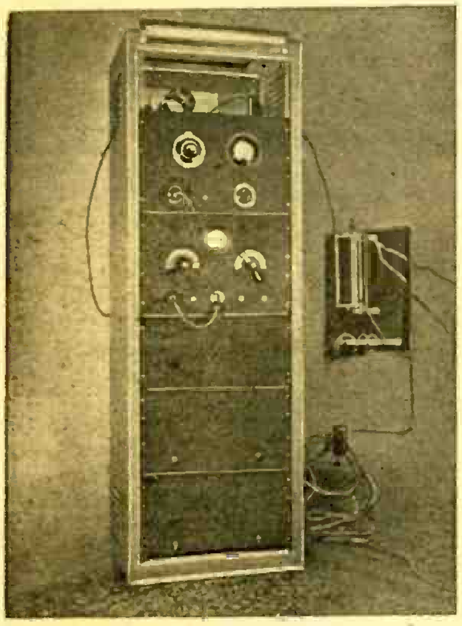
By HARRY D. HOOTON, W3KPX

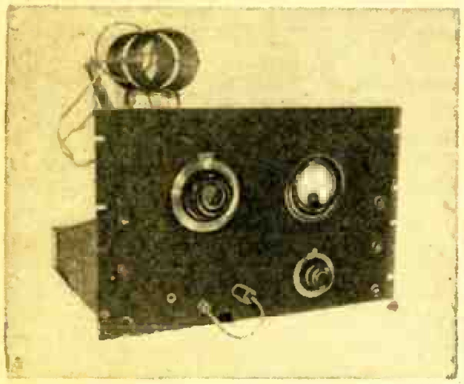
UNIVERSAL 1-KW AMPLIFIER

Tuning Up and Adjustment Are Completely Described

THE average amateur starts out with what appears to be a good r.f. final amplifier design *on paper* and by the time that the rig is completed and all of the "bugs" ironed out, usually winds up with an entirely different layout. Sometime later when the urge to try out a pair of the new pentodes, tetrodes or triodes, as the case may be, becomes unbearable, he is very much surprised and shocked to learn that, although the amplifier functioned perfectly with the previous tubes, it is again necessary to go through the entire "debugging" procedure with the new ones.



Amplifier is in the top section of this rack.



Closer view of the one-kilowatt final stage.

A rear view of the unit. Note swinging link.

The author spent his spare time over a period of several months in an intensive experimental effort to develop a simple and stable high-power r.f. amplifier design which would be suitable for use with practically *all types of* pentode, tetrode and triode tubes. It was also felt desirable that the number of mechanical changes required when going from one type of tube to another should be reduced to the minimum. A multitude of arrangements were tried, some of which were good from a mechanical viewpoint but lacked stability when used with several different types of tubes; others had good electrical stability but were difficult to construct. As might be expected, the resultant design is a compromise between the various factors involved; the practical working model amplifier is described in this article.

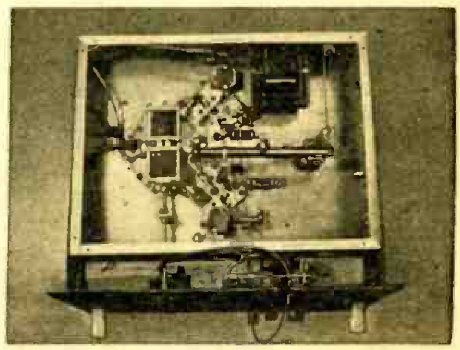
As the photographs and drawings show, the unit is built up on a 17 x 13 x 3-inch cadmium-plated heavy-duty steel chassis and a 12x19-inch aluminum panel. The chassis is mounted *spaced two inches from the aluminum panel*, which also gives a two-inch spacing between the rear of the chassis and the back of the standard cabinet when the door is closed. The purpose of the offset type of construction is: 1. to permit a symmetrical layout of the parts on the top of the chassis; 2. to allow the plate tank coil to be electrically balanced with respect to ground. The center lines of the chassis and the center lines of the Parmetal 66-inch metal cabinet coincide; therefore, the two "hot" ends of the tank coil are equidistant from ground when the cabinet door is closed.

This amplifier is designed to operate on the 3.5, 7, 14 and 28 megacycle amateur bands with practically any modern transmitting tubes such as the Eimac 100TH, 250TH, 4-125A or 4-250A; the Gammatron HK-54, HK-254 or HK-257B; or the Taylor TW75 or TW150. Using suitable tubes, the amplifier is easily capable of input powers up to 1,000 watts with excellent efficiency and stability. The only changes required when going from one type of tube to another are: 1. A filament transformer of the proper voltage and current capacity; 2. proper sockets for the tubes used; 3. incorporation of proper capacity and voltage rating neutralizing capacitors if the tubes are triodes.

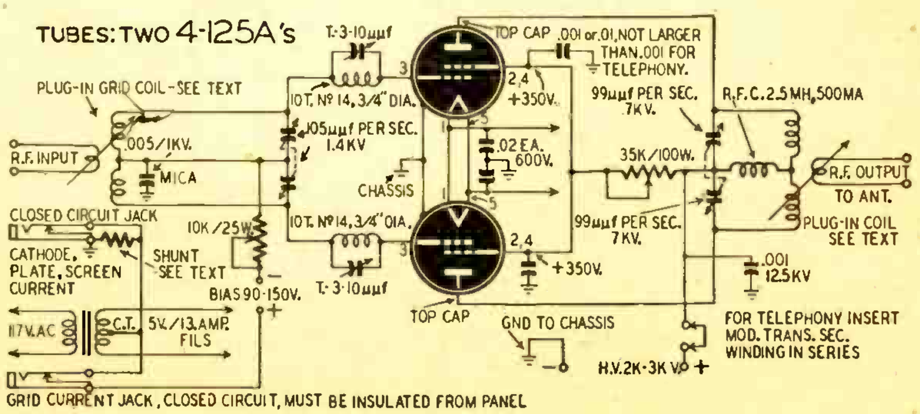
GRID CIRCUIT ISOLATED

As shown in the under-chassis view photograph, the grid tank tuning condenser is mounted under the chassis. Experiments with previous amplifiers had convinced the author that much of

(Continued on page 57)



Grid tuning condenser is under the chassis.



Circuit is designed to accommodate tetrodes, pentodes and triodes, with slight adaptations.

UNIVERSAL 1-KW AMPLIFIER

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the instability in high-power beam tetrode and pentode r.f. amplifiers may be due to *electrostatic* coupling between the grid and plate tank tuning condensers as well as electromagnetic coupling between the two tank coils. This point is frequently overlooked and many amateurs construct amplifiers in which only a few inches separate the "hot" tank condenser plates of the two circuits. When the grid tank condenser was placed under the chassis, all troubles from oscillation when using the 4-125As and the HK-257Bs disappeared *in spite of the fact that the grid coil is unshielded*. This arrangement also allows more room on top of the chassis for physically larger tubes such as the RCA 810 or Taylor T125.

Both the grid and plate coils are of the Barker and Williamson swinging-link type. Variable-coupling coils in both the input and output circuits of the amplifier give the unit extreme flexibility and permit the use of almost any exciter which will supply the minimum grid power requirements. The plate coil is a HD type conservatively rated at 1,000 watts; the grid coil is rated at 75 watts. The swinging link assembly is constructed as an integral part of the jack bar. When changing bands it is only necessary to remove and insert the plate coil —the swinging link coil is not disturbed. The adjustable grid coil link is constructed as a part of the plug-in grid coil assembly. In this unit, the link is removed with the coil when it is desired to operate on another frequency band. The grid condenser is a two-section type of 105 μμf per section maximum capacity, spacing 0.045 inch, peak voltage rating 2,000 volts. The plate condenser is also a two-section transmitting type of 99 μμf per section maximum capacity, spacing 0.175 inch, peak voltage rating 7,000 volts.

THE METERING SYSTEM

The milliammeter on the front panel is a 0-50 ma d.c. 3½ inch General Electric type and was obtained from war surplus stock. It is connected into grid and plate circuits by means of the flexible coaxial lead and phone plug and the two jacks along the left bottom of the panel. When the plug is inserted into the jack at the right nearest the small tuning dial, the meter reads directly from the scale and indicates grid current. With the plug inserted into the jack at the left, the meter indicates plate current (or in this unit, the combined plate and screen currents) and the scale readings are multiplied by ten. This is accomplished by placing a suitable shunt across the *plate current jack terminals* which automatically converts the 0-50 milliammeter into a 0-500 milliammeter. About 1.8 ohms of Advance wire are needed. Adjust till meter reads 500 ma full-scale when compared with a standard meter.

The large four-inch dial is the plate tank tuning control; the small dial is the grid tank tuning control.

TUNING-UP PROCESS

Adjustment and operation of the amplifier is simplicity itself. The unit should be perfectly stable and free from spurious radiations or parasitics if the layout shown in the photographs and drawings is duplicated. To place the amplifier in operation:

1. Put the two 4-125A tubes in their sockets and connect the primary of the filament transformer to the 110 volts, 60 cycles a.c. line. Using a good quality a.c. voltmeter, with a scale of *not over 25 volts*, check the filament voltage of each tube in turn *right at the filament terminals of the tube socket*. If the filament voltage is high or low, as compared with the manufacturer's specifications, take steps to correct the condition. The use of a Variac or other voltage-adjusting device is a practical necessity when working with expensive transmitting tubes. The tubes not only will last much longer when operated at the proper filament voltage, but better *r.f. efficiency* will be obtained.

2. With a co-axial line or twisted pair, connect the output link of your exciter to the adjustable link of the amplifier grid coil. Adjust the grid coil link for minimum coupling. *Do not apply plate and screen voltage*. Insert the milliammeter plug into the jack at the right. Connect the proper fixed bias voltage in series with the grid return as shown in the schematic diagram.

3. Apply r.f. excitation to the grid circuit link coil. Rotate the grid tank tuning dial and watch the milliammeter. Grid current will be indicated when the grid tuning control is adjusted to resonance with the excitation frequency. If no grid current or too low a grid current reading is obtained at resonance, move the link toward the center of the coil and carefully retune the grid circuit for maximum grid current indication. When the grid current is of the value specified for the plate voltage in use, carefully "peak" the grid tuning control and leave it alone. NOTE: Unless the r.f. driver stage regulation is very good, the grid current will drop slightly after the plate and screen voltages are applied. After the amplifier is in operation, the link coil may be re-adjusted to give proper grid current reading with the plate and screen voltages applied.

4. Leave the grid circuit alone. Remove the plug from the grid current jack and insert it into the plate current jack. Connect a 110 volt, 100- to 200-watt lamp across the terminals of the plate circuit swinging link coil to act as a dummy antenna. The plate voltage should be reduced to approximately 1,000 to 1,500 volts for the preliminary tune-up procedure. This may be accom-

(Continued on page 71)

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(Continued from page 57)

plished by means of the Variac or by means of a 200 watt, 110 volt lamp wired in series with the high-voltage transformer primary together with a switch for shorting out the lamp resistance for normal operation.

5. Apply the reduced plate and screen voltage and quickly tune the plate tank for minimum plate and screen current indication on the milliammeter. Adjust the coupling between the plate coil and the output link circuit until the combined plate and screen currents are about 200 to 250 milliamperes. Watch the color of the 4-125A plates at this current indication: they should be a dull orange in color and should be of equal brilliance. If the plate colors are not of equal brilliance, this indicates that one tube is either receiving inadequate excitation or is being loaded too heavily. It is sometimes necessary to move the center connection of a grid coil one way or the other before equal excitation to the two tubes is obtained.

6. If amplifier operation appears normal with excitation and reduced screen and plate voltages applied, momentarily remove the r.f. excitation from the input circuit and watch the plate and screen current milliammeter. If the fixed bias is sufficient, the plate and screen currents should drop to a very low value or zero. If the plate and screen current rises when the grid excitation is removed, insufficient fixed bias is being applied to the grids, the amplifier is oscillating, or there are parasitic oscillations taking place at some frequency far removed from the resonant frequency of the plate and grid tuned circuits. The grid current should indicate zero. If grid current is indicated when the r.f. excitation is removed, this is a sure sign of oscillation in the amplifier. If no grid current is indicated but the plate and screen currents rise when the r.f. excitation is removed, the trouble is almost certain to be insufficient fixed bias voltage.

7. Now, with the r.f. excitation removed, adjust the fixed bias voltage so that the total plate and screen currents are approximately 100 to 150 milliamperes. Rotate the grid and plate tank tuning condensers throughout their scales; at the same time watch the plate and screen current milliammeter. The current indication should remain constant. If it does not, parasitic or spurious oscillation may be taking place.

8. If there was a change in plate and screen current as discussed in step 7 above, adjust the trimmer condensers of the two parasitic traps under the chassis until the plate and screen currents remain constant at any setting of the plate and grid tank tuning condensers.

9. Connect the antenna to the output link, re-apply r.f. excitation to the grids and apply the full plate and screen voltage. Tune the grid and plate tank circuits as before and adjust the antenna loading for a combined plate and screen current of 300 to 400 milliamperes. Readjust the coupling between the r.f. excitation source and the amplifier grid circuit to give the proper grid current required for full power input operation.

10. If the operation of the amplifier now appears to be normal, the screen and control grid power dissipation should be checked before prolonged operation has taken place. The screen dissipation may be calculated by measuring the screen currents from the two tubes and the voltage applied to the screens. The power dissipation will be equal to $E_s I_s$, where E_s is the screen voltage and I_s is the total screen current. The total screen dissipation should not exceed the values given in the 4-125A operating conditions charts.

The grid dissipation is calculated from the following expression:

$$P_g = E_{cmp} I_c$$

Where P_g = Grid dissipation

E_{cmp} = Peak positive voltage

I_c = d.c. grid current

The grid dissipation for the 4-125As must not be allowed to exceed 3 watts per tube.

As the tables issued by the manufacturer show, the maximum plate dissipation per 4-125A tube for c.w. telegraph operation is 125 watts; for radio-telephone operation, the maximum plate dissipation per 4-125A tube is 85 watts. This means that at 100% modulation with a sustained sine wave, the plate dissipation will reach 125 watts per tube and, therefore, for radio-telephone operation, with normal efficiency, the plate power input will be limited to slightly over 700 watts per pair of 4-125As. On c.w. telegraph operation, however, the full input of 1,000 watts may be used.

Plate voltages up to 3000 may be

(Continued on page 77)

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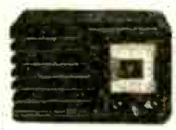

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(Continued from page 71)

used for c.w. telegraphy; for telephony, however, plate voltages from 2200 to 2500 are recommended. Although the author has successfully operated the 4-125As with plate voltages as low as 1000 volts, such low-voltage operation is not recommended as the efficiency and power gain of these tubes drops off sharply as the voltage is decreased below 2500 volts.

Adequate cooling must be provided for the envelopes and seals of the 4-125As where medium or full input power is applied to the tubes. A small inexpensive blower or fan will usually be sufficient to move the two or three cubic feet of air per minute required for cooling of the stem structure. Better cooling efficiency can be obtained by directing the stream of air upward through the holes of the Johnson type 275 socket and the ceramic base of each tube.

List of Parts

CONDENSERS

1—Variable condenser, 2-gang, 99 μμf per section, 7000 volts peak, 0.175 inch spacing. Johnson Type 100DD70 or equivalent.
1—Variable condenser, 2-gang, 105 μμf per section, 2000 volts peak, 0.045 inch spacing. Johnson Type 100FD20 or equivalent.
1—Fixed condenser, mica, .005 μf, 1000 volts d.c.
1—Fixed condenser, mica, .001 μf, 12,500 volts d.c.
2—Fixed condensers, mica, 0.01 μf, 1000 volts d.c., or fixed mica condensers, .001 μf, 1000 volts d.c. See schematic.
2—Fixed condensers, paper, 0.02 μf, 600 volts d.c.
2—Adjustable trimmer condensers, mica (or air), 3 to 30 μμf.

COILS, ETC.

1—Complete set (80, 40, 20 and 10 meters) Barker and Williamson 75 watt plug-in, adjustable link type inductors. B. & W. Type JVL.
1—Complete set (80, 40, 20 and 10 meters) Barker and Williamson 1000 watt plug-in, swinging link type inductors. B. & W. Type HDVL.
1—Jack bar—swinging link assembly for above HDVL inductors.
1—R.f. choke, 2.5 mh., 500 ma.
2—Parasitic trap inductors—10 turns No. 14 enameled wire ¾-inch diameter, pulled out to form a coil 1½ inches long. Self-supporting.

RESISTORS

1—Fixed resistor, 35,000 ohms, adjustable, 100 watts.
1—Fixed resistor, 10,000 ohms, adjustable, 25 watts.

OTHER PARTS

1—Filament transformer, primary 110 v.a.c.; secondary 5 v.a.c., c.t. 13 amperes.
2—Closed-circuit jacks (for grid and plate milliammeter connections).
2—Eimac 4-125A beam tetrode transmitting tubes.
2—Special ceramic sockets for above tubes. Johnson Type 275.
1—Milliammeter, 3½-inch diameter, 0-50 ma. d.c.
1—High-voltage coupler, ceramic, ¼ to ¼-inch shaft.
1—Coupler, insulating type, ¼ to ¼-inch shaft.
1—Dial, direct drive, 0-100 clockwise over 180°, 4 inches diameter.
1—Dial, direct drive, 0-100 clockwise over 180°, 2¾ inches diameter.
1—Phone plug, bakelite shell.
1—Standard aluminum panel, 12¼x19x⅛ inches, black crackle finish. Parmetal Type 6681.
1—Standard steel chassis, 13x17x3 inches, cadmium plated finish. Parmetal Type C-4536.
2—Chassis mounting brackets. Parmetal SB-713.
1—Cabinet for complete transmitter. Parmetal Type "A" rack, 61¼x19-inch panel space, No. ER-225.

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