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807 DRIVES 8005 FINAL IN FLEXIBLE FOUR STAGE RIG

READY FOR A RAG-CHEW

UNIT COVERS 80 TO 10 METER BANDS FOR PHONE AND CW WITH MEDIUM POWER

By GEORGE D. HANCHETT, JR., W2YM

The desire for a compact and flexible transmitter that would cover all the bands from 80 meters to 10 meters with an input of 300 watts for cw and 250 watts for phone prompted the design of the rig to be described. Many hours of thought resulted in plans for a unit using 80-meter crystals and having a minimum of four stages with an 8005 final driven by an 807. A fully electronic keying system, quick band-change, plug-in coils, meter switching for convenience and low cost, and symmetry of panel controls completed the goals we set up for our transmitter. Then we rolled up our sleeves and went to work.

The transmitter was built completely on a 17" x 13" x 3" cadmium plated chassis. Its panel size is 19" x 10 1/2". The power supply, not illustrated, was built on another chassis of the same size.

The oscillator and multiplier plate-tuning condensers, as well as the meter switch, are mounted under the chassis with their control knobs brought out to the front panel. In order to keep the oscillator tank leads as short as possible, the oscillator tuning condenser is mounted slightly to one side; drive is accomplished through a flexible shaft.

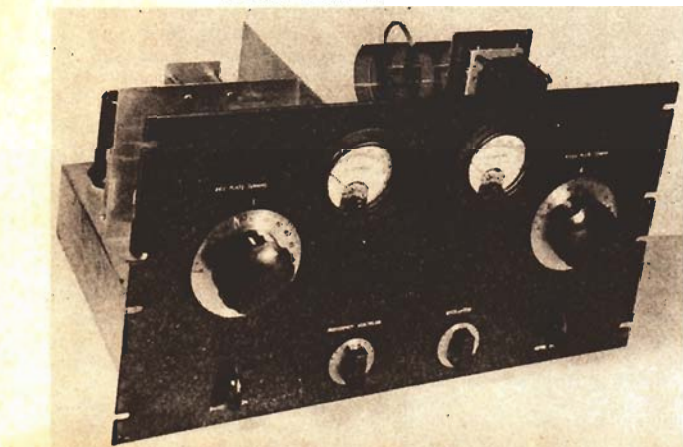
Both oscillator and multiplier tank condensers are mounted on

polystyrene strips which are, in turn, affixed to metal supporting brackets. By means of this insulating method together with bakelite shafts, it is possible to isolate the condensers from ground, thereby allowing the dc voltage to be applied to the rotors. The arrangement eliminates the need for costly mica blocking capacitors capable of carrying tank currents.

Quick Band Changing

The band-change switch is a four-pole, three-position wafers type. The first pole of the switch in both the 20-meter and the 10-meter position applies plate voltage to the 6L6 multiplier. The second pole is used

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This fine looking rig has an electronic keying system, quick band change, plug in coils, and meter switching—important in a unit designed for convenient operation and quality service.

AN ANALYSIS OF GRID DRIVING POWER AS LISTED IN TUBE OPERATING DATA

One important question that's sure to come up in the design of a new transmitter is how much power is needed to adequately drive the individual stages. Tube manufacturers have set up driving power figures in typical operating data, but unless this information is interpreted correctly, the driver stages may be under-designed.

The value of driving power shown in tube data bulletins includes only the actual power input to the grid plus the power lost in the bias supply. It does NOT include rf losses that occur in the tube, tank circuit, socket and wiring, or losses in the tubes, caused by transit-time loading.

It is not feasible for the tube manufacturers to give total driving power figures, because there is no way of anticipating conditions under which the tubes will be used. Grid power requirements will vary considerably, even in well-engineered designs, and the extreme ranges are quite large. It is better, therefore, that printed specifications indicate only the sum of grid power and bias losses.

Because the driver tube must supply all the losses between its plate and the grid of the driven tube, these losses must be added to the figure given in the tube data for driving power requirements. On an average, in the frequency range up to 30 Mc, the losses are large enough to dictate the choice of a driver tube which has a rated output of about twice the grid power rating of the driven tube.

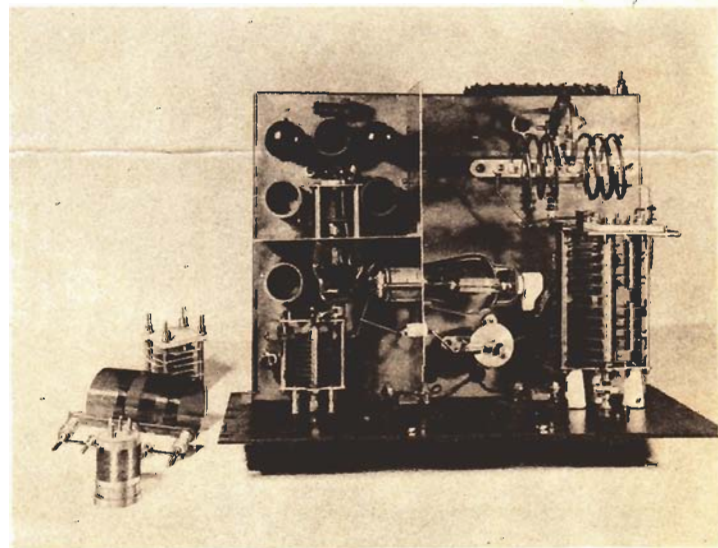
Driving-power measurements are usually made at 100 kc—where rf losses in the tube are negligible—by measuring the peak rf grid voltage (Eg) and the average grid current (Iav). Then, the relation $Wd = 0.9 E_g I_{av}$, gives the driving power in watts. This is the figure shown in tube bulletins.

At higher frequencies consideration must be given to rf and transit-time loading losses. If the stage in question is to operate above 30 Mc, it is advisable to provide 3 to 10 times the published low-frequency driving power figure in order to insure sufficient drive plus a reasonable margin for safety.

After the design has been crystallized and the transmitter constructed, tests and adjustments should be made to insure that the

(Continued on Page 3, Column 4)

BEHIND THE SCENES



A top view of the transmitter discloses a symmetrical layout to achieve maximum operating efficiency as well as an attractive appearance.

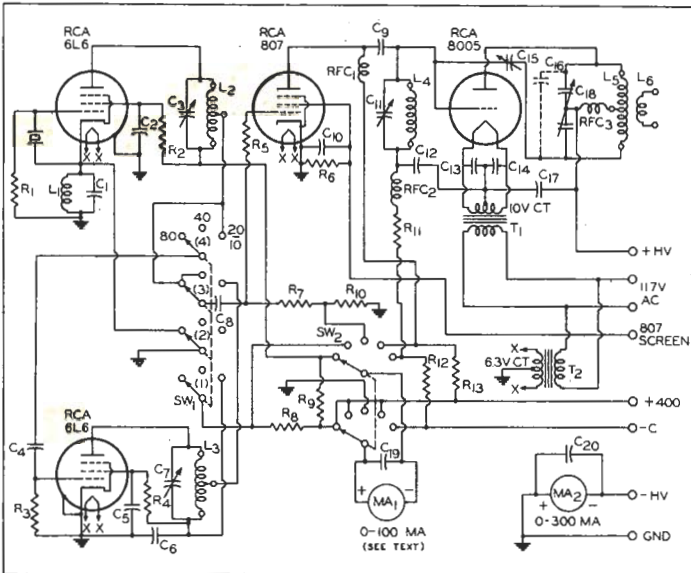


Figure 1. Transmitter schematic.

FOUR STAGE RIG

(Continued from Page 1, Column 4)

to short the cathode coil of the oscillator only when its plate circuit is tuned to the fundamental wave length of 80 meters. The third pole connects the grid of the 807 to the proper driving circuit. The fourth and last pole removes the excitation to the 6L6 multiplier when it is not in use.

One novel feature of this transmitter is that both the 807 buffer and the 8005 final are mounted horizontally. Better placement of parts can be accomplished when the tubes are placed in this position. The photographs show that the grid connection comes close to the grid tank and that the plate is near the plate tank. Those short connections are extremely helpful for 28-Mc operation.

When a filamentary tube such as the 8005 is mounted horizontally, care should be taken to see that the plane of the filament is vertical. Tubes other than the 8005 may be used in this manner except those

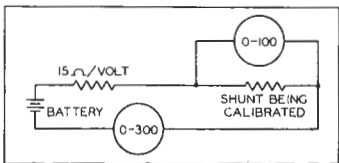


Figure 2. Schematic used in adjusting meter shunts.

employing helical filaments which are not recommended for horizontal mounting.

Note that the 8005 has its socket mounted on the vertical shield partition. Shielding of the 807 is achieved with two aluminum shields. One shield runs perpendicular to the panel and a little to the left of center. The other is mounted parallel to the panel and slightly back of the chassis center. This arrangement adequately shields the 807 plate from its input

circuit and also shields the 807 from the final tank circuit.

To eliminate the possibility of parasitic oscillations in the 807 buffer stage, connect a 50-ohm non-inductive resistor in the grid circuit. This resistor should be placed as close as possible to the grid socket terminal.

On 3.5 to 4.0 megacycles, in order to obtain a desirable tank Q of 12, essential for reduction of unwanted harmonic output, it is necessary to add extra capacitance to the split-stator condenser. This is provided by the plug-in condenser, C 16. Two turns are removed from each end of the coil (L5) in order to obtain resonance with the larger total capacitance.

Metering Procedure

Metering of the 8005 plate circuit takes place in the negative return of the high-voltage supply. This method permits the meter to be mounted on the panel and not be a shock hazard. Metering the low-power stages as well as the grid of the 8005 is accomplished with a meter switch and a 100-ma instrument. The installation of new shunts permanently wired in for each position permits the meter to be switched to any of several circuits. This provides a very simple arrangement, but one precaution must be taken. The meter switch must be of the non-shorting type. Use switches such as Centralab #1405 or Mallory #1315L. For this transmitter the internal shunt was removed from the meter and five new shunts of equal resistance were constructed. Each was made from about 4 feet of #28 enameled wire, wound on a solder-lug terminal strip.

To adjust the new shunts, use a battery, a fixed resistor having about 15 ohms per battery volt, and the 300-ma meter (8005 plate), all in series with the 100-ma meter and shunt to be adjusted. This hookup is shown in Fig. 2. Wire should be

removed from the home-built shunt until both meters read the same.

The meter positions of the switch are as follows:

- 1—oscillator plate current
- 2—multiplier plate current
- 3—807 grid current
- 4—807 plate current
- 5—8005 grid current

The two power supplies required for the transmitter are both mounted on a single 3" x 13" x 17" chassis. One is a low-voltage supply for the oscillator, multiplier, and buffer, and the second is a high-voltage supply for the 8005. Fig. 3 is a schematic diagram of the supplies. Bias voltage is obtained from a half-wave rectifier connected to the bias tap on the 400-volt power transformer. With no excitation to the 8005 final amplifier the grid bias should not be less than 70 nor more than 90 volts.

Electronic Keying

Keying of the transmitter is done electronically in the screen-grid circuit of the 807. This method was originated by W2RYI, and gives excellent clickless keying. In the key-up condition, the grid of the control tube, a 6L6 in this case, operates at zero bias resulting in a low internal tube resistance. This low resistance reduces the voltage at the anode of the voltage regulator tube (OC3/VR105) below that required for ionization. With no ionization, the VR tube is non-conductive and the result is an open circuit to the screen grid of the 807. Note in the circuit diagram that a 0.15-megohm resistor is connected between screen grid and ground to bleed off any charges collecting on the screen grid and to hold it at ground potential in the key-up position.

When the key is in the key-down position, cutoff voltage is applied to the control grid of the 6L6. This produces a very high internal resistance in the 6L6 so that adequate ionizing voltage appears at the

anode of the VR tube. Now, the VR tube will ionize or fire, and complete the circuit between the screen grid and its supply voltage.

Capacitor C5 of the power supply is used to prevent key clicks. Increasing the size of the capacitor will increase the lag; reducing it decreases the lag. The novel features of this system are that only very small currents need be keyed and that the keying lag may be adjusted by changing the size of the capacitor.

Tuning Up the Rig

Tuning up the transmitter is quite simple. After the proper crystal and coils for the band desired are selected, the oscillator tuning condenser should be rotated to obtain the usual dip. The plate current of the oscillator will run about 20 to 25 ma on 80 meters and 25 to 30 ma on all other bands.

When the multiplier is to be used, tune it to resonance as quickly as possible because abnormally large currents flow when its plate circuit is out of adjustment. Normally, the plate current of the 6L6 will run about 30 ma on all bands.

Next, switch the meter to the 807 grid position and retune the multiplier or oscillator plate tuning condenser for maximum grid current. The 807 grid current should be between 4 and 5 ma on all bands. Switch the meter to the 807 plate circuit and hold the key down, then tune the 807 plate circuit for minimum current. The value should be in the neighborhood of 60 to 70 ma for all bands except 40 meters. On 10 meters the 807 plate current will run about 85 ma because in this position the 807 is operating as a doubler. When tuning the low power stages do not apply high voltage to the 8005.

When the driver stages have been tuned, the grid circuit of the 8005 should then be tuned. No high voltage should as yet be applied to the 8005. The meter switch is turned to the 8005 grid position and the

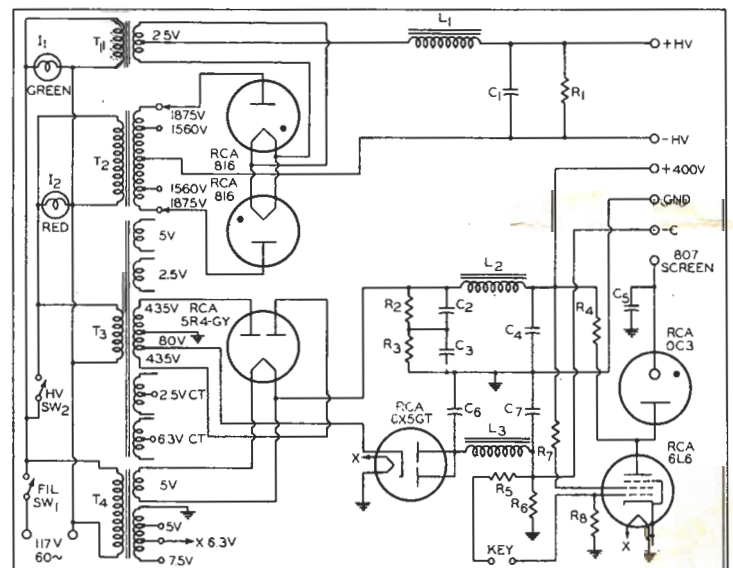


Figure 3. Schematics of power supplies.

Coil Data			
Wavelength Band meters	L ₂	L ₃	L ₄
80	A		B
40	C		D
20	C	E	F
10	C	E	G

80 meters Coil A — 30 turns # 22 wire, winding length 1 3/8", tap at 12 turns.
 Coil B — 27 turns # 20 wire, winding length 1 1/4", no tap.
 40 meters Coil C — 17 1/2 turns # 20 wire, winding length 1 1/4", tap at 8 turns.
 Coil D — 15 turns # 18 wire, winding length 1 1/4", no tap.

20 meters Coil E — 10 turns # 18 wire, winding length 1", tap at 5 turns.
 Coil F — 6 turns # 18 wire, winding length 1", no tap.
 10 meters Coil G — 3 turns # 14 wire, winding length 1 1/4", no tap.
 All coils wound on National XR-5 forms or equivalent, 1 1/2" diameter, 2 1/4" long.

807 plate tank adjusted to obtain maximum 8005 grid current. This grid current should run 30 to 35 ma on all bands but will be lower on the higher frequency bands. It is worth mentioning that the 807 does a good job of driving the 8005, even though it has a plate supply of only 400 volts and is capacitively coupled to the 8005 grid.

After the final amplifier has been neutralized as described below, the high voltage may be applied and the plate circuit tuned to resonance. Then, the pick-up loop can be connected to the antenna transmission line and the antenna coupling adjusted to load the tube to the desired plate current which, however, must not exceed 200 ma.

Neutralizing the 8005

Neutralization of the 8005 can be done as follows: with the high voltage off, tune the plate tank of the 8005 through resonance and observe the needle kick on the meter caused by a shift in grid current. Change the setting of the neutralizing condenser and check grid-current kick again. If the kick becomes less than before, the adjustment of the neutralizing condenser was in the correct direction. This procedure should be repeated until there is absolutely no kick noticeable on the grid meter. When the final has been neutralized, it will not require readjustment with change in operating frequency.

The 1875 volt power transformer T2 is tapped at 1560 volts. The full secondary will provide 1500 volts for the 8005 when it is used on CW. The 1560-volt ac tap will provide 1250 volts for the tube when it is plate modulated.

The builder of this transmitter should not experience any trouble in obtaining top performance. It is one of the most easily constructed and conveniently operated rigs that the author has used in his 18 years of Ham radio.

PARTS LIST—TRANSMITTER

- C1 200 μf, mica, 500 volts working
- C2, C5, } 0.002 μf, mica, 500 volts working
- C6, C10 } 100 μf, variable, 500 volts working
- C3, C4 }
- C7 50 μf, variable
- C8 500 μf, mica, 500 volts working
- C9 500 μf, mica, 600 volts working
- C11 65 μf, mica, 0.070 spacing
- C12 0.002 μf, mica, 600 volts working
- C13, C14 0.005 μf, mica, 500 volts working
- C15 National, NC 800 neut. condenser
- C16 25 μf, padding condenser, 0.25" spacing
- C17 0.003 μf, mica, 2500 volts working
- C18 50 μf per section, 0.171" spacing
- C19, C20 0.002 μf, mica
- R1 250,000 ohms, 1/2 watt
- R2, R4 20,000 ohms, 1 watt
- R3 100,000 ohms, 1 watt
- R5 50 ohms (carbon) 1/2 watt

- R6 150,000 ohms, 1 watt
- R7 25,000 ohms, 1 watt
- R8, R9, R10, } Special meter shunt
- R12, R13 } (#28 enameled wire on tie strip) see text
- R11 3,000 ohms, 10 watts
- RFC1, RFC2 National R-100
- RFC3 National R-300
- L1 10 turns of #20 wire wound 1" length on National form XR-5
- L2, L3, L4 See coil data
- L5, L6 B & W TVL coils
- SW1 4 pole, 3-position Isolantite switch, non-shorting type
- SW2 2 pole, 5-position switch
- T1 10 volt, filament transformer
- T2 6.3 volt, filament transformer

PARTS LIST — POWER SUPPLY

- C1 4 μf, at 2000 volt, oil impregnated paper
- C2, C3 8 μf, 450 volt, electrolytic
- C4 20 μf, 450 volt, electrolytic
- C5 0.05 to 0.25—adjust to suit keying requirements
- C6, C7 20 μf, 150 volt, electrolytic
- R1 50,000 ohms, 100 watts
- R2, R3 0.5 megohm, 1 watt
- R4 5,000 ohms, 25 watts
- R5 10,000 ohms, 1/2 watt
- R6 3,000 ohms, 10 watts
- R7 50,000 ohms, 10 watts
- R8 100,000 ohms, 1/2 watt
- L1 12 h at 300 ma.
- L2 13 h at 250 ma.
- L3 8 h at 55 ma.
- SW1, SW2 SPST toggle, 12 amp rating, 115 volt, 6-watt indicator panel lamp
- I1, I2 Thordarson T19F75 or equivalent, 2.5 volt at 5 amps.
- T2 Thordarson T19P60 or equivalent, 1875-0-1875 and 1560-0-1560 at 300 ma.
- T3 Thordarson T75R30 or equivalent, 435-0-435 at 250 ma., 80 volt bias tap
- T4 Thordarson T19F76 or equivalent, 5 volt at 3 amps, 6.3 volt at 6 amps.

GRID DRIVING POWER

(Continued from Page 1, Column 2)

stages are being properly driven. If, as in many cases, an amplifier tube is to be operated with conditions differing somewhat from those published under a set of suggested typical operating conditions, the performance can be checked as follows. First, load the amplifier to the desired value of plate current. Then vary the grid current slowly (tank circuit tuning remaining unchanged) and note the change in output.

If the change in output is roughly proportional to the change in grid drive, the stage is underdriven. Then drive should be increased until very little increase in output results from a large increase in drive. Under this condition, the stage is said to be saturated. Of course, the maximum rated value of dc grid current should not be exceeded.

The penalties for an underdriven stage are low power output, low efficiency, and if the stage is plate modulated, severe distortion at high levels of modulation. The latter condition will readily be recognized as downward modulation, and if a pure sine wave is used for test, a decrease in average plate current will be noted as the modulation level is increased.

Correct Grid Drive Important

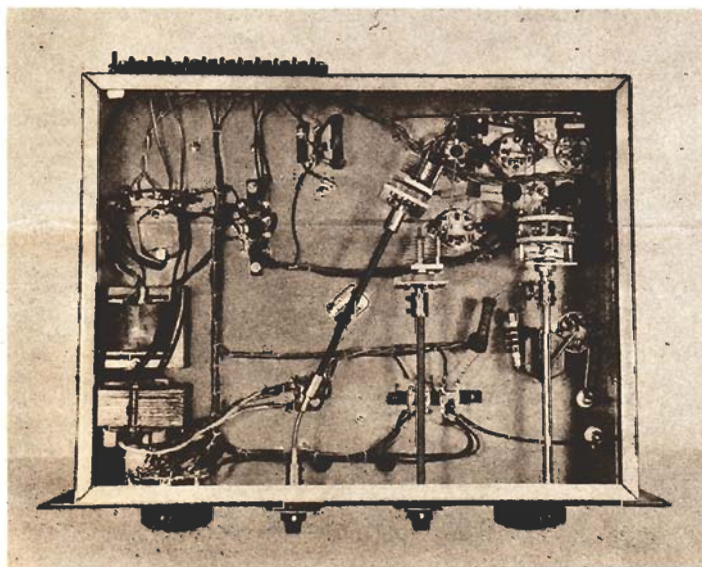
It is very desirable to saturate amplifiers, especially those driven by a series of frequency multipliers. This comes about because it is rarely possible to saturate frequency multipliers and stay within tube ratings. Consequently, a small decrease in supply voltage on the multiplier stages may cause a large decrease in grid drive and in output of the final amplifier stage. It is important, therefore, that the amplifier grid be saturated so that full output is maintained regardless of variations in supply voltages.

It is possible to overdrive as well as underdrive tubes. However, overdrive occurs rarely. There is little to be gained by over-driving and something to lose. Although there should be no actual damage to the grid or cathode unless the maximum ratings for dc grid current or dc grid bias are exceeded, over-driving can cause excess harmonic radiation and low power gain.

Over-driving a beam tube or pentode may cause the screen grid to be overloaded before the control grid. This condition may be checked by metering the screen current to determine whether the screen input is within ratings. Adjustment of both bias and screen voltage may be necessary to allow the tube to be properly saturated and still remain within screen input ratings.

The correct amount of grid drive is an important detail of power tube application. With other conditions properly maintained, it insures high power gain, high plate efficiency, and long tube life.

AN UNDER CHASSIS VIEW



Logical arrangement of components and wiring adds to the transmitter's operating stability.

NEW 816 VOLTAGE RATINGS

7500 volts is the new peak inverse voltage rating for the RCA-816. A pair of these tubes can now be used in a full-wave rectifier with a standard plate transformer having a 5000-volt center-tapped secondary. Such use is well within the new rating and with average quality components in a choke-input circuit will provide 250 ma. and a filter output voltage of about 2150 volts.

ECHOS

The "Torpedo Twin" article which appeared in the May-June issue of HAM TIPS listed R10 and R11 as 2-6000 ohm resistors in series. Actually the total resistance should have been 42,500 ohms minimum. A value of 45,000 ohms, or more, will be required in practice, and this can be obtained from a 20,000-ohm resistor in series with a 25,000-ohm resistor.



RCA-8005 TRANSMITTING TRIODE

FULL INPUT TO 60 MEGACYCLES.

Amateur Net **\$7.00**

Features

- Ceramic washer minimizes corona discharge—provides superior bond to glass and plate cap, eliminating strain.
- Nonex hard-glass envelope will not crack, buckle or puncture under high operating temperatures.
- Oversized 32.5 watt filament—the same as used in much larger tubes—has enormous reserve of emission.
- Drawn-tungsten seal rods have smoother surfaces—hence, provide superior seals against air leakage.
- Zirconium-coated molybdenum anode provides unusually rapid heat dissipation and permits greater power input.
- Sturdy metal base and low-loss ceramic insert combine strength with high heat and insulation resistance.
- A pair of 807's in Class B will plate modulate an 8005. A pair of 811's in Class B will handle two 8005's.
- The 8005 can be used within its ratings to replace any of the older types such as the 203A, 211, and 845. It is only necessary to install a new socket, install a flexible lead to the plate cap, and re-neutralize the circuit.

Application Considerations

- **Power Gain.** Figure on a grid-to-plate power gain of 20 to 1 and you will have ample drive available. One 807 driver is okay. At 30 Mc, an 807 or 6L6 doubler with only 400 volts on its plate will do the job. An 807 buffer or doubler will drive a pair of 8005's.
- **Neutralization.** Adjust neutralizing condenser so that the grid-current peak and the plate-current dip occur at exactly the same point of plate tank tuning.
- **Circuit Q.** In single-ended service, the split-stator plate-tuning capacitance should be approximately 0.8 μf per section, per meter.
- **Mounting.** The 8005 can be mounted horizontally as well as vertically.

8005 TRANSMITTING TRIODE GENERAL DATA

Electrical:	
Filament, Thoriated Tungsten:	
Voltage	10 ac or dc volts
Current	3.25 amp
Amplification Factor	20
Direct Interelectrode Capacitances:	
Grid to Plate	5 μf
Grid to Filament	6.4 μf
Plate to Filament	1.0 μf

Mechanical:	
Mounting Position	Vertical, base down; or Horizontal, pins 1 and 4 in vertical plane
Overall Length	6-13/32" \pm 5/32"
Seated Length	5-23/32" \pm 5/32"
Maximum Diameter	2-7/16"
Bulb	ST-19
Cap	Medium, with insulating Collar
Base	Medium Metal-Shell Small 4-Pin, Bayonet

AF POWER AMPLIFIER AND MODULATOR—CLASS B

Maximum Ratings, Absolute Values:			
	CCS†	ICAS‡	
DC Plate Voltage	1250 max.	1500 max.	volts
Max.-Signal DC Plate Cur.*	200 max.	200 max.	ma.
Max.-Signal Plate Input*	225 max.	250 max.	watts
Plate Dissipation*	75 max.	85 max.	watts
Typical Operation:			
<i>Values are for 2 tubes</i>			
DC Plate Voltage	1250	1500	volts
DC Grid Voltage‡	-55	-67.5	volts
Peak AF Grid-to-Grid Voltage	290	330	volts

Zero-Signal DC Plate Current	40	40	ma.
Max.-Signal DC Plate Current	320	330	ma.
Effective Load Resistance (plate-to-plate)	8000	9800	ohms
Max.-Signal Driving Power (Approx.)	4	5.5	watts
Max.-Signal Power Output (Approx.)	250	330	watts

PLATE-MODULATED RF POWER AMPLIFIER—CLASS C TELEPHONY

Carrier conditions per tube for use with a max. modulation factor of 1.0

Maximum Ratings, Absolute Values:			
	CCS†	ICAS‡	
DC Plate Voltage	1000 max.	1250 max.	volts
DC Grid Voltage	-200 max.	-200 max.	volts
DC Plate Current	160 max.	300 max.	ma.
DC Grid Current	45 max.	45 max.	ma.
Plate Input	160 max.	240 max.	watts
Plate Dissipation	50 max.	75 max.	watts
Typical Operation:			
DC Plate Voltage	1000	1250	volts
DC Grid Voltage§	-195	-195	volts
Peak RF Grid Voltage	350	350	volts
DC Plate Current	160	190	ma.
DC Grid Current (Approx.)¶	28	28	ma.
Driving Power (Approx.)‡	9	9	watts
Power Output (Approx.)	115	170	watts

RF POWER AMPLIFIER AND OSCILLATOR—CLASS C TELEGRAPHY

*Key-down conditions per tube without modulation**

Maximum Ratings, Absolute Values:			
	CCS†	ICAS‡	
DC Plate Voltage	1250 max.	1500 max.	volts
DC Grid Voltage	-200 max.	-200 max.	volts
DC Plate Current	200 max.	200 max.	ma.
DC Grid Current	45 max.	45 max.	ma.
Plate Input	240 max.	300 max.	watts
Plate Dissipation	75 max.	85 max.	watts
Typical Operation:			
DC Plate Voltage	1250	1500	volts
DC Grid Voltage**	-115	-130	volts
Peak RF Grid Voltage	3800	4000	ohms
DC Plate Current	520	560	ma.
DC Grid Current	240	255	ma.
DC Plate Current (Approx.)‡	190	200	ma.
DC Grid Current (Approx.)‡	30	32	ma.
Driving Power (Approx.)‡	6.5	7.5	watts
Power Output (Approx.)	170	220	watts

† Continuous Commercial Service.
 ‡ Intermittent Commercial and Amateur Service.
 * Averaged over any audio-frequency cycle of sine-wave form.
 # For ac filament supply.
 § Obtained preferably from grid resistor of value shown, or combination of grid resistor with either fixed supply or suitably by-passed cathode resistor.
 ¶ Subject to wide variations depending on the impedance of the load circuit.
 ** Modulation essentially negative may be used, if the positive peak of the audio-frequency envelope does not exceed 115% of the carrier conditions.
 *** Obtained from a fixed supply, by grid resistor (3800, 4000) or by cathode resistor (520, 560).

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