ELECTRON TUBES

RCA Application Note

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# Use of VHF Beam Power Amplifier RCA-5763 as Frequency Multiplier up to 175 Megacycles

The RCA 5763 is a nine-pin miniature beam power amplifier developed for use in the low-power multiplier stages of high-frequency transmitters in which the operating requirements are too severe to be met adequately with receiving type tubes. The small size of the 5763 and its high emission capability at low values of heater voltage make it particularly desirable for use either in compact mobile transmitters or in low-power stages of stationary equipment.

## General Considerations

The high-frequency characteristics of a tube in class C amplifier service depend in part upon the low-frequency properties of the tube such as: (a) high current at low plate voltage (because the rf output peak voltage is subtracted from the supplied dc voltage to determine the actual instantaneous plate voltage), (b) a large change in plate current between cutoff and a moderately positive grid, and (c) sharp cutoff. In the curves of average plate characteristics for the 5763, given in Fig.1, a grid-No.1 voltage $E_{c1}$ = -15 volts may well be taken as the value for plate current cutoff at a plate voltage of 60 volts. A grid-voltage swing from -15 to +15 volts causes a 280-milliampere change in plate current. These increments in grid voltage and plate current show the effective amperes per volt to correspond approximately to 10000 micromhos, a high value for the conduction part of the cycle.

The peak value of cathode current required of a tube in class C amplifier service is high; in multiplier service, this value is increased because smaller plate-current conduction angles are required for efficient operation. Moreover, tubes for mobile service are quite likely to be operated at heater voltages above or below rated values because of supply voltage variations. In order to take care of such operating conditions the 5763 is provided with a cathode having a large emitting area. In normal operation, the heater should be operated at 6.0 volts rather than



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TUBE DEPARTMENT
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the usual 6.3 volts. When this tube is used with stationary equipment having a 6.3-volt ac heater supply, a series resistor should be used to drop the heater voltage to 6.0 volts. Failure to observe this precaution is likely to result in slightly reduced tube life and a tendency

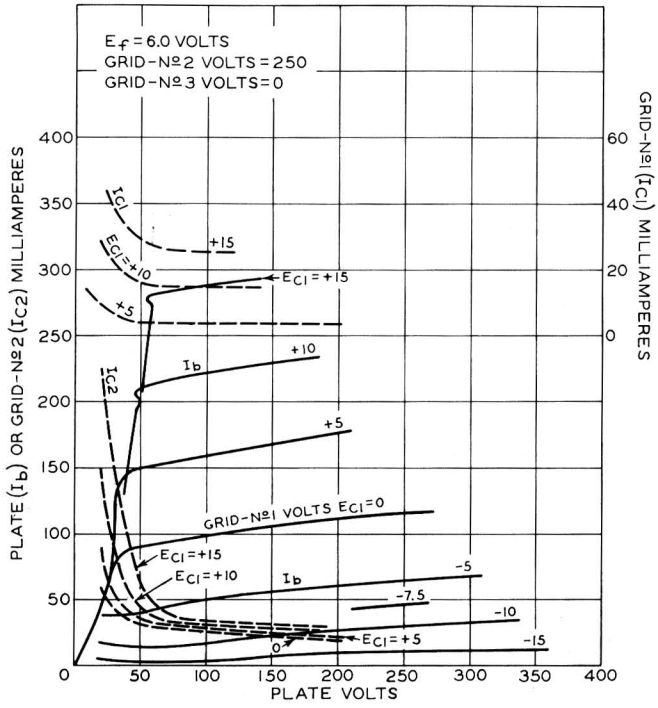



*Fig. 1 - Average Characteristics of VHF Beam Power Amplifier RCA-5763.*

toward grid emission at high line voltage. As a result of the heater and cathode design, the oscillator power output drops less than 10 per cent for a change in heater voltage from 6.0 to 5.25 volts.

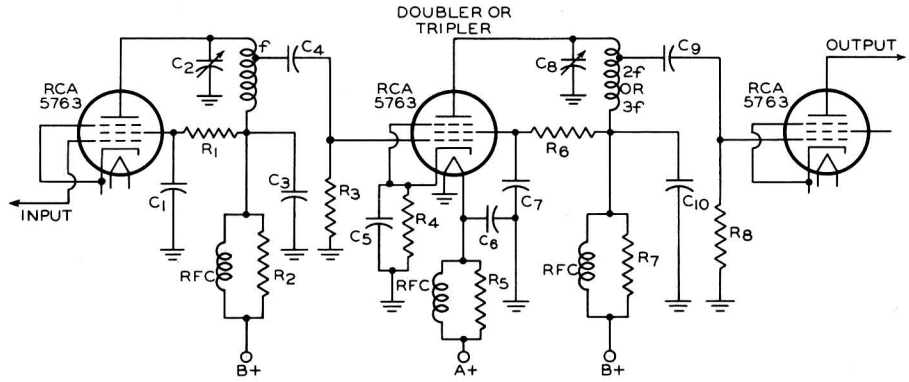
The 5763 has several features which contribute to its efficient performance at high frequencies. One of these features is the 9-pin miniature envelope with its integral base and stem which provides a structure with low values of lead inductance, reduced interelectrode capacitances, and low rf losses. The low rf losses permit application of full plate power input at frequencies up to 175 megacycles. It is well to note that above 125 megacycles, greater power gain is obtained when the tube is used as a doubler rather than as a straight-through neutralized power stage because loading of the driving stage due to the input resistance of the 5763 is less severe at the lower frequency.

The 5763 has been designed so that a relatively high value of grid resistance (up to 100000 ohms) may be safely used. This high resistance value makes it possible to obtain the moderately high value of grid bias required for good multiplier plate-circuit efficiency with low values of dc grid current.

Two control-grid connections, pins 8 and 9, are provided to aid in cooling the grid. These connections should be tied together at the socket. As a further aid to heat conduction, it is recommended that heavy copper leads be used for all grid and plate connections at the socket. The normal operating temperature of the tube is 200 to 250 degrees centigrade. Sufficient ventilation should be provided to keep the tube temperature within this range.

**Application as Frequency Multiplier**

In the circuit of Fig.2, the 5763 is used as a frequency multiplier in a conventional manner. The same circuit employing tapped coils is used for either doubler or tripler operation. Although the use of




C1 C3 C5 C6 C7 C10: 5000 μμf, 500 volts
C2 C8: Tuning Capacitor, 1 - 8 μμf
C4 C9: 500 μμf
R1: 12500 ohms, 0.5 watt
R2 R5 R7: 100000 ohms, 1 watt, Allen-Bradley
R3 R8: 75000 ohms, 1 watt for doubler service; 100000 ohms, 1 watt for tripler service
R4: 62 ohms, 0.5 watt
R6: 12500 ohms. 1 watt
RFC: RF Choke, #24 enamel-covered wire close wound on resistors R2 R5 and R7

*Fig. 2 - Frequency-Multiplier Circuit.*

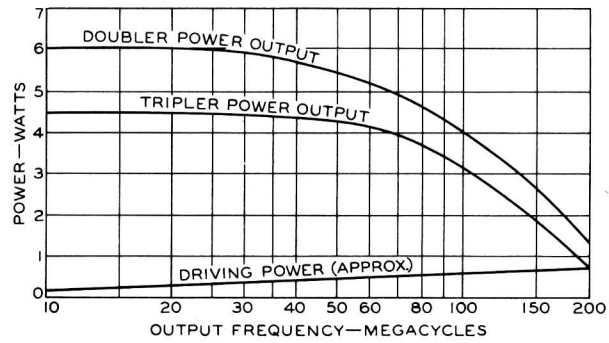
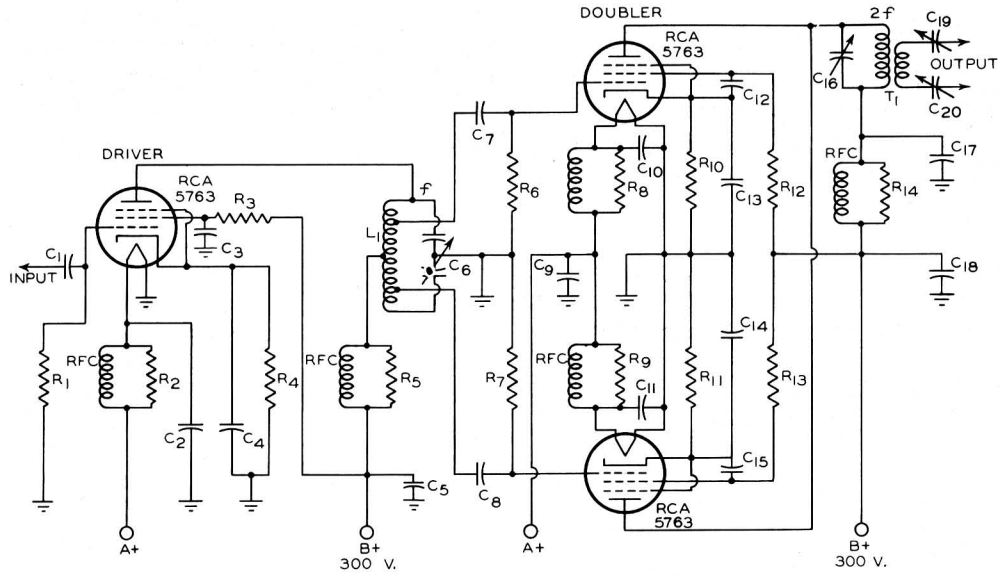



*Fig. 3 - Required Driving Power and Useful Power Output as a Function of Frequency for Frequency-Multiplier Circuit of Fig. 2.*

tapped coils can lead to parasitics, no difficulty was experienced with the circuits described in this Note. Because of the high amplification factor of the 5763, a small cathode resistance of 62 ohms can




C1 C7 C8: 500 $\mu\mu$f
C2 C3 C4 C5 C9 C10 C11 C12 C13 C14 C15 C17 C18: 5000 $\mu\mu$f, 500 volts
C6: Split-stator tuning capacitor - value depends on operating frequency (f)
C16 C19 C20: Tuning capacitor - value depends on doubler frequency (2f)
L1: Tank inductance - value depends on operating frequency (f)

R1 R6 R7: 75000 ohms, 1 watt
R2 R5 R8 R9 R14: 100000 ohms, 1 watt Allen-Bradley
R3 R12 R13: 12500 ohms, 0.5 watt
R4 R10 R11: 62 ohms, 0.5 watt
RFC: RF choke, #24 enamel-covered wire close wound on resistors R2 R5 R8 R9 and R14
T1: Transformer - value depends on doubler frequency (2f)

*Fig. 4 - "Push-Push" Doubler Circuit.*

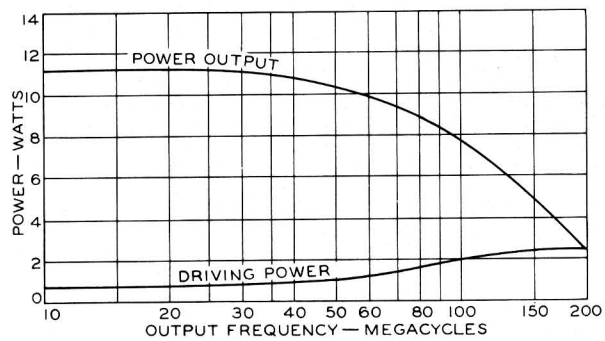



*Fig. 5 - Required Driving Power and Useful Power Output as a Function of Frequency for "Push-Push" Doubler Circuit of Fig. 4.*

**furnish sufficient bias voltage to protect the tube for a limited time in the event of temporary failure of excitation and resultant loss in bias developed by the grid resistor.**

**Table I includes the operating conditions for both doubler and tripler service. In general, best multiplier operation occurs with a high driving voltage and grid-No.1 bias which results in a small conduction**

angle, grid-No.2 dissipation being the limiting factor. Fig.3 gives the useful power output of the circuit of Fig.2 in doubler and tripler service as a function of operating frequency. "Useful power output" is the power delivered to the grid of the following tube; it is equal to the tube power output less circuit and radiation losses. At 150 megacycles the power loss in the tank circuit of the multiplier is approximately 1.5 watts, a reasonable value for a high-frequency low-power circuit using "lumped" constants. When the circuit is used in a closely shielded transmitter additional losses will be encountered, depending on the design. In a compact mobile transmitter, for example, a total power loss of 3 watts for this circuit is not unreasonable. The driving power indicated in Fig.3 is the power at the grid for either doubler or tripler operation.

**"Push-Push" Doubler Circuit**

Fig.4 is a "push-push" doubler circuit using a pair of 5763's. In this application, in which the plates of the tubes are connected in parallel, the low value of output capacitance (4.5 μμf per tube) is advantageous. A single 5763 used as a tripler provides more than adequate driving power for the "push-push" doubler. This circuit arrangement is particularly suitable for low-power transmitters. The useful power output of this circuit as a function of operating frequency is given in Fig.5. The driving power indicated is measured at the grids of the 5763's.

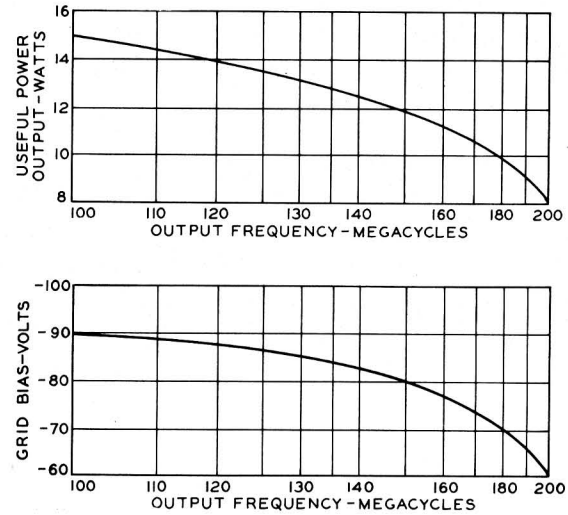



*Fig. 6 - Useful Power Output and Grid Bias as a Function of Frequency for Neutralized 2E26 Driven by Single-Tube Doubler Circuit of Fig. 2.*

An important application of the 5763 is as a frequency doubler to drive the popular vhf transmitting tube RCA-2E26. When the single-tube doubler circuit of Fig.2 is used to drive the 2E26 in a carefully neutralized circuit, the useful power output of the 2E26 and the developed grid bias voltage at the grid of the 2E26 obtained with a grid resistor of 30000 ohms are given in Fig.6 for frequencies above 100 megacycles.

The useful power output of a properly neutralized 2E26 at 175 megacycles is shown in Fig.7 as a function of driving power at the grid of the 2E26.

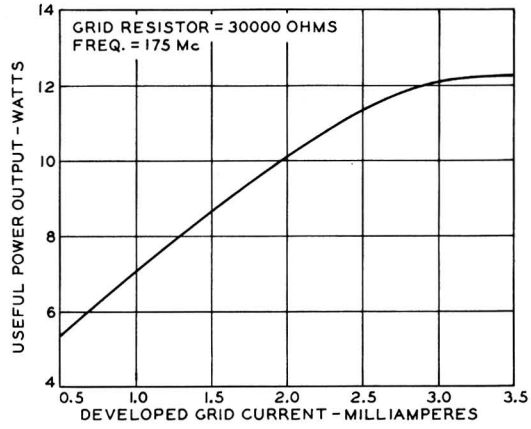



*Fig. 7 - Useful Power Output as a Function of Driving Power for Neutralized 2E26 at 175 Megacycles.*

Because of the possibility of spurious radiation resulting from the use of a final stage which is improperly neutralized, it may be preferable for mobile transmitters operated by non-technical personnel to substitute a doubler stage which does not require neutralization. In such cases, the use of a 5763 "push-push" doubler stage may be advantageous.

**Electrical:**

| | | |
|---|---|---|
| Heater, for Unipotential Cathode: | | |
| Voltage (AC or DC) | 6.0 ± 10% | volts |
| Current | 0.75 | ampere |
| Transconductance for plate current of 45 ma | 7000 | μmhos |
| Mu-Factor, Grid No.2 to Grid No.1 | 16.0 | |
| Direct Interelectrode Capacitance (No external shield): | | |
| Grid No.1 to Plate | 0.3 max. | μμf |
| Input | 9.5 | μμf |
| Output | 4.5 | μμf |

## RF POWER AMPLIFIER & OSC. - Class C Telegraphy■ AND RF POWER AMPLIFIER - Class C FM Telephony

**Maximum CCS● Ratings,** *Absolute Values*:

| | | |
|---|---|---|
| DC PLATE VOLTAGE | 300 max. | volts |
| DC GRID-No.3 (SUPPRESSOR) VOLTAGE | 0 max. | volts |
| DC GRID-No.2 (SCREEN) VOLTAGE | 250 max. | volts |
| DC GRID-No.1 (CONTROL-GRID) VOLTAGE | -125 max. | volts |
| DC PLATE CURRENT | 50 max. | ma |
| DC GRID-No.2 CURRENT | 15 max. | ma |
| DC GRID-No.1 CURRENT | 5 max. | ma |
| PLATE INPUT | 15 max. | watts |
| GRID-No.2 INPUT | 2 max. | watts |
| PLATE DISSIPATION | 12 max. | watts |
| PEAK HEATER-CATHODE VOLTAGE: | | |
| Heater negative with respect to cathode | 100 max. | volts |
| Heater positive with respect to cathode | 100 max. | volts |
| BULB TEMPERATURE AT HOTTEST POINT ON BULB SURFACE | 250 max. | °C |

**Typical Operation:**

| | *At 50 Mc* | |
|---|---|---|
| DC Plate Voltage | 300 | volts |
| Grid No.3 | Tied to cathode at socket | |
| DC Grid-No.2 Voltage | 250 | volts |
| DC Grid-No.1 Voltage | -60 | volts |
| From a grid resistor of | 22000 | ohms |
| Peak RF Grid-No.1 Voltage | 80 | volts |
| DC Plate Current | 50 | ma |
| DC Grid-No.2 Current | 5 | ma |
| DC Grid-No.1 Current (Approx.) | 3 | ma |
| Driving Power (Approx.) | 0.35 | watt |
| Power Output (Approx.)° | 8 | watts |

■ Key-down conditions per tube without amplitude modulation. Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

● Continuous Commercial Service.

° The useful power output is approximately 7 watts.

## FREQUENCY MULTIPLIER

**Maximum CCS● Ratings,** *Absolute Values*:

| | | |
|---|---|---|
| DC PLATE VOLTAGE | 300 max. | volts |
| DC GRID- No.3 (SUPPRESSOR) VOLTAGE | 0 max. | volts |
| DC GRID-No.2 (SCREEN) VOLTAGE | 250 max. | volts |
| DC GRID-No.1 (CONTROL-GRID) VOLTAGE | -125 max. | volts |
| DC PLATE CURRENT | 50 max. | ma |
| DC GRID-No.2 CURRENT | 15 max. | ma |
| DC GRID-No.1 CURRENT | 5 max. | ma |
| PLATE INPUT | 15 max. | watts |
| GRID-No.2 INPUT | 2 max. | watts |
| PLATE DISSIPATION | 12 max. | watts |
| PEAK HEATER-CATHODE VOLTAGE: | | |
| Heater negative with respect to cathode | 100 max. | volts |
| Heater positive with respect to cathode | 100 max. | volts |
| BULB TEMPERATURE AT HOTTEST POINT ON BULB SURFACE | 250 max. | °C |

**Typical Operation:**

| | *Doubler to 175 Mc* | *Tripler to 175 Mc* | |
|---|---|---|---|
| DC Plate Voltage | 300 | 300 | volts |
| Grid No.3 | Tied to cathode at socket | | |
| DC Grid-No.2 Voltage | * | * | volts |
| DC Grid-No.1 Voltage | -75 | -100 | volts |
| From a grid-No.1 resistor of | 75000 | 100000 | ohms |
| Peak RF Grid-No.1 Voltage | 95 | 120 | volts |
| DC Plate Current | 40 | 35 | ma |
| DC Grid-No.2 Current | 4.0 | 5.0 | ma |
| DC Grid-No.1 Current (Approx.) | 1.0 | 1.0 | ma |
| Driving Power (Approx.) | 0.6 | 0.6 | watt |
| Power Output (Approx.)# | 3.6 | 2.8 | watts |

**Maximum Circuit Values (for maximum rated conditions):**

| | | |
|---|---|---|
| Grid-No.1-Circuit Resistance | 0.1 max. | megohm |

● Continuous Commercial Service.

* Obtained from plate supply voltage of 300 volts through a series resistor of 12500 ohms.

# Useful power output is approximately 2.1 watts for doubler service and 1.3 watts for tripler service.

## CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

| | *Note* | *Min.* | *Max.* | |
|---|---|---|---|---|
| Heater Current | 1 | 0.69 | 0.81 | ampere |
| Grid No.1 to Plate Capacitance♦ | - | - | 0.3 | μμf |
| Input Capacitance♦ | - | 8 | 11 | μμf |
| Output Capacitance♦ | - | 3.8 | 5.2 | μμf |

Note 1: With 6 volts ac on heater.

♦ With no external shield.

*Table I - Technical Data for RCA-5763.*