ELECTRON TUBES

RCA Application Note

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Use of the 2E24 and 2E26 at 162 Megacycles

RCA-2E24 and RCA-2E26 are beam power transmitting tubes for use at full input up to 125 megacycles and reduced input at considerably higher frequencies. This Note gives circuit and performance data on the use of these tubes as rf power amplifiers and frequency multipliers at 162 megacycles, the upper frequency of the FM band (152-162 Mc) designated for railroad, police, and other telephone communications.

The 2E24 because it has a quick-heating, low-drain filament and low plate voltage requirements is particularly suited for portable operation. Its filament requires 4 watts of power at 6.3 volts. The filament temperature 1.8 seconds after the application of filament voltage is 80% of normal. The filament is designed for intermittent operation and, therefore, should not be used under standby conditions because short tube life would result.

In a 162-megacycle amplifier, a single 2E24 at a plate voltage of 350 volts can deliver 13.5 watts of useful power. As a 162-megacycle doubler, a 2E24 can deliver 6 watts of useful power; and as a tripler, 3 watts. The 2E24 can be operated under ICAS ratings at an ambient temperature of 60° Centigrade provided the maximum bulb temperature does not exceed 210° Centigrade.

The 2E26 because it has an indirectly heated cathode is especially useful for standby operation. Operating within ICAS ratings as a single-ended, 162-megacycle amplifier, it can deliver a useful power output of 13.5 watts. When operated within CCS ratings, it can deliver up to 9.5 watts of useful power output.

The maximum plate-to-grid capacitance of the 2E24 is 0.11 μμf; that of the 2E26 is 0.2 μμf. The plate-to-grid capacitance together with the inductance due to the screen lead may cause a 2E24 or 2E26 amplifier operating in the 152-to-162-megacycle band to oscillate. Some precautions, therefore, must be taken to prevent such oscillations. For this purpose,

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screen (grid-No.2) tuning has been used with good results in single-ended and push-pull amplifiers employing either 2E24's or 2E26's. Such amplifiers operate over the entire 152-to-162-megacycle band without readjustment of the screen tuning and are illustrated in Figs.1 and 2. It has been found that the value of the screen-tuning capacitor necessary to make the amplifier stable is to a large part dependent upon the physical layout of the amplifier as well as upon the type of capacitor used. Consequently, the value of the screen-tuning capacitor needed to make the amplifier stable is best found by experiment. Its value is usually within the range of 25 to 100 μμf. The test for oscillation should be made at reduced plate and screen voltages and without fixed bias. The capacitance value should be chosen so that the amplifier without grid drive and with unloaded plate circuit does not oscillate with any combination of plate and grid circuit tuning. A particular value of capacitance can also be determined to decrease the feedback to a minimum. The proper value is indicated by minimum reaction of plate-circuit tuning on the dc grid current when plate and screen voltages are zero.

An rf choke, identified as L in Figs.1 and 2, should be placed in the dc screen-voltage lead at the tube-socket terminal. A choke of 20 turns wound for a length of 1 inch on a form 1/4 inch in diameter should suffice.

The rf grounding of the filament and filament mid-tap or the cathode socket terminals is also important because of its effect upon the stability of the amplifier. The most satisfactory method of grounding these terminals is to ground directly or to bypass to ground by the shortest possible path as shown in Fig.3. Uncased mica bypass capacitors of 100 μμf are suitable for this purpose.

The details of the plate tank circuits used with the single-ended and push-pull amplifiers are shown in Figs.4 and 5. Since the output capacitances of the 2E24 and 2E26 are the same, the same plate tank circuits can be used with either tube type. The input capacitance of the 2E26, however, is almost twice that of the 2E24 and, therefore, the same grid circuits can not be used. Circuit elements with lumped constants of suitable values are used in the grid circuits of both tubes. Power output and tube driving-power data for the 2E24 and 2E26 operating as single-ended amplifiers at 162 megacycles are shown in the curves of Figs.6, 7, and 8. The power output was measured into a lamp load and is the tube output minus the tank-circuit losses. The tube driving power does not include any losses in the grid circuit external to the tube except the power absorbed by the grid-bias resistor.

The 2E24 performance curves of Fig.5 show conditions necessary for operation of the tube under ICAS ratings of 13.5-watts maximum plate dissipation and 85-milliamperes maximum dc plate current. The values of useful power output and tube driving power are for a single-ended, 162-megacycle amplifier. The plate tank-circuit loss was found to be 3 watts so that with an input of 30 watts, the plate dissipation rating of 13.5 watts is exceeded when the useful power output drops below 13.5 watts.

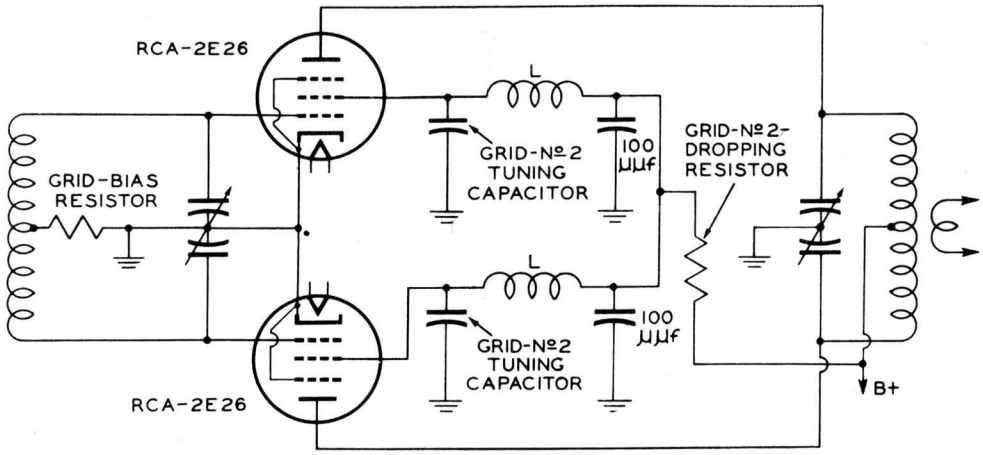


Fig. 1 - Schematic Diagram of 2E26 Push-Pull Amplifier Circuit (Identical Circuit Except for Filament and Cathode Connections Used with 2E24).

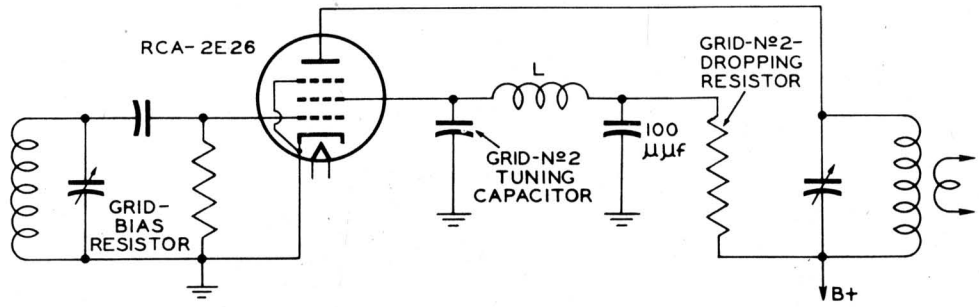
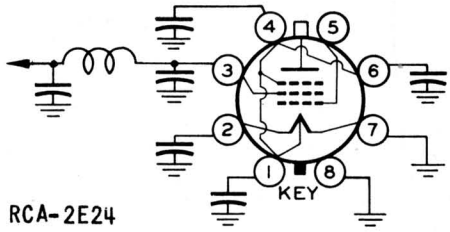


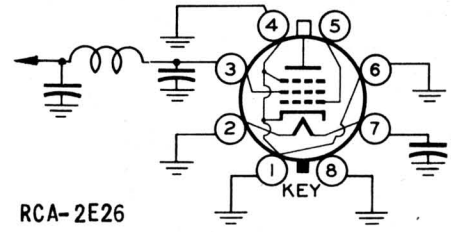
Fig. 2 - Schematic Diagram of 2E26 Single-Ended Amplifier Circuit (Identical Circuit Except for Filament and Cathode Connections Used with 2E24).



RCA-2E24

PIN 1: FILAMENT MID-TAP, GRID No.3, INTERNAL SHIELD
PIN 2: FILAMENT
PIN 3: GRID No.2
PIN 4: SAME AS PIN No.1
PIN 5: GRID No.1
PIN 6: SAME AS PIN No.1
PIN 7: FILAMENT
PIN 8: BASE SLEEVE
CAP: PLATE

LEADS FOR RF GROUNDING SHOULD BE SHORT.



RCA-2E26

PIN 1: CATHODE, GRID No.3, INTERNAL SHIELD
PIN 2: HEATER
PIN 3: GRID No.2
PIN 4: SAME AS PIN No.1
PIN 5: GRID No.1
PIN 6: SAME AS PIN No.1
PIN 7: HEATER
PIN 8: BASE SLEEVE
CAP: PLATE

Fig. 3 - Socket Connections for RF Grounding

As can be seen from the curves of Fig.6, a tube driving power of at least 2 watts is necessary to obtain power output of 13.5 watts. This driving power, which is much larger than that required at low frequencies, is needed because of I^2R losses in the grid-cathode structure of the tube and transit-time losses between the grid and cathode. A push-pull 2E24 amplifier will deliver approximately twice the power of a single-ended amplifier.

The performance curves for the 2E26 in Figs.7 and 8 show conditions necessary for operation of the tube under ICAS and CCS ratings, respectively. The maximum plate dissipation of the tube under ICAS ratings is 13.5 watts, and under CCS ratings is 10 watts.

The 2E24 operating as a doubler at 162 megacycles will give a useful power output of 6 watts under the operating conditions shown below.

DC Plate Voltage	300	Volts
DC Plate Current	66	Milliamperes
DC Grid-No.1 (Control-Grid) Current	3.5	Milliamperes
DC Grid-No.1 Voltage*	-175	Volts
DC Grid-No.2 (Screen) Voltage#	170	Volts
DC Power Input	19.5	Watts
Useful Power Output	6	Watts

* Obtained with 30000-ohm grid resistor and 70 volts of fixed bias.

\# Obtained from the plate supply through a 15000-ohm series resistor.

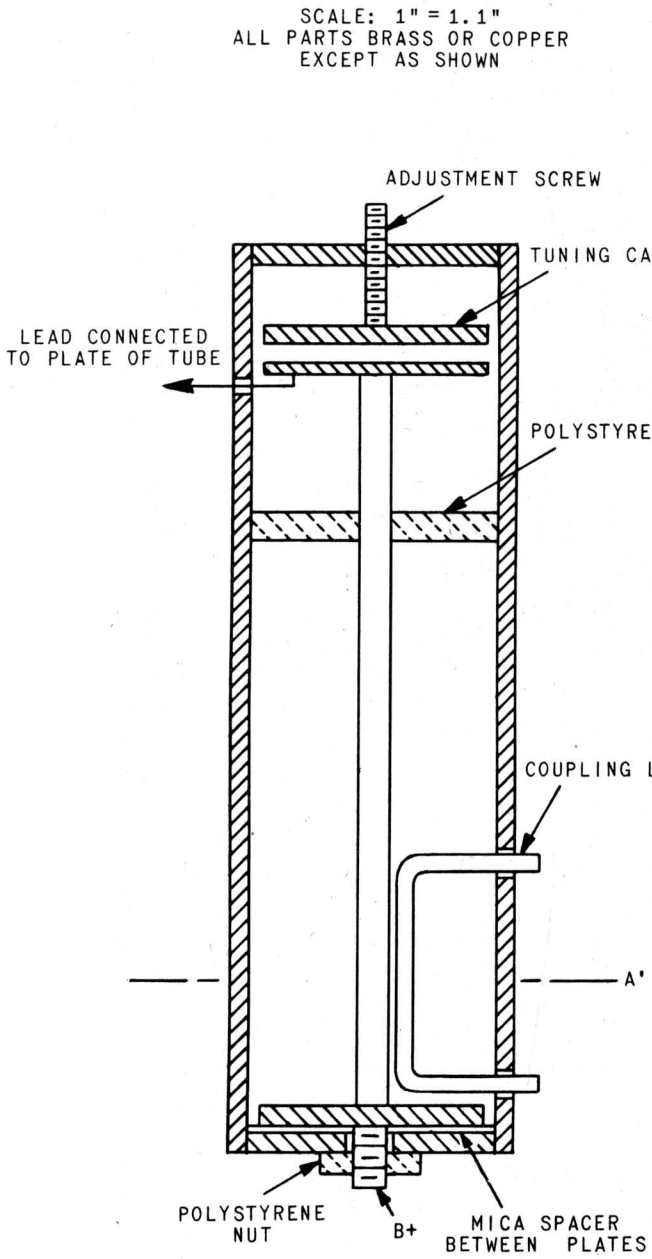
The 2E24 operating as a tripler at 162 megacycles will give a useful power output of 3 watts under the operating conditions shown below.

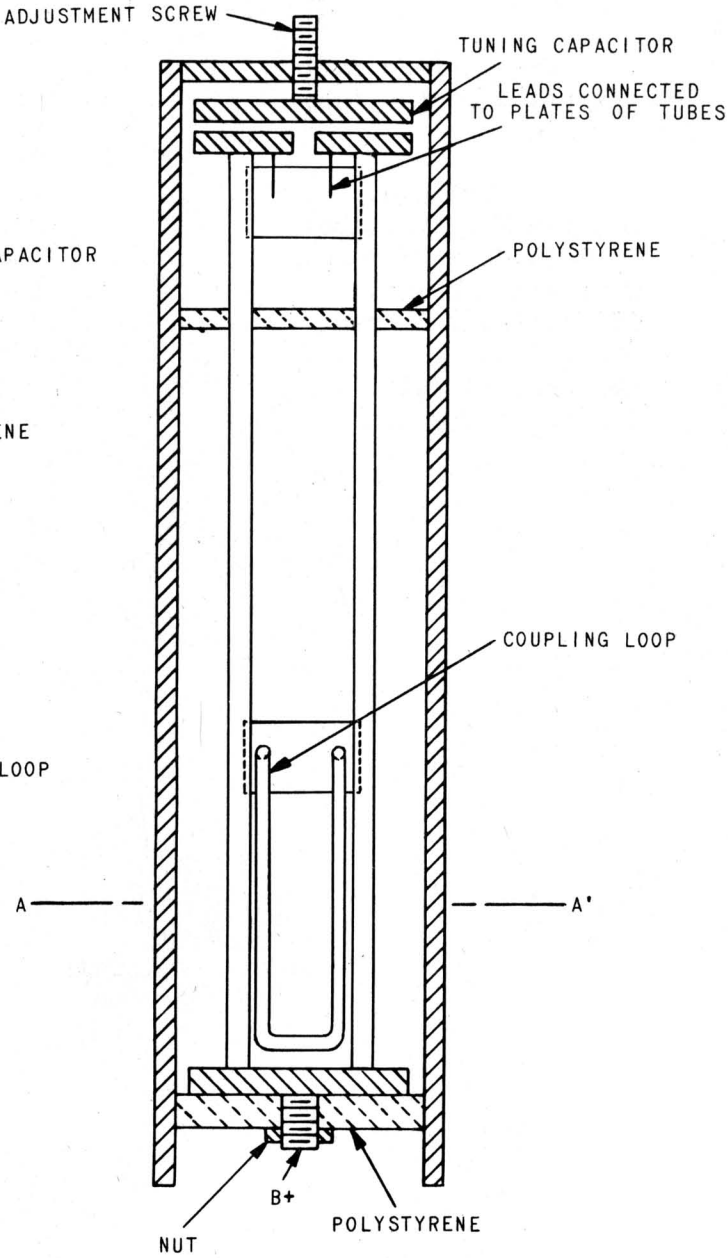
DC Plate Voltage	200	Volts
DC Plate Current	80	Milliamperes
DC Grid-No.1 Current	3.5	Milliamperes
DC Grid-No.1 Voltage*	-175	Volts
DC Grid-No.2 Voltage	200	Volts
DC Power Input	16	Watts
Useful Power Output	3	Watts

* Obtained with 30000-ohm grid resistor and 70 volts of fixed bias.

The maximum ratings of the 2E24 for ICAS class C telegraphy operation of the tube at 162 megacycles are given below.

DC Plate Voltage	450 max.	Volts
DC Grid-No.2 Voltage	200 max.	Volts
DC Grid-No.1 Voltage	-175 max.	Volts
DC Plate Current	85 max.	Milliamperes
DC Grid-No.1 Current	3.5 max.	Milliamperes
Plate Input	30 max.	Watts
Grid-No.2 Input	2.5 max.	Watts
Plate Dissipation	13.5 max.	Watts





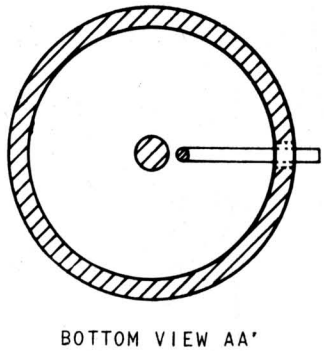


Fig. 4 - Single-Ended 162-Megacycle Tank Circuit

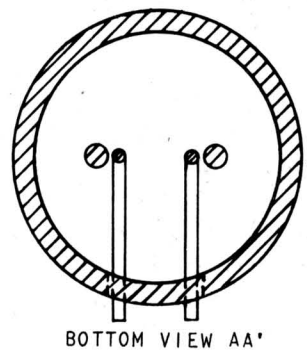


Fig. 5 - Push-Pull 162-Megacycle Tank Circuit

The maximum ratings of the 2E26 for CCS and ICAS class C telegraphy operation of the tube at 162 megacycles are given below.

	CCS	ICAS	
DC Plate Voltage.	375 max.	450 max. . . .	Volts
DC Grid-No.2 Voltage.	200 max.	200 max. . . .	Volts
DC Grid-No.1 Voltage.	-175 max.	-175 max. . . .	Volts
DC Plate Current.	75 max.	85 max.	Milliamperes
DC Grid-No.1 Current	3.5 max.	3.5 max.	Milliamperes
Plate Input	22.5 max.	30 max. . . .	Watts
Grid-No.2 Input	2.5 max.	2.5 max. . . .	Watts
Plate Dissipation	10 max.	13.5 max. . . .	Watts

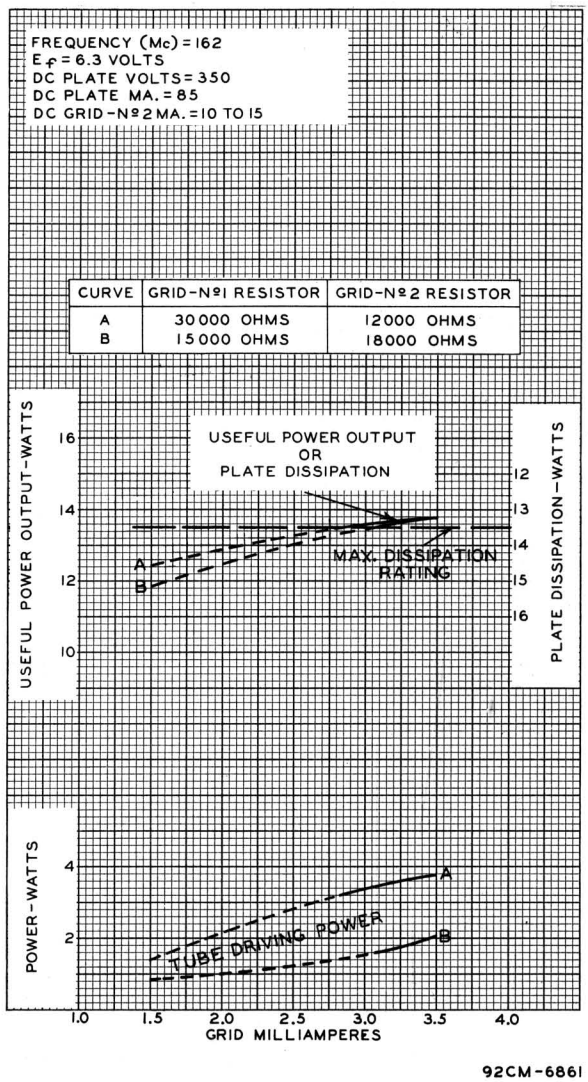


Fig. 6 - ICAS Operation Characteristics for Single-Ended 2E24

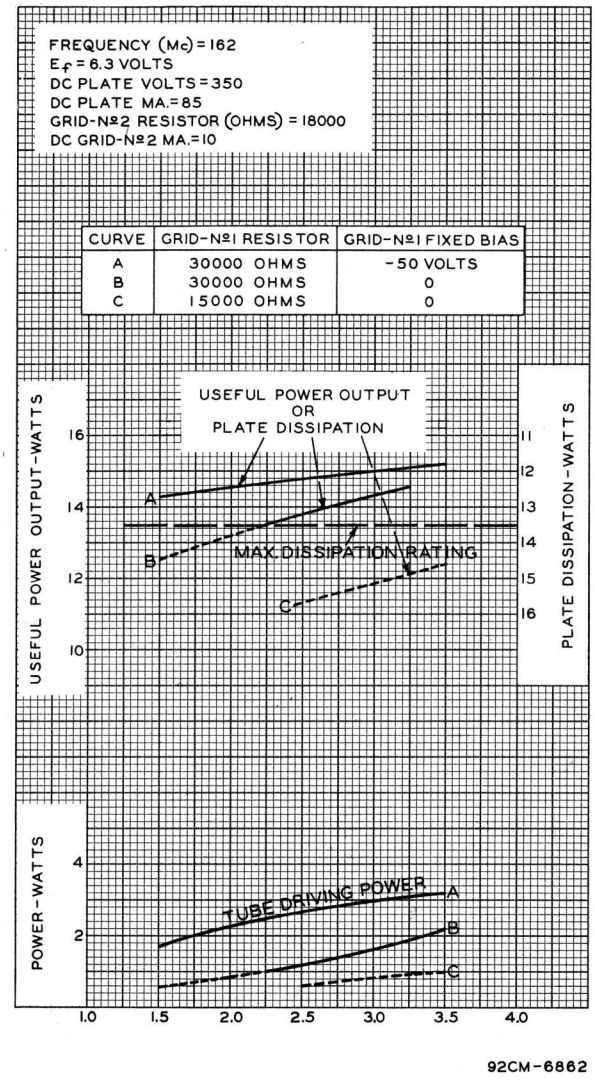


Fig. 7 - ICAS Operation Characteristics for Single-Ended 2E26

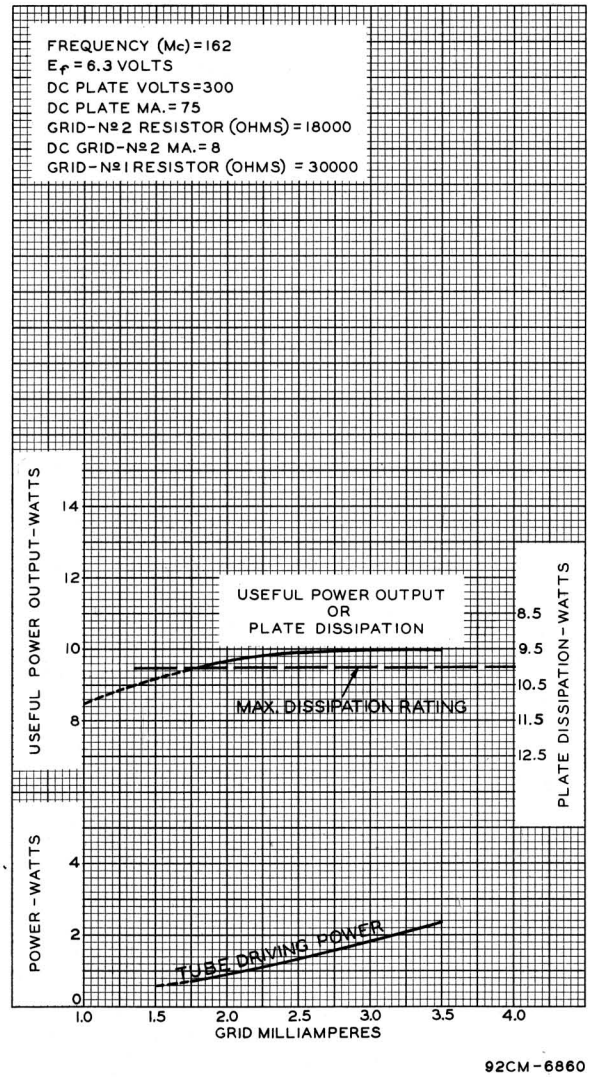


Fig. 8 - CCS Operation Characteristics for Single-Ended 2E26