POWER PEAKER

a 200-watt output linear amplifier for single sideband.

Fig. 1. Front view of Power Peaker

The Power Peaker is a complete single-tube linear amplifier featuring compact design for relay rack mounting. The 115-volt driving power, for full 200-watt peak output, is less than 8 quarts on 45 watt from 60 meters to 10 meters. Thus, use of the Power Peaker driven by a single-sideband exciter, such as the SSR, JR (C-E Ham News; Vol. 1, No. 8), allows the single-sideband enthusiast to increase power by approximately 20 db. Two hundred watts of single-sideband is more than the communication equivalent of a half-kilowatt (plate input), high-level modulated AM rig operating at 80% efficiency. The Power Peaker will serve as an effective link between the SSB exciter and the antenna or a super-power (about 5 KW) final.

GENERAL DESCRIPTION

The Power Peaker amplifier is entirely self-contained (except for plate power supply) on a 3½ x 19 inch relay rack panel. All parts mount directly from the rear, and that construction is easy and straightforward. The power amplifier tube is the socket and depends on the power transformer to provide a filter capacitor near the center of the panel. Control fittings are used for the i-f input and output connections, and input and output tuning controls are accessible on the front panel as well as grid and cathode current jacks for circuit tuning and turn-up. A filament transformer is mounted on the rear of the panel to simplify the metering circuits and to avoid voltage drop in long filament leads.

The power amplifier plug-in units are used for grid and plate circuits. Coupling adjustments may be made readily to match both input and output. These adjustments, once made for each band, "go with the kit" and need not be done again when changing bands. Input grid coupling adjustment remains fixed from one band to another.

CIRCUIT DESIGN DETAILS

The circuit diagram of a linear amplifier is almost the same as that of a class "C" amplifier. Close inspection, however, will reveal an important difference between them. The plate current of a "C" amplifier, that of power, is dependent on the grid voltage, whereas the plate current of the Power Peaker, that of gain, is fixed. A 50-day drive is operated at zero bias and this feature makes additional biasing unnecessary. Actually this linear amplifier is self-biased. Operating at zero bias reduces the driving power required, simplifies the input impedance to reduce amplifier distortion, and, of course, eliminates the need for a bias supply.

The grid circuit is used as a phase inverter (accomplished by a split-stator tuning condenser) in per-
The Power Peakeram linear amplifier uses standard components throughout except for modification of the grid coils. This is necessary to obtain the required L/C ratio. Fig. 4 gives the layout of the 35/21 inch (steel or aluminum) panel. Remember to reserve a clear space of at least one inch at each end of the panel for mounting on the rack. The plate tank condenser, C1, is spaced 1/2 inch from the panel by the three spacers furnished with the Hammondline TC-220R con-
denser. Before mounting this component, scrape the paint from the rear of the panel under the standoff post to assure good electrical connection. The socket for the plate coil is mounted directly on the panel. The socket condenser, C7, with 7/8-inch spacers, and oriented so that the axis of the coil is as shown in Fig. 4. The coil socket pins 1 and 6 should be toward the top of the panel. Ground pin 6 and use pin 1 for the adjustable tap connection. It will be necessary to drill and tap the back of the plate tank condenser in order to mount the coil socket. Be certain to use fiber washers next to the ceramic socket to prevent cracking as it is tightened.

The grid tuning condenser, C1, is mounted on the rear of the front panel after the plate is removed from the area immediately around the mounting holes. In general, it is best to do this for all grounded components. The National STN neutralizing condenser, C1 is mounted on a metal bracket 1/8 inch by 1/8 inch long fastened to the rear of the grid tuning condenser, C1. The rear shaft bracket of the Hammondline MCD-100M condenser already has two tapped holes (No. 4–40 thread) which can be used to mount the bracket. The edge plate of the STN condenser must be insu-
lated from this bracket by means of the two stand-off insulators supplied with the condenser.
The tube socket should be spaced from the panel by two 5/16-inch metal or ceramic spacers. The plate of pins 1 and 3 (filament pins) must be connected to the socket panel to be mounted. This is necessary to protect the tube from damage due to filament short. The B plus end of the condenser is soldered to a lug mounted on a ceramic stand-off insulator. This part also serves to support the cold end of the National R-190, 2.5 millihenry shunt-feed t.f. choke. The plate blocking condenser, C5, is mounted between the stator lug of the plate tank condenser, C7, and the hot end of the shunt-feed choke, L3. A solid wire connects from this last-mentioned point to the plate of the STN neutralizing condenser, C2. The objective here is to provide a rigid mounting for the blocking condenser, C5, and the tap of the plate choke, L3, and to provide a connection point for the short insulated stranded-wire plate lead. The tap of the blocking condenser, C5, should be located toward the center of the bottom of the plate of the tube to prevent interference of large amounts of heat radiated from the tube. A straight-across mounting of the blocking condenser should be avoided, right, because aluminum snaps for inserting the GL-817-A. Fig. 3 shows these details clearly. A solid wire connection should be made from the same lug that mounts one end of the blocking condenser to the hot pin of the plate coil socket mounted on the end-plate of the tuning condenser. Use 22-gauge AWG (or larger) for these solid-wire leads. The filament transformer, T1, is mounted 1/2 inch from the panel on metal spacers to clear the leads which come out the bottom of the transformer. A terminal board is fastened to the top of the transformer by means of two right-angle metal brackets.

This terminal board serves to connect the d-c supply and the 1500-volt d-c plate supply to the amplifier. A secondary terminal board is recommended for the sake of safety and to prevent inadvertent short circuits.

The center tap of the 6.3-volt winding of transformer T1 should be connected to the tip spring terminal of the closed-circuit cathode-coupled jack, J1. Be certain to ground this jack securely to the metal panel. There is space on the panel below the transformer for a primary filament switch, if separate control of the filament is desired.

The ceramic socket, for the grid coil L1, is mounted on a stand-off insulator so that the axis of the coil is vertical as shown in Fig. 3. The socket pins used for the swinging link should be toward the end of the panel for convenience in wiring and adjustment of the swinging link. The end connections (pins 1 and 5) of the grid tank coil should be connected with solid wire to the two stator sections of C5. The stator section away from the panel should be connected to the rotor of the STN neutralizing condenser. The stator section nearest the panel should be connected to the grid pin of the GL-811-A socket (pin 3) through a 10-ohm, 1-watt non-inductive resistor (R1). This resistor is bypassed by its pigtails lead between the stator connection and the terminal board. The center tap of the grid coil socket pin 2 should connect through a National R-190, 3.5 millihenry t.f. choke (L3), to the tip connection of the closed-circuit grid-current meter jack, J2. This choke may be supported by its pigtails leads from the socket connection and the jack terminal. Ground pin 3 of the grid coil socket to the panel with a short lead as a precaution.

The filament wires may be twisted together and run between the plate condenser and the panel from the transformer to pins 1 and 4 of the GL-811-A socket. The leads should run from the terminal board to the ceramic post supporting the tip feed lead of t.f. choke. This lead should be kept clear of the stator connection of the plate tank condenser. Be certain to use wire with adequate insulation to withstand the 1500 volts.

CIRCUIT CONSTANTS

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1, C2, C3</td>
<td>0.035 pf diak tpe ceramic condensers</td>
<td>0.035 pf diak tpe ceramic condensers</td>
</tr>
<tr>
<td>C4, C5</td>
<td>0.01 pf diak tpe ceramic condensers</td>
<td>0.01 pf diak tpe ceramic condensers</td>
</tr>
<tr>
<td>C6</td>
<td>0.05 pf diak tpe ceramic condensers</td>
<td>0.05 pf diak tpe ceramic condensers</td>
</tr>
<tr>
<td>L1, L4</td>
<td>National AR-37 coil, modified. See coil table</td>
<td>National AR-37 coil, modified. See coil table</td>
</tr>
<tr>
<td>L2</td>
<td>3.5 mh t.f. choke, National R-190</td>
<td>3.5 mh t.f. choke, National R-190</td>
</tr>
<tr>
<td>R1</td>
<td>0.1 om carbon, 1 watt resistor</td>
<td>0.1 om carbon, 1 watt resistor</td>
</tr>
<tr>
<td>T1</td>
<td>110 volt, 15 amp, 1 st stage, C. Stanczak P01-19 or equivalent</td>
<td>110 volt, 15 amp, 1 st stage, C. Stanczak P01-19 or equivalent</td>
</tr>
<tr>
<td>J1, J2</td>
<td>Closed circuit phone jack</td>
<td>Closed circuit phone jack</td>
</tr>
<tr>
<td>J3, J4</td>
<td>Closed circuit phone jack</td>
<td>Closed circuit phone jack</td>
</tr>
<tr>
<td>V1</td>
<td>GL-811-A valve</td>
<td>GL-811-A valve</td>
</tr>
</tbody>
</table>

(Note all resistors and capacitors ±20% unless specified otherwise)
COIL DATA

It is essential to use coils having the correct inductance in order to meet the operating circuit Q's. The coils selected require modification in most cases in order to reach the required values. In addition, the two low-frequency-band grid coils require padding condensers mounted on the coil base as shown in Fig. 3.

Band Cell Laby Description

2.5-4.0 14 10 National AR1-450. Remove and rule. Remove 3 turns. Provide 10 taps at 1 turn intervals from Pin No. 1 end. Connect Pin No. 6 to Pin No. 2 across top of coil base. Use a lead connected to Pin No. 1 for connection to tap.

4.1-5.0 14 1 National AR1-330. Remove outer tap of swinging link. Connect 100-ohm MICA condenser from each end of coil to Pin No. 3 of coil base. See Figs. 3 and 1

7.0-7.2 14 4.6 National AR1-320E. Remove end link. Tap each 1 turn for 2 turns and make other connections as described for 3.5-4.0 MC plane coil.

11.0 7 National AR1-405. Remove 1 turn from outer end of each coil cell. Remove center tap of swinging link from Pin No. 3 and connect a 100-ohm MICA condenser from each end of coil to Pin No. 3 of coil base. See Figs. 2 and 1

16.4-16.4 14 3.7 National AR1-320E. Remove end link. Remove 4 turns. Tap coil every 1 turn for 3 turns and make other connections as described for plane coil.

11.2 National AR1-320. Remove end link. Connect Pin No. 1 end to Pin No. 3 of coil base. See Figs. 2 and 1

The inductance values for each cell are given for those who wish to make their own coils. It might be necessary to remove some of the turns in the swinging link of the grid coils to facilitate matching the exciter and plate circuit of the Power Peaker. Do this if the exciter does not load properly when the link coil is fully meshed with the grid-tank coil.

POWER SUPPLY CONSIDERATIONS

A special word is in order concerning the plate power supply used with the Power Peaker linear amplifier. The 1:1 frequency ratio chosen for the plate tank circuit is based on the use of a power-supply voltage of 1850 volts. One of materially lower voltage (such as 1200 volts) would be satisfactory for proper operation of the amplifier, when it is used as described under the section entitled MATCHING AND LOADING. A serious consequence of low output circuit Q is an abnormally high harmonic output. Thus, to develop rated output power coils providing suitable load conditions for the amplifier tube, the power supply should deliver 1500 volts under load.

Good-power-supply regulation is desirable for achievement of the best performance from any linear amplifier. A power supply that can deliver, say, 1500 volts at a load current of 200 ma, which allows the voltage to rise to 1800 volts at the resisting or static current of the Power Peaker amplifier will cause even the stand-by dissipation within the GLA 1-A to exceed its rating—this will mean a short and unsatisfactory life for the tube. Design of a satisfactory power supply is discussed in G.E. HAM NEWS, Vol. 7, No. 2 and THE RADIO AMATEUR'S HANDBOOK.

The type of load presented by a linear amplifier with single-ended input is identical to that of a class B modulator stage. To the information given in Vol. 7, No. 2 should be added that dynamic regulation of the power supply be considered also. Without going into details, one will end up with a really satisfactory plate power supply by following the design information given (especially with regard to input chokes, which affects "static" regulation) and then increasing the size of the output capacitor of the filter to a value corresponding more nearly to that required for satisfactory ripple performance.

Generally speaking, a power supply which has sufficient input chokes to take care of static regulation will have more than enough. Dynamic regulation, the ripple requirement. This is provided the total value of capacitance is sufficient to give the output filter a chance to respond to the ripple created by the intermittent load characteristic of the amplifier grid. When the tube of the Peaker was tested, an output capacitance of 45 microfarads was found to supply the power supply to provide good dynamic voltage regulation. An input choke of 60 henries is used to obtain good static regulation.
Of course, transformer, rectifier tubes, and chokes of sufficient current rating (about 300 ma for the Power Peaker!) and filter condensers of adequate voltage rating should be used.

**INITIAL TUNE-UP PROCEDURE**

After checking the wiring and construction, apply power to the filament circuit, insert the GL-311-A in its socket and connect the plate amp. Do not apply plate voltage—indeed, disconnect the plate power supply from the terminal board for the present. Plug in the set of coils covering the band you intend to operate and plug in a 0-50 ma meter in the grid current jack (23). With power applied to the filament, it is normal to see about 3 or 3 ma grid current with no excitation.

Arrange to supply excitation to the amplifier at the desired frequency. Start with the center link loosely coupled and tune the grid circuit resistance until the meter is indicated by maximum grid current. Set the neutralizing condenser about 1/8 of the way down and check grid circuit resistance. The amount of excitation used at this point is determined by the distance of the selected frequency from 15 ma to 40 ma (maximum) will do. Adjust the coupling so that the meter of voltage is centered. If a single-sideband suppressed carrier exciter is used, it must be driving some sort of a signal. A tone modulation, unbalanced carrier, or some reproducible signal will suffice.

**MATCHING AND LOADING**

For further tune-up, it is necessary to provide a load for the Power Peaker. Failure to do so will result in damaged coils. A dummy load which has the same resistance as your antenna is ideal for making coupling adjustments. Do not attempt to use brandnew lamp-bulbs as a load because its resistance depends greatly on its temperature. An ammeter is also needed to check linearity and power when making a test with a two-tone signal. (See R. J. Borus, Linen R.F. Amplifiers, QST, May 1949, and R. W. Ehrlich, How To Test and Align a Linear Amplifier, QST, May 1953.)

Adjust the single-sideband exciter used as a driver for two-tone operation; feed this signal into the input jack (23), at a level as low as will connect the output link to a suitable load. Arrange the ammeter so that it can read the r.f. signal across the load. Enough signal will be available to see with the r.f. applied directly from the grid-circuit output. Change the grid plate voltage and resonate the grid tank (maximum grid current) and the plate tank (maximum load voltage) with both grid and plate of circuit closely coupled.

**CAUTION—HIGH VOLTAGE:** Although this tube is designed with safety in mind, it is well to recognize the fact that this equipment will be in use. The circuit is used and that all ‘“BACK OF THE GARDEN”’ procedures would be made before making certain that the high voltage supply is not only off but that the filter condensers are discharged. We don’t want any of our readers just yet. Stick around and find out how well the Power Peaker Really works. (Nuff said?)
We have mentioned at several places in the article on resonant circuits that the maximum power transfer occurs when the impedance of the load is equal to the impedance of the source. This is a general result that holds for all types of resonant circuits, whether they are series or parallel. The reason for this is that at resonance, the input impedance of the circuit is equal to the load impedance, and the power delivered to the load is maximum. This is true regardless of whether the circuit is a series or parallel resonant circuit, or whether it is a radio-frequency circuit or a low-frequency circuit. The principle is the same in all cases.

In practice, it is often desirable to match the impedance of a transmitter to the impedance of a remote receiver in order to maximize the power transfer. This can be done by using a matching network, which is a set of components (such as inductors and capacitors) that are connected in such a way as to transform the impedance of the source to the impedance of the load. The matching network is designed to operate at the frequency of the signal to be transmitted, and it can be adjusted to match the impedance of the load to the impedance of the transmitter.

In summary, the principle of maximum power transfer is a fundamental concept in the design of resonant circuits, and it is important to understand how to apply it in practical situations. By using the right matching network, it is possible to maximize the efficiency of a resonant circuit and to ensure that the maximum amount of power is delivered to the load.
frequency at which it is operated. Pure reactances are
to talk about, but coils are not actually
100% pure reactances by the time you buy or make
one—the wire has resistance! This reactance is
generally distributed throughout the coil, so in
the reactance, but let us think of it as being all drained
down to the bottom of the coil in one chunk of pure
resistance, leaving pure reactance at the top. If this
reactance portion of this series circuit of pure react-
ance and pure reactance has a value of 250 ohms
and the resistance is one ohm, the Q of the coil is 250,
or

Q = Reactance (X) / Resistance (R) = 250 / 1 = 250

This is consistent with the basic definition
given earlier. What we have said about coils is usually true
of capacitors, but it turns out that condensers can be
made with much higher Q’s than coils generally
have, so we worry about coils a little more than capaci-
tors when speaking about Q’s of the circuit elements
we use.

Well, if we apply 1000 volts RMS to this coil hav-
ing a reactance of 250 ohms and a resistance of one
ohm (this is a very, very, very nearly 250 ohms,
not 251 ohms), 1 amperes of current will flow through
both reactance and resistance, and the real power
in the coil is then 1000 x 1 = 1000 watts! Of course
the reactive power is 4000 volt-amperes, so called
to distinguish reactive power from real power.
The best generated in this transaction represents energy
lost to at least energy converted from electrical
form (that can be used conveniently) into heat
that warms the coil and does not even show up as
energy in the attennata. What if we try to calculate
about 16 watts lost when we have 4000 volt-amperes reactive
power in the coil? If volt-amperes were what we were
after, this would be fine. Think of it—4000 volt-
amperes that cost only 16 watts! A good bargain!
But had we known our Q’s (power) and Q’s, but
that is the rest of the story. The circuit designer
can now take over where the coil builder left off.

As we all know, a capacitor in parallel with a coil
makes a tuned circuit. It turns out that at the resonant
frequency of this circuit the reactance of the
 capacitor is equal to the reactance of the coil. If we
let our coil with a capacitor having a Q of 500 (not unusual)
we can truly neglect the R/10 of a watt lost in the equivalent resistance of the capacitor
component, and you will find that the total power
lost is only 16 watts in the coil and capacitor, and
the 16 watts in the coil. Now let us add a fourth
circuit element to the reactance and resistance of
the circuit and the reactance of the capacitor comprising
the tuned (tank) circuit we are talking about.

Let us make the resistance still 1 ohm, and lets
see how the power distribution changes. If the
16 watts has already been accounted for in the
coil, we have a 538 volt-amperes reactive
power lost in the tank circuit is justifiable, since we have
limited used so far the actual load power “resistance”
and the tube characteristics; i.e., the optimum load
necessary for each tube. We have seen that the
output power of the generator depends on the load resistance
characteristics of the circuit. For a given tube and mode of
operation (class A, AB, B, or C) there is a definite best
output load. Too light a load will not allow a reasonable
output power, too heavy a load, on the other hand, wastes
power in the tube (generation) and makes it
inefficient. Audio amplifier circuits, with the circuit
designer as referee. It has been found that the Q’s of 10 to 15 are good

How much power does this generator put out?

The answer is easy. One. The reactance of the circuit
is Q X R, or 250 x 1 = 250, which is the
reactance of the coil, and the Q of the circuit is not
Q (circuit) = 250 / 1 = 250

Real Power = E X R / (Q x R) Since the voltage E
is 1000 volts, RMS, by hypothesis. If R is 500 ohms,
the power is the 250 watts and the circuit Q is not
Q (circuit) = 250 / 1 = 250

Real Power = 250 / (250 X 1) = 1.0

This is very much smaller than the 500 watt output of
the generator, as we expected.

The circuit designer

The response of a tuned circuit to harmonics is approximately

where H is the order of the harmonic

This is consistent with the basic definition of Q stated at the outset.

The same conclusion can be reached about the

The resonant frequency of the circuit is

The response of a tuned circuit to harmonics is approximately

where H is the order of the harmonic
want to present the optimum load to the tube, but we must keep it happy. We also want to have good discrimination against harmonics present in the output of the tube. In addition, we want to waste as little of the tube's output power as possible; that is, we want good power-amplifier efficiency. Having chosen the operating voltage for the tube, the optimum-element load resistance is fixed. Taking this and a value of circuit Q around 12 to 15 we can solve for the reactance of the coil and the condenser by substituting values in the following equation: 

**Reactorance = Load Resistance desired / Q (circuit)**

This is the value that must be used to obtain the desired output power at good tube efficiency, at reasonable circuit efficiency, and with reasonable harmonic attenuation. Circuit Q affects all these things. The Q of the coil alone determines the power loss in the coil, once its reactance is established. Doubling the Q of the coil alone will cut the power loss in the coil itself by half—a desirable move for the sake of the coil—but this is not so easy, and the circuit efficiency will be raised only a little bit (from 90%, say, to 98%), a little difficult to detect on the scale of the output power. Doubling the coil Q will not affect the load line occurring in the tube in any way, determined by the load into which the tube works, and by the mode of operation; i.e., class A, B, or C.

It takes no magician to apply the foregoing informa-
tion intelligently. In the Power Peaker amplifier, for example, the output circuit Q was chosen at about 13. (This will vary somewhat throughout a given band because of tuning.) The choice of 1300 volts (the highest allowed by the tube manufacturer) was made to get the greatest usable output power, and this sets the value of load resistance and coil reactance in any operating frequency. The numbers used in the foregoing rule-of-thumb examples are quite close to those actually appearing in the Power Peaker amplifier. That is all there was to it. Easy? You betcha!

One more criterion. If a Q of 12 or 15 is so good for the output circuit why was a Q of 5 chosen for the input (grid) circuit of the Power Peaker? Two main considerations guided this choice. The input load of the G-E grid circuit determines somewhat how the loading in the output circuit. In order to have just the right amount for error, the Q of the input circuit was made higher than actually necessary so that those things would be on the safe side. The other consideration was this: the exciter, which couples to the amplifier grid circuit, lowers the grid-circuit Q. Thus, it is quite probable that the working Q of the grid tank circuit will be around 13, after all.

Watch your Ps and Qs. Keep your tubes happy, get more power out of your rig, lower the harmonic output, and save money in the choice of suitable components.