



the power output, but it also doubles the power wasted. And an extra tube used this way does absolutely nothing to prevent the minutest of changes in load from affecting the stability of your transmitted signal. A breezy day tossing your antenna about will continue to be made painfully obvious to the fellow listening to your signal---the only difference is your warble will be 3 dB louder with the two tubes!

By adding an extra tube(s) as a power amplifier for your basic Hartley, you'll minimize the effects of antenna sway. You'll also make it possible to add vintage AM phone to your 1929 rig at some future time. The handbooks of the era admonished the prospective AM'er from attempting to directly modulate a self-excited oscillator due to excessive FM'ing (or, as they called it then, "wobulation"). Progressive radio amateurs knew that adopting the master oscillator power amplifier (MOPA) circuit was the best way to add power, stability and flexibility to a self-excited one-tuber.

### *Amplifier Background*

The little 245 triode always intrigued me because contemporary manuals and spec sheets listed it both as a receiving and a transmitting tube. I was also fortunate in that I had several fine used examples of this venerable bottle at hand, along with matching sockets. These tubes, together with a quantity of other key "period" parts that were available in my junkbox, convinced me that a pair of 245's in parallel (driven by my single 245 Hartley) would be just the ticket for my next foray into the 1929 QSO Party.

The transmitting tube data sheet in my 1938 edition of Jones' The Radio Handbook gives the following specifications for a single 245 operating as a class C RF amplifier:

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Plate Voltage -- 400 volts
Plate Current --- 50 mA
Bias Voltage --- 200 volts
Grid Current ----- 4 mA
Power Input ----- 20 watts
Power Output ---- 15 watts
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The quoted power input/output ratio translates to an optimistic 75% efficiency for the tube---fully twice (and then some) that of a 245 when used as a self-excited oscillator/transmitter. When utilizing hard-to-find old bottles like the 245, why not strive for maximum efficiency? Power output to an antenna is power put to good use; power lost to plate dissipation merely makes a semi-rare (and expensive!) tube heat up needlessly.

Class C parameters were chosen for this very reason, and also because I plan on modulating the amplifier some time in the future. Even the relatively simple Heising AM system requires that the modulated RF stage be run in class C.



## PARTS LIST

C1--.001-.005 mFd  
(not critical), 2.5  
kV mica  
C2--100 pF air  
variable (receiver  
type)  
C3--at least 330 pF  
air variable  
(Cardwell XP-330-KS  
or  
equivalent)  
C4--50-pF, 2.5 kV  
mica added as padder  
by author (see text).  
For 160-meter  
operation, switch to  
a 510-pF, 2.5 kV  
mica.  
C5--.001-.005 mFd  
(not critical), 2.5  
kV mica (two needed)  
C6--.001-.005 mFd  
(not critical), 2.5  
kV mica  
RFC1--2.5-mH, 250 mA  
(not critical)  
RFC2--2.5-mH, 500 mA  
(not critical)  
R1--left section of  
center tapped  
filament resistor  
(not labeled  
on schematic);  
100-Ohm, 1-Watt  
R2--right section of  
above; 100-Ohm, 1-  
Watt  
R3, R4--25,000-Ohm,  
1-Watt  
L1--10 tpi, 3"-  
diameter air inductor  
(B&W 3035, AirDux  
2410T, or  
equivalent). I used a  
3" length, but a 2"  
length  
should be more  
than adequate, even  
for 160-meter work.  
Tap  
shown at top (see

schematic) is placed about 7 turns up from bottom of coil. Lower tap is placed halfway between top tap and bottom of coil.  
L2--6 tpi, 2" diameter, 10" long air inductor (B&W 3025, AirDux 1606T, or equivalent). Tap for best output (see text).  
L3--5 turns of #14 ga. wire, 1/4" i.d., spaced 1/2" (2 req.)

There was no question but that the output tank would consist of the classic parallel tuned output arrangement (no pi-network circuitry here!). The large 330-pf Cardwell air variable capacitor that I had on hand, as well as some still-in-the-box Barker & Williamson coil stock, were practically crying out for a deserving application. Happily the sizes/values of these components allowed coverage on 3.5-MHz.

With some padding of the Cardwell by a fixed mica capacitor (see parts list), future 160-meter coverage should also be possible. An alligator-clip-and-tap system would enable the necessary tank coil adjustments.

Determining proper plate tuning capacitor and tank coil values for a given band seems like black magic to many experimenters. This certainly does not need to be the case. A review of the 1938 edition of RCA Air-Cooled Transmitting Tubes (Technical Manual TT-3)

shows that the tank capacitance to achieve a given "Q" may be readily calculated from the formula:

$$C = 300QI/fE, \text{ where}$$

C = total capacitance of the tank capacitor in picofarads

Q = a constant from 12 to 15

I = total plate current in milliamperes

f = frequency in MHz

E = d.c. plate voltage in volts

A Q of 12 is normally utilized in these applications, with higher values--up to 15--reserved for those instances where plate impedance might be inordinately high. More in-depth reads in the matter of tank Q are readily available in most any of the Bill Orr Radio Handbooks.

With the value of C in hand, it is a simple matter to consult the charts in most any of the older Handbooks to see what inductance might be required to achieve resonance on the band of choice. I personally prefer using my old ARRL slide rule-style "Lightning Calculator."

Plugging into the RCA formula to find C, I used a frequency of 3.5-MHz, a Q of 12, and an E of 300-volts (as produced by my present power supply). I used a current of 100 mA on the assumption that the two parallel 245's would draw about 50 mA each of plate current as indicated in the Frank Jones handbook. Of course I knew that the draw would be somewhat less with my smaller plate supply, though I didn't know how much less. (Later I measured it at 90 mA.) C was now calculated at:

$$300 \times 12 \times 100 / 3.5 \times 300 = 360,000 / 1,050 = 342.85 \text{ pf}$$

This value was close enough to the specs of my 330-pF Cardwell (I eventually added a 50-pF padder across it) and would resonate at the bottom end of 80 meters with an inductance of some 6 microhenries. I made no specific provisions for input tuning. I felt that the integral antenna tuning circuitry of my Hartley, in conjunction with its continuously variable coupling, would afford more than enough flexibility in driving the amplifier. So the input to the latter is strictly "straight through."

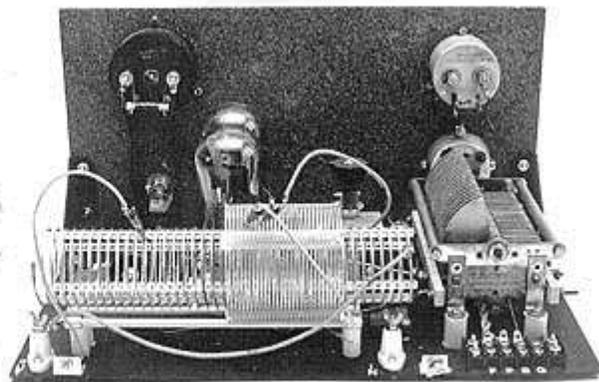
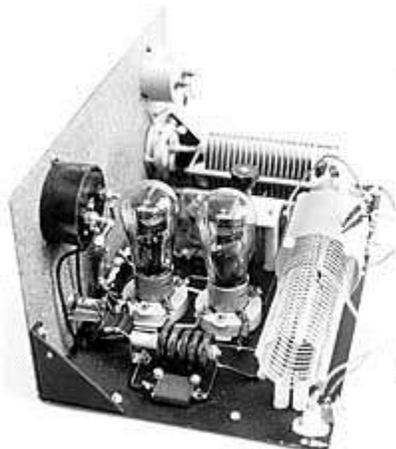
Additional flexibility was provided in the arrangement of the grid bias resistors--which makes possible the use of either a pair of 245's, or a single, standalone tube. The resistance value for a single tube was calculated using the Frank Jones numbers and Ohm's law:

$$R = E \text{ (bias voltage)} / I \text{ (grid current in amperes)} = 200 / .004 = 50,000 \text{ ohms}$$

Switching to a pair of 245s (for post-1929 QSO Party activities), the required grid resistance is cut by 50%:

$$R = E \text{ (bias voltage)} / I \text{ (grid current in amperes)} = 200 / .008 = 25,000\text{-ohms}$$

Accordingly, two 25,000-ohm resistors are connected in series from chassis ground to the grids. A simple shorting



Two rear views of the completed unit. Note meter shunts (left photo). Standoff insulator (right photo) behind the tubes supports neutralizing capacitor.

wire, terminated in an alligator clip, allows me to cut out one resistor for single-tube operation. Note: be sure to have the B+ turned off whenever reaching behind the front panel of your amplifier. Safety First! So far I have not calculated, or arranged for, the "ideal" capacitance and appropriate inductance for single-tube operation on 80 meters. However, the tank circuit as calculated for two tubes seems to perform well with one.

Both plate and grid currents are monitored. I utilized a homebrewed 300 VDC power supply for the 2000 edition of the 1929 QSO Party, but switched to a 400-volt unit for 2001. A filament supply delivering 2.5 VAC at a minimum of 3 amperes is also required.

## ***Construction***

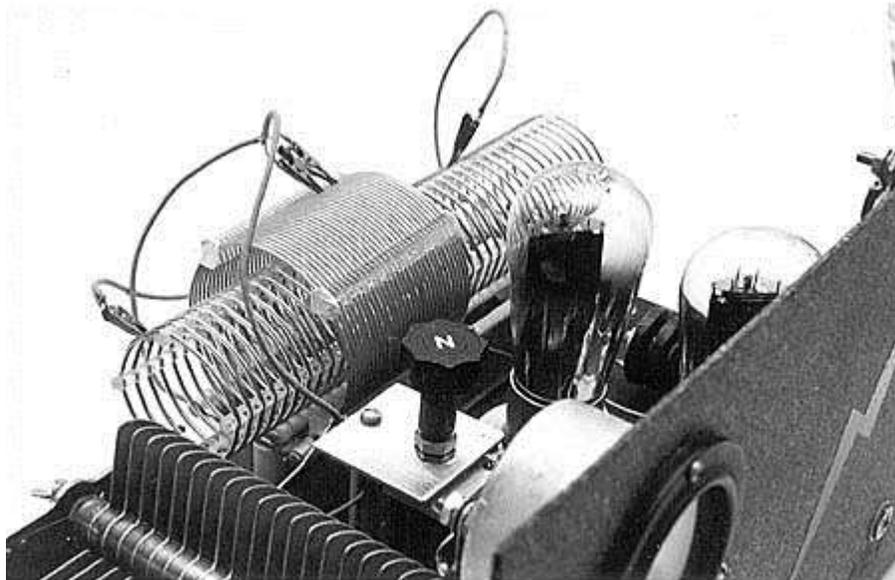
The foundation for the amplifier consists of a 16" x 18" sheet of aluminum, which was folded to form a 16" (wide) x 8" (high) front face, and a 16" (wide) x 10" (deep) foundation/build area. A pair of right-angle side gussets helps to stiffen things considerably.

The circuit is very simple and easy to put together. If you strive to lay out your components such that the input to your amplifier can't effectively "see" the output, you should experience a minimum of problems with its final operation (I'm thinking here of nasty things like unwanted feedback, etc.). The usual admonitions, of course, apply: keep leads short & direct as may be practical; minimize wires crossing overtop of one another, etc. etc.

The tank inductor is mounted atop two parallel quarter-inch wood dowels (see detailed photo of the coil assembly), held in place with a few drops of epoxy glue. The dowels, in turn, are supported above the base by four stand-off insulators. Two additional parallel quarter-inch dowels pass through the tank coil and are glued to the same supports that hold the first two. Spacing between the two sets of dowels is 1 1/8." The antenna coil is loose-installed within the tank, resting on the second pair of rods. All of the dowels were treated with two generous coats of clear nail polish to guard against any possible moisture absorption.

The inductance of the tank is more than enough to permit operation, even on 160-meters. Of course, C3 would then have to be padded with an additional capacitor, as represented by C4 on the schematic. This capacitor could be cut in and out with a switch for dual band operation. Manual shorting taps preclude the need for bandswitching the tank coil, and simplify construction considerably.

The front panel paint finish is a story in itself. Repeated efforts at applying a wrinkle finish met with repeated failures. The film build-up after no less than four such ill-fated attempts was so thick that I had to consider whether the panel should be stripped clean for further paint experiments (A most undesirable proposition by that point!). Happily I found a can of so-called "granite-finish" texture spray paint at the local craft shop. A light application of this atop the existing layers effectively hid the mess and resulted in a unique "period" look. The round meters I used also helped with the vintage appearance. I would have preferred that the two meters be a better match, but I decided to limit myself to the contents of my junk box. The vernier tuning dial drive is an E.F. Johnson generously provided by friend Rick, W9QZ. The physical dimensions of the amplifier could have been considerably reduced. However,



Details of tank and antenna coils. Insulated extension shaft on neutralizing capacitor provides safety when adjusting and minimizes hand capacity effects.

after having labored in close quarters before, it was a refreshing change to have room to spare.

### *Tune-Up*

Visually inspect your handiwork before applying any voltages, and compare it to the schematic. That way you should be able to ensure an uneventful "smoke test."

Begin by neutralizing the amplifier. My method may be simplistic, but it is time-honored, and seems to work well. Leave the tubes in, and apply filament voltage to the amplifier, but no B+. Hook-up your exciter to the input (a short length of coaxial cable will do), and a VTVM to the output (or antenna) terminal. With the VTVM set to read 3 VAC maximum scale, turn on the exciter and hold the key down. Slowly adjust the amplifier plate tuning capacitor for a peak on the VTVM.

Now adjust the neutralizing capacitor for a null in the VTVM reading. Re-peak the reading by adjusting the plate tuning capacitor again, nulling it immediately afterward with the neutralizing capacitor. After some 3 or 4 such adjustments, the VTVM reading will remain at zero at any setting of the plate tuning capacitor, and the amplifier will have been neutralized for those tubes installed in it. You will have to go through the procedure again should you change either or both of the tubes.

As always, NEVER "first-time test" any new rig--especially one of these types--on the air.

Having established that your 1929-style oscillator/exciter is properly set-up and neutralized, attach a 15-watt light bulb to the output terminal as a dummy load and apply B+. Tune your receiver to around 3570-kHz and key the rig (Note: it matters little if the key is plugged into the oscillator key jack, or that of the amplifier. Since both stages employ 245's fed with the same filament transformer, keying either stage will automatically key the other).

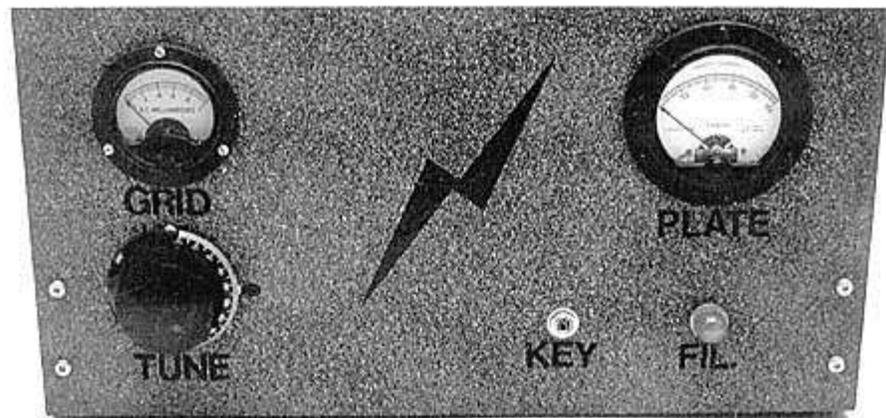
Now adjust the oscillator frequency to the frequency of the receiver. It helps considerably to have a digital frequency counter on the table beside the transmitter to instantly "spot" the transmitted signal frequency. Once detected and verified to be your signal (it shouldn't be too hard to miss---it WILL be loud), dip the final amplifier by tuning the plate tuning capacitor. The light bulb should noticeably increase in brightness upon doing so.

Monitor your signal at all times on the receiver--resonating the amplifier doubtlessly caused the frequency to shift. Bring it back into the receiver pass-band by adjusting the oscillator. Next peak the grid current reading of the amplifier by slowly adjusting the oscillator antenna coupling capacitor and the coupling between the oscillator tank and its antenna coil. Again, monitor the signal, and re-adjust the frequency of the oscillator to bring it back into the receiver passband (such frequency excursions become progressively smaller with each step in the tuning process).

Using a single 245 driver, one hardly needs to be worried about the possibility of dangerously over-driving the grids of the `45s in the amplifier; the only concern here is to maximize the grid current reading--the actual numbers on this meter are merely relative. Likewise, having grown accustomed to commercial tube-type transmitters and the mantra of "minimum loading/maximum capacitance" as the first step in achieving output resonance, it may help to think of the taps on L2 as a sort of "loading capacitor."

Specifically, in your initial tuning exercise, the taps on L2 should be close to the ends the portion of L1 that is in use. This effectively simulates the "minimum loading/maximum capacitance" setting of a conventional pi-network loading capacitor. Initially here, with 260-volts on the amplifier, plate current was less than 50 ma. The dummy load bulb, while lit, was not at maximum brilliance. As the taps on L2 were spread progressively further apart, plate current rose to over 60 ma. and the bulb became considerably brighter.

These techniques may not be startling new for the OT reading this. But they certainly were to a ham like myself, who cut his



Front panel sports craft shop "granite" finish and nifty lightning-bolt logo.

teeth on DX-60's and the like in the early 1970s.

### ***Operation***

As mentioned, I used this exact MOPA set-up--a single 245 Hartley driving the 2x245 amplifier--in the 2000 running of the AWA "Bruce Kelley 1929 QSO Party." And I was rewarded with a 4th place, finishing with 55 QSOs. (To comply with the rules governing power, one tube was removed, for pre-midnight contacts.) But there is still room for improvement.

While instability due to a wind-tossed antenna is now minimized, even the smallest adjustment to the final amplifier affects the frequency. This problem could be alleviated by adding another stage (possibly a 245 run in class A) between the Hartley and the final. In the absence of stiff voltage regulation (was there such a thing in 1929?), separate power supplies for the exciter and amplifier are a must if one wishes to minimize chirp.

Frankly I was somewhat taken aback during the course of QSO Party at the amount of "C's" that were post scripted to my received RST reports--but then I measured the plate voltage from my common, choke-input 300 volt supply and was really taken aback! During key up/no load conditions, the supply idled at 320 volts: with the key down, however, the voltage to both the Hartley and the amplifier dropped to 260-volts! This amounts to no regulation at all, and is most assuredly not a good state of affairs for either the overtaxed supply or the quality of my signal.

A new, stand-alone 400-volt unit for the amplifier is definitely in the offing, in spite of conciliatory comments received about my "quaint-sounding" station.

### ***Conclusion***

It's remarkable how building something as "retro" as a rig like this can seduce one into cracking open the books and absorbing hitherto unknown electronic design concepts. Through this marriage of theory and practical application, you find yourself walking in the footsteps of Ross Hull, George Grammer, and other true giants in the development of radio state of the art. So enjoy the view from up there--you're in good company!

### ***References***

*The Radio Handbook*, 5th edition, 1938, Radio Ltd.,  
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*The Radio Amateur's Handbook*, 7th edition, 1930,  
The American Radio Relay League, Hartford, CT., pp. 85-106.

*The Radio Amateur's Handbook*, 9th edition, 1932,  
The American Radio Relay League, Hartford, CT., pp. 84-99, 115-130.