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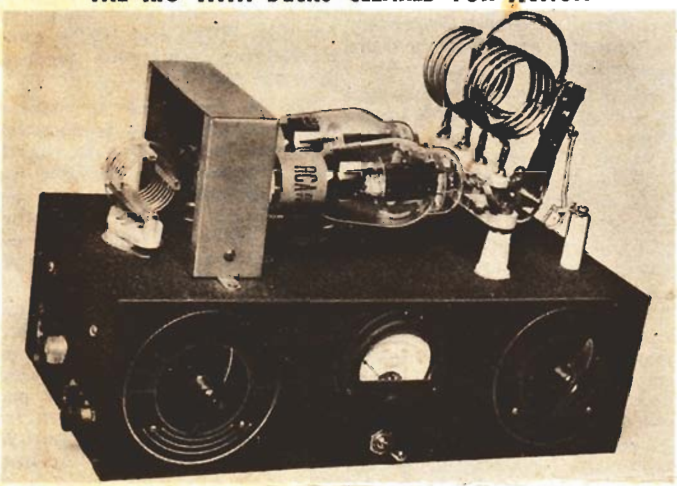
807's VERSATILE IN RF SERVICE AND CLASS B MODULATION

THE RIG WITH DECKS CLEARED FOR ACTION



Those 807's mounted in "torpedo" fashion are one good reason this fine looking transmitter has no fear of parasitics.

NEW MODULATOR CIRCUIT UTILIZES 807's IN CLASS B WITH ZERO BIAS

A. M. Seybold, W2RYI

During the intervening years since its development by RCA back in 1936, the 807 has become the Amateurs' number one favorite rf transmitting tube. However, comparatively little use has been made of its excellent class AB_2 characteristics in af modulator service, perhaps because of the difficulties encountered in providing the required regulation of control-grid bias and screen-grid voltages.

In order to avoid these difficulties, the possibility of using this tube as a zero-bias triode in class B audio service was intriguing. Its low price, its small size, and its ability to deliver a great deal of power at low plate voltage provided the impetus for a series of experiments.

The first idea was to tie the control grid and the screen grid together in a manner similar to the way the old type 46 was operated in zero-bias class B service. This produced a low-perveance triode with a plate family of curves that looked like the receding hair line of the Java Ape Man. It would be no brain wave to operate on such a plate family either, for distortion is high and efficiency low.

Another idea was to ground the control grids and put the driving signal on the screen grids at zero-bias. This arrangement produced a good plate family, but required excessive driving voltage for satisfactory power output. Several other schemes were tested with varying results— and then it happened!

One-hundred and twenty watts of audio—with less than six watts of driving power—at only 750 plate volts. And from two tubes which cost only $4.60! What's more, it's very simple. Just connect the cathodes to ground, put the driver transformer between the screen grids, and ground the center tap. Then, connect the control grid of each tube to its screen grid through a 20,000-ohm resistor. That's all there is to it.

During the development of this circuit, plate families were taken with various values of resistance between the #2 grid and the #1 grid. The series of curves shown in Fig. 4 illustrate the effect of the resistance in the #1 grid circuit upon the

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TORPEDO TWINS IN 150 WATT FINAL WORKS ALL BANDS FROM 3 TO 30 MC.

By J. H. Owens, W2FTW

One-hundred-and-fifty watts input to a cw final with a plate supply of only 750 volts! All-band coverage in the HF region from 3 to 30 Mc, with plug-in coils! Complete freedom from parasitics, without neutralization! And less than two watts of grid-driving power easily obtainable from a 6V6-GT doubler! It's readily possible with a pair of RCA-807's.

Fig. 1a illustrates the usual layout for 807's. Little wonder that it causes so much difficulty when the three prominent feed-back paths are recognized and understood. As the arrows show, direct electrostatic coupling exists between the grid and plate circuits, (1) from the plate tank coil to the grid lead inside of the tube stem, (2) from the plate electrode to the grid tank coil, and (3) from the plate tank condenser to the grid tank condenser. The heavy dashed lines indicate the shielding required to eliminate these sources of stray coupling.

The Torpedo Attack

Fig. 1b shows a preferred mechanical layout for the 807's. Because the tube is mounted horizontally, "torpedo" fashion, it is naturally more stable than it would be in a conventional arrangement because of space isolation alone. The tube socket is mounted through a metal plate which acts as a shield against electrostatic and electromagnetic forces above the chassis. The plate coil is mounted as illustrated at right angles to the grid coil. A tube shield is not necessary.

Under the chassis, the grid and plate tank condensers are mounted with their rotor sides face to face. This arrangement, plus the greater distance of separation, usually provides sufficient isolation. For additional isolation, however, a shield, transformer, capacitor, or some other metal-cased component can be installed in the space indicated by the dashed line. External feedback is thus reduced to a minimum.

Beam Tubes Versus Triodes

Usually unwanted oscillations in electron tube apparatus result from interaction between the input and output circuits. The tendency toward instability depends on the degree of coupling and the grid-plate power gain. If there is zero coupling, there can be no feedback oscillation. Likewise, if there is zero power gain, there can be no oscillation. In a practical circuit, the degree of coupling and the

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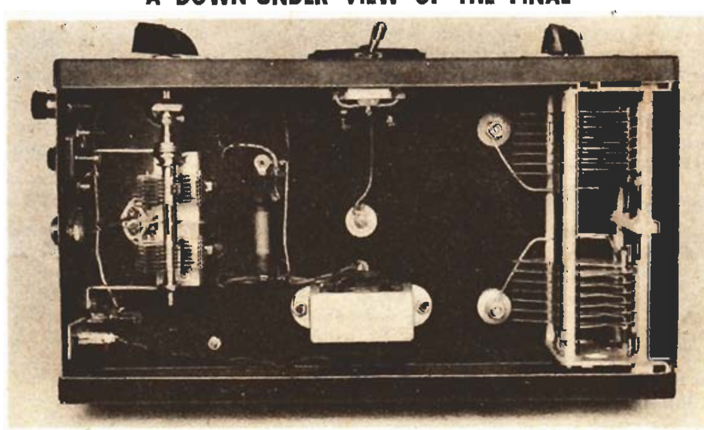
A DOWN-UNDER VIEW OF THE FINAL



The mechanical arrangement of components contributes to its highly stable operation.

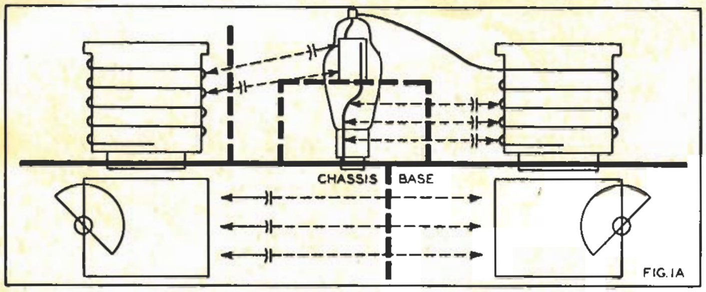


Fig. 1a. This customary layout for the 807 tube may result in feedback difficulties.

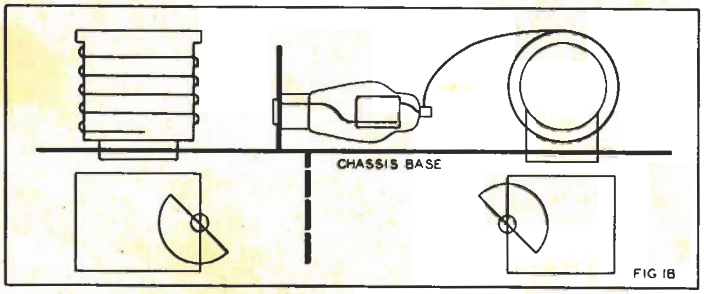


Fig. 1b. A preferred mechanical layout for the same tube which reduces feedback to a minimum.

TORPEDO TWINS

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grid-plate power gain are positive factors, and oscillations are therefore possible whenever the feedback path is capable of transferring driving power to the grid.

In comparison with a beam tube, a triode having a power gain of only twenty is quite easy to stabilize. Since the power gain is relatively low, satisfactory operation may be expected even though neutralization and grid-plate isolation are imperfect.

However, a beam tube such as the 807, having a power gain of approximately 250, requires more careful handling. The plate has only to "breathe" on the grid to make the circuits oscillate. However, if the power gain of the beam tube is lowered to the level of the triode, it is more easily stabilized than the latter because of its internal shielding. It follows, then, that beam tubes are more stable than triodes when operated under identical performance conditions.

Parasitics

Parasitics are less likely to occur in equipment using old-type low-gain triodes; that is, tubes that have a power gain of less than ten or tubes that have wide electrode spacings and heavy electron transit-time loading. Parasitics will be found, however, in modern equipment using modern tubes, triodes included.

Although parasitics are invisible, they furnish plenty of evidence of their presence. They are the commonest cause of plate tank condenser flash-overs. They heat plate and grid terminal caps. They prevent a pronounced dip in plate current when the unloaded tank circuit is tuned through resonance. They keep the plate efficiency low, and they are responsible for much modulation splatter and BCI.

If a circuit is free of parasitics, the tube will act like a pure resistance when excitation is removed. With full plate (and screen) voltage applied and with the plate tank unloaded, the grid current should drop to zero. Under such conditions, it should not be possible to light a neon bulb at the plate. In making such a test, it is essential to drop the plate voltage so that the rated plate dissipation is not exceeded.

LFP's, NFP's, HFP's?

There are three common forms of parasitics, LFP's, NFP's, and HFP's. LFP's are parasitics lower in frequency than the operating frequency. NFP's are parasitics that are simply self-oscillations at the normal operating frequency. HFP's are parasitics higher than the operating frequency.

LFP's are encountered in electron tube amplifiers having rf chokes in both the grid and plate circuits. When these chokes resonate, low-frequency parasitics can be generated in tuned-grid, tuned-plate fashion. They can be suppressed by removal of either choke or by the use of a plate choke having a different resonant frequency than the grid choke. NFP's, commonly spoken of as "regeneration", and HFP's, also a common type of parasitic, are not so easily eliminated.

RF Degeneration

Although degeneration is known to benefit audio systems, little consideration has been given to it for rf work. Yet its benefits can be essentially the same. It helps reduce the percentage of undesired harmonics and the trouble they cause when radiated. Moreover, when properly employed, it positively eliminates feedback parasitics.

Parasitic suppression through degeneration should be regarded as a desirable design practice rather than as an expedient for parasitic correction. It costs so little—just a slight increase in driving-power requirements. And the mechanics are so simple—just a few ohms of resistance in the proper places.

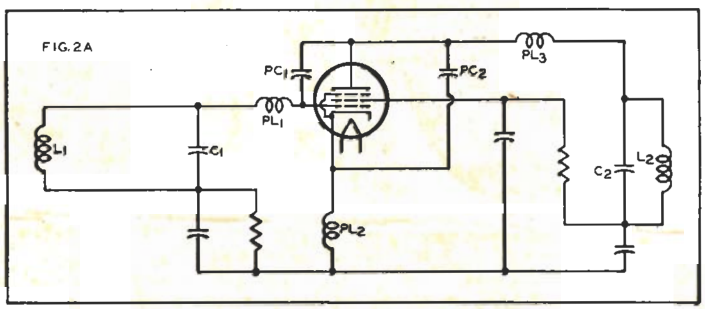

Fig. 2a. Parasifics are encouraged in this rf amplifier circuit arrangement.

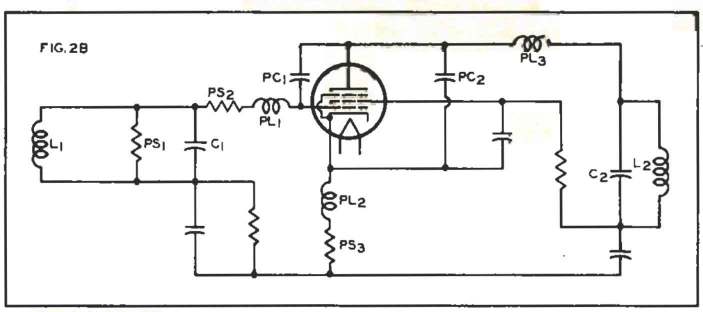

Fig. 2b. The same circuit after it has been stabilized by degeneration.

Fig. 2a shows a few of the inductive and capacitive elements that may cause parasitics in a typical rf amplifier. HFP's are quite likely to be found in such an amplifier because at the frequency where the parasitic elements resonate, the regular tuning condensers C_1 and C_2 act like bypass condensers and provide a return path for the parasitic currents.

Fig. 2b shows the same circuit after it has been stabilized by degeneration. A parasitic suppressor, PS_2 is located in the grid circuit where dc and normal-frequency rf currents are small, but where HFP currents would be large. It reduces the circuit power gain just a little but kills HFP's and NFP's which result from capacitive feedback from the plate.

PS_3 is connected to provide simple cathode circuit degeneration. It lowers the power gain slightly but compensates by reducing harmonic generation. Parasitic element PL_3 has been left undisturbed because without a cooperating element in the grid or cathode circuit it can do little harm.

Non-inductive carbon resistors are favored over parasitic chokes because the chokes simply shift the resonant frequency of the parasitic circuits. While this expedient may be very effective for a fixed frequency transmitter, it is not the answer to a multi-band Amateur unit.

Other Stabilizing Stunts

A very effective way of suppressing NFP's is to place a small load across the grid tank circuit. A carbon resistor (PS_1) having a value of something between 5000 and 50,000 ohms will really get results with an insertion loss of only a fraction of a watt. The resistor simply limits the impedance of the grid tank so that minute currents fed back from the plate cannot develop excessive grid voltages which react to cause greater plate-current fluctuations and eventually self-oscillations.

If the 807 is loaded to less than the maximum rated plate current of 100 milliamperes, the screen-grid

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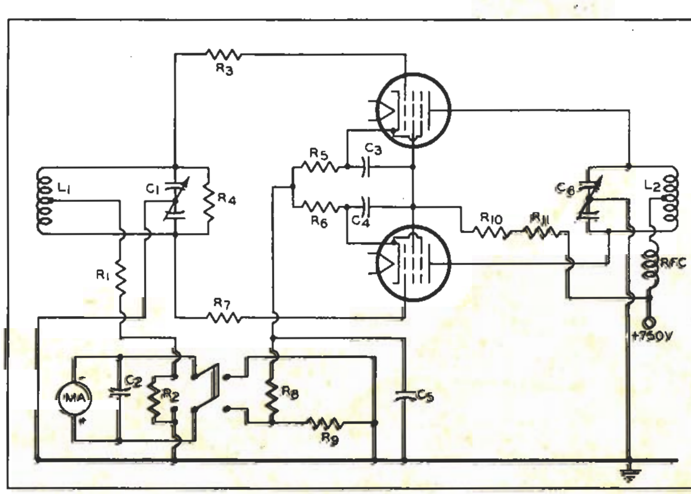

Fig. 3. Schematic of the 150-watt final amplifier using a pair of 807's.

CLASS B MODULATOR

(Continued from Page 1, Column 2)

shape of the diode line. The driving voltage designated Ec is that which is applied directly to the #2 grid. Low values of resistance give poor knees, but as the resistance is increased, the knees improve, until the optimum condition is reached at about 20,000 ohms.

With this value, it can be seen from Fig. 5 that a satisfactory plate family is produced. Grid-current curves for the new zero bias connection are shown as dotted lines, and plate load lines are shown for

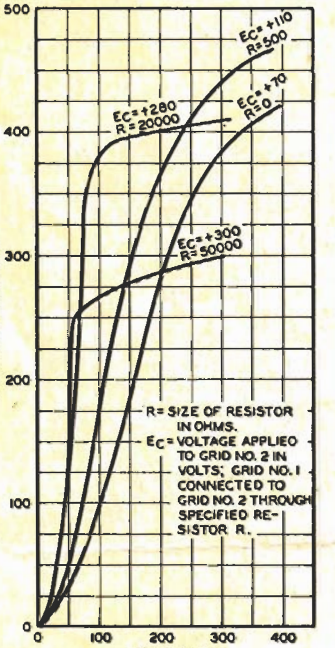

Fig. 4. Effect of the resistor in the #1 grid circuit upon EB vs IB characteristics.

three operating voltages. With a 750-volt supply, a plate-to-plate load of 6600 ohms, and a driving source giving 555 peak volts grid-to-grid, 120 watts of audio are available. The power to drive the grids is greater than that needed for class AB_2, but this is no bardship because a push-pull triode driver will easily furnish the 5.3 watts needed. Fig. 6 shows the circuit for driver and output stages used in the tests at W2RYI.

The only important technical difference between zero bias 807's and regular zero-bias class B triodes is in the values of positive grid impedance. Whereas most of the high-mu zero-bias triodes require low-voltage high-current driving signals, the 807's take excitation at high voltage but with low current.

Computations for driver tubes and transformer ratios for the new method of operation are not difficult to make. The 807's present to the driver a fairly constant load applied continuously, so the computations are just a matter of matching impedances. First, it is necessary to select the driver tubes and establish a set of conditions for them that will provide at least 20% more output than that required to drive the modulator tubes. For example, use a pair of 2A3's, which will give ten watts with a plate-to-plate load of 5000 ohms. The equivalent grid resistance of an 807 operated class B is 7100 ohms, so the driver transformer impedance ratio will be about a 1 to 1.4 step-up between total primary and one-half secondary (Impedance ratio $= 7100 \div 5000$). This is equivalent to a turns ratio of 1 to approximately 1.2, because the turns ratio is equal to the square root of the impedance ratio ($1.18 = \sqrt{1.4}$).

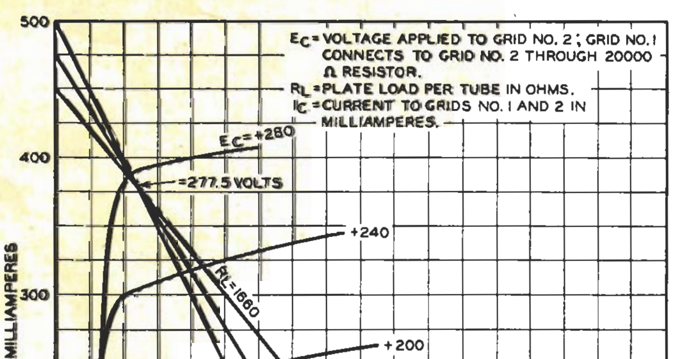

Fig. 5. The 807 plate family with a 20,000 ohm resistor in the #1 grid circuit.

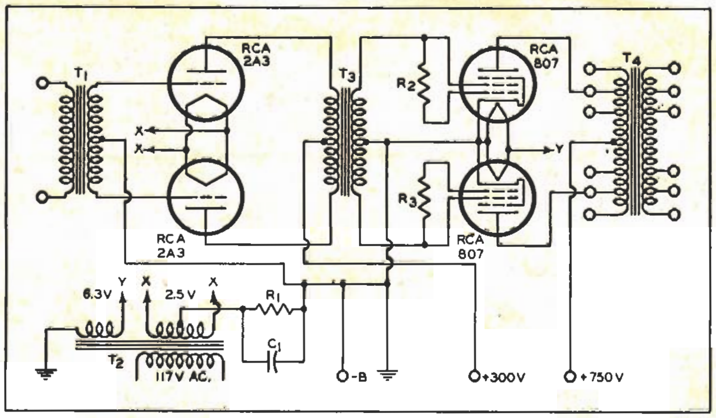

Fig. 6. Schematic for driver and output stages used in the tests at W2RYI.

If your driver transformer doesn't have the required turns ratio in the forward direction, it may be correct when reversed, i.e., with the primary used as the secondary. If this expedient does not work, it will be necessary to get a new driver transformer or a matching transformer to work in conjunction with the one you have. If you use a public address amplifier for a driver, one solution is to use a low-cost universal output transformer rated at 6 watts or more as a matching transformer. With its primary connected to the grids of the push-pull 807's, its secondary (used as a primary) will match a wide range of output impedances such as are common to most PA amplifiers.

RCA-807's, used as zero-bias class B modulators, will furnish enough high-quality audio to fully modulate a quarter-kilowatt transmitter!

PARTS LIST

T1	Input audio transformer
T2	Filament transformer
T3	Driver transformer
T4	Modulation transformer
R1	780 ohms, 10 watts, wire wound
R2, R3	20,000 ohms, 1 watt, carbon
C1	16 or 20 uf, 100 volt, electrolytic

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(Continued from Page 2, Column 4)

voltage can be reduced proportionately. The effect is an increase in stability resulting from the reduction in transconductance. The difference in power gain is so small that it is negligible.

Still another way to make the 807 meek and obedient if trouble is experienced is to let the driver tube give the grid all of the driving power it can handle. Then, the feedback power becomes small and ineffective by comparison. The procedure is to increase the bias over typical operating values and run the grid current up near maximum ratings.

A further recommended design practice is the use of a small amount of cathode bias or fixed bias. This precaution keeps the transconductance within reasonable limits and protects the tubes and other components during periods of momentary overload when excitation is lost or the plate circuit detuned.

The Torpedo Twin

The photograph and circuit diagram in Fig. 3 illustrate how a pair of 807's might be used in a 150-watt final amplifier. The same mechanical arrangement could be used on a larger chassis of a relay rack panel to provide space for a crystal oscillator and power-supply components. The circuit works all bands from 75 to 10 meters. The coils can be purchased units or they can be home-wound according to Amateur Handbook directions.

The meter arrangement is made by first removing the internal shunt from a 0-300 milliammeter. The shunt is then installed externally across one side of the DPDT toggle switch. Next, another shunt is made from a small piece of resistance wire which will make the meter read 0-30 ma. This shunt is placed across the other side of the toggle switch. A second meter, of course, is needed to calibrate the new shunt. In one position, the meter reads grid current, and in the other position it reads total cathode space current.

The foregoing arrangement is shown only for illustration. The important fact is that degeneration can be used to stabilize 807's. The effectiveness of the system is shown by the fact that the tank condenser does not flash over even when 200% modulation is applied together with other maximum rated voltages.

PARTS LIST

R1	5000 ohms ½ watt, carbon
R2	Homemade shunt (see text)
R3, R7	50 ohms (or less) ½ watt, carbon
R4	10000 to 100000 ohms 1 watt, carbon (see text)
R5, R6	25 ohms (or less) ½ watt, carbon
R8	200 ohms, 10 watt, wire wound
R9	Resistor shunt taken from meter
R10, R11	2—6000 ohms 10 watt, wire wound in series
C1	100 uuf variable, each section, Hammarlund MCD-100S
C2	500 uuf midget mica
C3, C4, C5	0.002 uf postage stamp, mica
C6	100 uuf each section, variable, 0.077" spacing, National TMC-100D
RFC	2 mh rf choke
L1, L2	See text

RCA-807 BEAM POWER AMPLIFIER

75 WATTS INPUT TO 60 MC.

Amateur Net **$2.30**

Features

- *High Perveance.* Takes 40 watts input at 400 volts, or 75 watts at 750 volts.
- *Power Gain.* A 6V6-GT tritet crystal oscillator quadrupler will drive it.
- *No neutralization.* Provides quick band change from 3 to 60 Mc.
- *Real Value.* Thirty-two-plus watts of power input per dollar.
- *Versatility.* Useful in class A, AB_1, AB_2, B, and C services for af and rf.
- *Unipotential Cathode.* Negligible hum. Requires no balancing circuit.
- *Xtal oscillator or ECO.* Will quadruple in the plate circuit and drive two 807's at 30 Mc.
- *AF Modulator.* Two 807's triode-connected, in class B will voice-modulate a quarter KW transmitter.

Application Recommendations

Follow these recommended design practices in stabilizing your transmitter:

1. **Bypass the screen grid to the cathode with a mica capacitor of not less than 0.002 uf. Use short leads.**
2. **Install an unbypassed carbon resistor of 25 ohms or less in the cathode-return circuit.**
3. **Install a carbon resistor of 50 ohms or less in the connection between the grid tank and the control-grid terminal.**
4. **Reduce the screen-grid voltage proportionately when the tube is operated at less than 100 ma plate current.**
5. **Overdrive the tube if stability is a problem. Increase grid current and grid bias but do not exceed maximum ratings.**
6. **Load the grid tank with a carbon resistor of something between 5000 and 50000 ohms.**
7. **Make sure that the grid and plate circuits are shielded against electrostatic and electromagnetic coupling.**

807 TRANSMITTING BEAM POWER AMPLIFIER

Heater for Unipotential Cathode:

Voltage	6.3 ac or dc volts
Current	0.9 amp.
Grid-Screen Mu-Factor	8.

Direct Interelectrode Capacitances:

Grid to Plate (With External shield)	0.2 max. μμf
Input	11 μμf
Output	7 μμf

A-F POWER AMPLIFIER AND MODULATOR CLASS B

Two tubes. Push-pull triode connection. Input to each grid No. 2. Grid No. 1 connected to grid No. 2 through 20,000-ohm resistor.

DC Plate Voltage	500	600	750	volts
DC Grid Voltage	0	0	0	volts
Peak AF Grid-to-Grid Voltage	555	555	555	volts
Equiv. Grid Resistance (1 tube)	7100	7100	7100	ohms
Zero-Signal DC Plate Current	6	10	15	ma.
Max.-Signal DC Plate Current	240	240	240	ma.
Max.-Signal DC Grid Current	25	25	25	ma.
Effective Load Resistance (plate to plate)	4000	5050	6650	ohms
Max.-Signal Driving Power	5.3	5.3	5.3	watts
Max.-Signal Power Output	72	91	120	watts

PLATE-MODULATED RF POWER AMPLIFIER—Class C Telephony

Beam tube connection. *Carrier conditions per tube for use with max. modulation factor of 1.0.*

DC Plate Voltage	325	400	475	600	volts
DC Grid-No. 2 Voltage***	225	225	225	275	volts
	20000	30000	50000	50000	ohms
DC Grid-No. 1 Voltage**‡	—75	—80	—85	—90	volts
Grid Current bias resistor	25000	22800	21300	22500	ohms
Peak RF Grid No. 1 Voltage	90	95	110	115	volts
DC Plate Current	80	80	83	100	ma.
DC Grid-No. 2 Current	5	5.75	5	6.5	ma.
DC Grid-No. 1 Current (Approx.)	3	3.5	4	4	ma.
Driving Power (Approx.)	0.25	0.3	0.4	0.4	watt
Power Outpnt (Approx.)	17.5	22.5	27.5	42.5	watts

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H. S. STAMM — Editor
J. H. OWENS — Technical Editor

RF AMPLIFIER AND OSCILLATOR—Class C Telegraphy

Beam tube connection. *Key-down conditions per tube without modulation*

DC Plate Voltage	400	500	600	750	volts
DC Grid-No. 2 Voltage§	250	250	250	250	volts
Series resistor	20000	42000	50000	85000	ohms
DC Grid-No. 1 Voltage **†	—45	—45	—45	—45	volts
Grid current bias resistor	12800	12800	12800	12800	ohms
Cathode bias resistor	410	410	410	410	ohms
Peak RF Grid-No. 1 Voltage	65	65	65	65	volts
DC Plate Current	100	100	100	100	ma.
DC Grid-No. 2 Current	7.5	6	7	6	ma.
DC Grid-No. 1 Current (Approx.)	3.5	3.5	3.5	3.5	ma.
Driving Power (Approx.)	0.2	0.2	0.2	0.2	watt
Power Output (Approx.)	25	30	40	50	watts

FREQUENCY DOUBLER

Beam tube connection. *Key-down conditions per tube without modulation.*

DC Plate Voltage	750 volts
DC Grid-No. 2 Voltage§ (Series resistor 91000 ohms)	250 volts
DC Grid-No. 1 Voltage **†	—90 volts
Grid Current bias resistor	18000 ohms
Cathode bias resistor	900 ohms
Peak RF Grid-No. 1 Voltage	110 volts
DC Plate Current	90 ma.
DC Grid-No. 2 Current	5.5 ma.
DC Grid-No. 1 Current (approx.)	5 ma.
Driving Power (approx.)	0.45 watt
Power Output (approx.)	40 watts

***Obtained from modulated fixed supply, or from modulated plate supply through resistor of value shown, or from unmodulated supply through audio choke.

**The total effective grid-No. 1 circuit resistance should not exceed 25000 ohms.

§Obtained from separate source, from a bleeder network, or from plate supply through a series resistor of value shown.

†Bias can be obtained from a fixed supply, or from a cathode resistor of value shown, or grid resistor of value shown, or from any combination that provides specified bias voltage.

‡For linear 100% modulation the total bias should be obtained from a grid resistor of the value shown, bypassed for rf only.