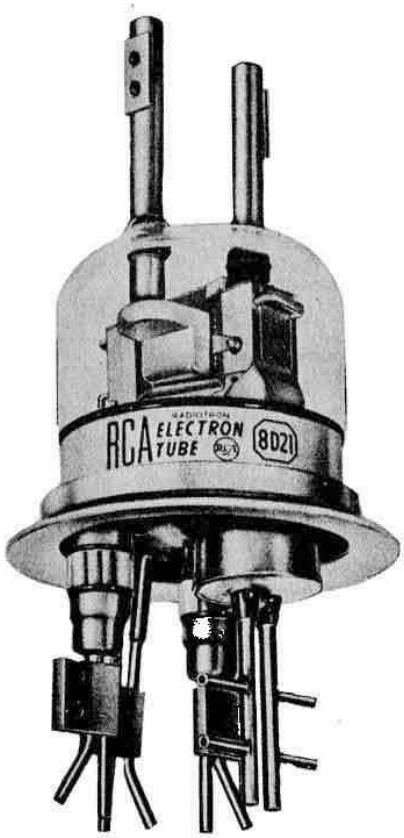
**IMPORTANT**
**See p.5 for Information on Conserving Filament Life.**

# 8D21

## PUSH-PULL POWER TETRODE

Water & Forced-Air Cooled

RCA-8D21 is a water- and forced-air-cooled, high-power, twin tetrode of unique design intended for use as a class C rf power amplifier in television transmitters. In such service, it has a maximum plate-voltage rating of 6000 volts, a maximum total plate input of 10000 watts, and a maximum total plate dissipation of 6000 watts. It may be operated with maximum rated input up to 300 megacycles.




The 8D21 is unique in that high power capability at very high frequency is obtained by the use of a compact, high-current-density structure in which all electrodes are water cooled close to the active electrode areas.

The structure features a thoria-coated, multistrand filament; low interelectrode capacitances; excellent internal shielding between input and output circuits; internal neutralization of the small feedback capacitance to eliminate need for external neutralization; internal bypassing of screen to filament to maintain the rf potential of the screen at ground potential; and short internal leads with consequent low inductances. The overall length of the 8D21 is only about 12 inches and its maximum diameter is 5-3/4 inches.

Because of electron optical principles incorporated in its design, the 8D21 features very low current to its grids with resultant flexibility and simplification of circuit design.

### GENERAL DATA

**Electrical:**

| | | |
|---|---|---|
| Filament, Thoria-Coated: | | |
| Voltage (AC or DC) | 3.2 av. | volts |
| | 3.4 max. | volts |
| Current with 3.2 volts on filament | 125 | amperes |
| Starting Current | Must never exceed 220 amperes, even momentarily | |
| Cold Resistance | 0.0077 | ohm |
| Grid No.1—Grid No.2 Mu-Factor | 5 | |
| Direct Interelectrode Capacitances (Each Unit):* | | |
| Grid No.1 to Plate | ** | μμf |
| Input | 25.5 | μμf |
| Output | 6.5 | μμf |
| Internal Grid-No.2 Bypass Capacitor (Approx.) | 200 | μμf |

**Mechanical:**

| | |
|---|---|
| Mounting Position | Plane of grid-No.1 leads horizontal and below horizontal plane of plate leads |
| Maximum Overall Length | 12-9/32" |
| Maximum Diameter | 5-3/4" |
| Terminal Connections | See Outline Drawing |

Air Cooling:

Forced-air cooling of the glass envelope is required. The air flow must start with application of plate voltage, and should be directed from a 2"-diameter nozzle at the plate end of the tube so as to cool the area between the plate seals as well as the sides of the glass envelope. The air flow may be removed simultaneously with removal of plate voltage. Interlocking of the air flow with the power supplies is recommended to prevent the application of voltages to the tube without air cooling.

| | | |
|---|---|---|
| Air Flow | 40 min. | cfm |
| Bulb and Seal Temperature | 150 max. | °C |

Water Cooling:

Water cooling of the filament block, the No.1 grids, the No.2 grids, and the plates is required. The water flow must start before application of any voltages and preferably should continue for several seconds after removal of all voltages. Interlocking of the water flow through each of the electrodes with all power supplies is recommended to prevent tube damage in case of failure of adequate water flow.

Water Flow Required:

| | | |
|---|---|---|
| Filament Block (Cooling pipes connected in series) | 0.1 min. | gpm |
| No.1 Grids (Cooling pipes connected in series) | 0.1 min. | gpm |
| No.2 Grids | 0.1 min. | gpm |

| | | | |
|---|---|---|---|
| Water Flow Required (Cont'd): | | | |
| Plate of Each Unit: | | | |
| With dissipation of 1.5 kw . . | 0.3 min. | | gpm |
| With dissipation of 2.25 kw . . | 0.4 min. | | gpm |
| With dissipation of 3 kw . . . | 0.5 min. | | gpm |
| Water Flow Obtained with Pressure Drop of 60 psi: | | | |
| | *Min.* | *Max.* | |
| Filament Block (Cooling pipes connected in series). . | 0.18 | 0.37 | gpm |
| No. 1 Grids (Cooling pipes connected in series). . | 0.18 | 0.35 | gpm |
| No. 2 Grids. . . . . | 0.18 | 0.38 | gpm |
| Plate of Each Unit . . . . . | 0.55 | 1.00 | gpm |
| Water Pressure . . . . . | 100 max. | | psi |
| Minimum Recommended . . . . . | 60 | | psi |
| Outlet Water Temperature . . . . . | 70 max. | | °C |

## GRID-MODULATED PUSH-PULL RF POWER AMPLIFIER—Class C Television Service

*Synchronizing-level conditions unless otherwise indicated; values are total for both units*

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

| | | |
|---|---|---|
| DC PLATE VOLTAGE . . . . . | 6000 max. | volts |
| DC GRID-No. 2 (SCREEN) VOLTAGE. . . | 1000 max. | volts |
| DC GRID-No. 1 (CONTROL-GRID) VOLTAGE—White level . . . | -1000 max. | volts |
| DC PLATE CURRENT (At crest of modulation) . . | 2 max. | amperes |
| PLATE INPUT. . . . . | 10000 max. | watts |
| GRID-No. 2 INPUT. . . . . | 400 max. | watts |
| PLATE DISSIPATION. . . . . | 6000 max. | watts |
| GRID-No. 1 DISSIPATION. . . . . | 50 max. | watts |

**Typical Operation in Television Service up to 216 Mc—Bandwidth of 6 Mc:**

| | | | |
|---|---|---|---|
| DC Plate Voltage . . . . . | 5000 | . . | volts |
| DC Grid-No. 2 Voltage . . . . . | 800 | . . | volts |
| DC Grid-No. 1 Voltage: | | | |
| Synchronizing Level. . . . . | -220 | . . | volts |
| Pedestal Level . . . . . | -400 | . . | volts |
| White Level. . . . . | -820 | . . | volts |
| Peak RF Grid-No. 1-to-Grid-No. 1 Voltage. . . | 1300 | . . | volts |
| DC Plate Current: | | | |
| Synchronizing Level. . . . . | 1.9 | . . | amperes |
| Pedestal Level . . . . . | 1.45 | . . | amperes |
| DC Grid-No. 2 Current: | | | |
| Pedestal Level . . . . . | -0.025 | . . | ampere |
| DC Grid-No. 1 Current: | | | |
| Synchronizing Level. . . . . | 0.050 | . . | ampere |
| Pedestal Level . . . . . | 0.010 | . . | ampere |
| Driving Power (Approx.)*** . . . . | 300 to 500 | | watts |
| Power Output: | | | |
| Synchronizing Level. . . . . | 5300 | . . | watts |
| Pedestal Level . . . . . | 3100 | . . | watts |

## PUSH-PULL RF POWER AMPLIFIER—Class C Telegraphy or FM Telephony

*Key-down conditions without amplitude modulation; values are total for both units*

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

| | | |
|---|---|---|
| DC PLATE VOLTAGE . . . . . | 6000 max. | volts |
| DC GRID-No. 2 (SCREEN) VOLTAGE. . . | 1000 max. | volts |
| DC GRID-No. 1 (CONTROL-GRID) VOLTAGE | -1000 max. | volts |
| DC PLATE CURRENT . . . . . | 2 max. | amperes |
| PLATE INPUT. . . . . | 10000 max. | watts |
| GRID-No. 2 INPUT. . . . . | 400 max. | watts |
| PLATE DISSIPATION. . . . . | 6000 max. | watts |
| GRID-No. 1 DISSIPATION. . . . . | 50 max. | watts |

**Typical Operation in CW Service at 300 Mc:**

| | | | |
|---|---|---|---|
| DC Plate Voltage . . . . . | 6000 | . . | volts |
| DC Grid-No. 2 Voltage . . . . . | 800 | . . | volts |
| DC Grid-No. 1 Voltage$^{oo}$ . . . . . | -275 | . . | volts |
| Peak RF Grid-No. 1-to-Grid-No. 1 Voltage. . . | 1350 | . . | volts |
| DC Plate Current . . . . . | 1.6 | . . | amperes |
| DC Grid-No. 2 Current . . . . . | 0.040 | . . | ampere |
| DC Grid-No. 1 Current (Approx.) . . | 0.085 | . . | ampere |
| Driving Power (Approx.). . . . . | 500 | . . | watts |
| Power Output (Approx.) . . . . . | 6500 | . . | watts |

**Typical Operation in FM Service up to 216 Mc:**

| | | | |
|---|---|---|---|
| DC Plate Voltage . . . . . | 4500 | . . | volts |
| DC Grid-No. 2 Voltage . . . . . | 700 | . . | volts |
| DC Grid-No. 1 Voltage$^{oo}$ . . . . . | -300 | . . | volts |
| Peak RF Grid-No. 1-to-Grid-No. 1 Voltage. . . | 1150 | . . | volts |
| DC Plate Current . . . . . | 1 | . . | ampere |
| DC Grid-No. 2 Current . . . . . | 0.050 | . . | ampere |
| DC Grid-No. 1 Current (Approx.) . . | 0 | . . | amperes |
| Driving Power (Approx.). . . . . | 400 | . . | watts |
| Power Output (Approx.) . . . . . | 2500 | . . | watts |

**Maximum Circuit Value (CW or FM Service):**

| | | |
|---|---|---|
| Grid-No. 1-Circuit Resistance . . . | 6000 max. | ohms |

## CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

*Values are for each unit, unless otherwise indicated*

| | *Note* | *Min.* | *Max.* | |
|---|---|---|---|---|
| Filament Current . . . . . | 1 | 110 | 140 | amperes |
| Input Capacitance. . . . . | — | 22.5 | 28.5 | $\mu\mu f$ |
| Output Capacitance . . . . | — | 5.3 | 7.7 | $\mu\mu f$ |
| Plate Current. . . . . | 1,2 | — | 0.1 | ampere |
| Plate Current. . . . . | 1,3 | 3.0 | 5.0 | amperes |
| Plate Current Average of Both Units. . . | 1,3 | 3.35 | — | amperes |
| Grid-No. 1 Current. . . . . | 1,3 | 0.15 | +0.40 | ampere |
| Grid-No. 1 Current Average of Both Units. . . | 1,3 | — | 0.25 | ampere |
| Grid-No. 2 Current. . . . . | 1,3 | — | 1.5 | ampere |
| Grid-No. 2 Current. . . . . | 1,4 | — | 0.15 | ampere |
| Grid-No. 2 Current Average of Both Units. . . | 1,4 | — | 0.10 | ampere |
| Peak Cathode Current . . . | 1,5 | 7 | — | amperes |

Note 1: AC filament volts = 3.2.
Note 2: With 5000 volts on plate, 800 volts on grid No. 2, and -220 volts on grid No. 1.
Note 3: With 1500 volts on plate, 800 volts on grid No. 2, and +500 volts on grid No. 1.
Note 4: With 2500 volts on plate, 800 volts on grid No. 2, and +300 volts on grid No. 1.
Note 5: Designers should limit the maximum usable cathode current to this value.

* With no external shielding.

** Grid-No. 1-to-plate capacitance is internally neutralized by the tube structure to within 0.02 $\mu\mu f$.

● Continuous Commercial Service.

*** Driving power is accounted for largely by circuit losses and is less at lower frequencies. In practical, grid-modulated circuit design with damping resistors, the indicated driving power, depending on frequency, is required to take care of the losses in the damping resistors, the circuit losses, and the tube driving power.

oo Obtained from combination of fixed bias and 2500- to 3000-ohm grid resistor.

## INSTALLATION

The *serial number* which identifies each individual 8D21 and which should be used in any correspondence concerning the tube, is stamped on the structure within the glass envelope between the plate terminals. Other numbers stamped externally on the tube are for purposes of manufacturing records only.

In *transportation and storage* of the 8D21, care should be taken to protect the tube from rough handling that would damage the metal-to-glass seals or other parts. The 8D21 is supported within its shipping container so that it will not come in contact with the sides of the container during shipment. It should be stored in the container with the plate terminals down and should be protected from moisture and extreme temperature changes.

While the tube is being removed from its container, it should be lifted by grasping both filament-pipe assemblies near the mounting flange, or by grasping one filament-pipe assembly and the grid-No. 2-pipe assembly near the mounting flange.

under no circumstances should the 8D21 be handled by the grid-No.1-pipe assembly. After the tube is removed from its container, it should be handled by the bulb or mounting flange. The weight of the 8D21 packed for shipment is approximately 12-1/2 pounds; unpacked, approximately 4-1/2 pounds.

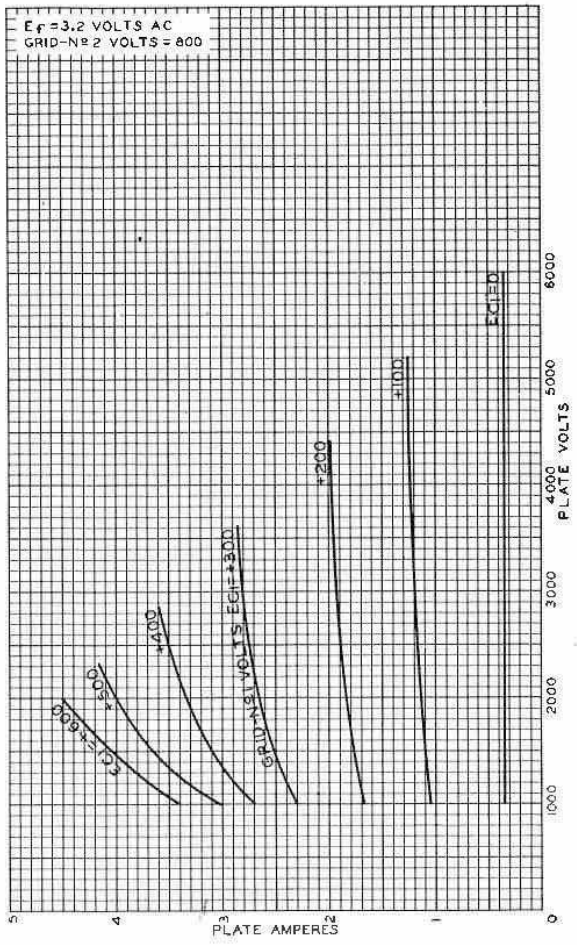



*Fig. 1 - Average Plate Characteristics for Each Unit of Type 8D21.*

It is recommended that the tube be tested upon receipt in the equipment in which it is to be used. Before the tube is placed in operation, any foreign material clinging to it should be removed. After the tube has been tested and before it is placed in storage, its cooling pipes and the ducts in the tube electrodes should be blown free of water. Care should be taken to prevent any foreign matter from entering the cooling pipes at any time. As a safeguard, it is recommended that during storage the 8D21 be completely enclosed in a container made of Pliofilm, or equivalent, and then sealed.

***Mounting*** of the 8D21 requires the use of a mechanism to engage the mounting flange and clamp it firmly to hold the tube in a horizontal position with the plane of the grid-No.1 leads horizontal and below the horizontal plane of the plate leads. Care should be taken to prevent vibration from being transmitted to the tube. Vibration of the tube and its associated circuit may cause undesired modulation of the signal output. Circuit elements adjacent to the tube terminals should put no strain on the terminals.

Extreme care should be taken to assure that no strain is placed on the seals when connecting or disconnecting the water hoses and the electrical connections to the tube. Particular care must be exercised with the grid-No.1 seals. The grid-No.1-pipe assembly should be supported with one hand while attaching or detaching the water hoses with the other.

The *water-cooling system* consists, in general, of a source of cooling water, a feed-pipe system which carries the water to the filament blocks, the No.1 grids, the No.2 grids, and the plates of the tube, and provision for interlocking the water flow through each of the electrodes with the power supplies. When the plate is at high potential above ground, the feed-pipe system should have good insulating qualities and proper design to reduce leakage current to a negligible value.

It is recommended that the water-cooling system be of the closed type utilizing distilled water to prevent the possibility of scale formation and corrosion, both of which can be expected with tap water. Scale not only restricts water flow but prevents proper transfer of heat from the tube electrode to the cooling water, while corrosion may destroy the electrodes and pipes. The water-supply system should be capable of supplying at least 2 gallons per minute at a pressure of 60 pounds per square inch at the tube.

A strainer should be provided in the water-supply line to the tube in order to trap any foreign particles likely to impair the water flow through the tube pipes. It is suggested that a strainer with an 80-mesh screen (0.005" openings) be used.

The piping system must be arranged so that the water flow through the grid-No.1 pipes is in the direction indicated in the detail sketch of this terminal on the Outline Drawing. The grid-No.1 pipes of tetrode unit No.1 should preferably be connected in series with the grid-No.1 pipes of tetrode unit No.2 with due regard to the direction of water flow. The series connection provides simplicity and reduces the number of flow interlocks required. Similarly, the pipes to the two filament blocks should preferably be connected in series, but without regard to the direction of water flow. It is essential that the water

hose used for the series connections have good insulating qualities and be of sufficient length to minimize leakage currents. The tube pipes should not support the hose connections.

Proper functioning of the water-cooling system is of the utmost importance. Even a momentary failure of the water will damage the tube. In fact, without cooling water, the heat of the filament alone is sufficient to cause serious harm. It is, therefore, necessary to provide a method of preventing operation of the

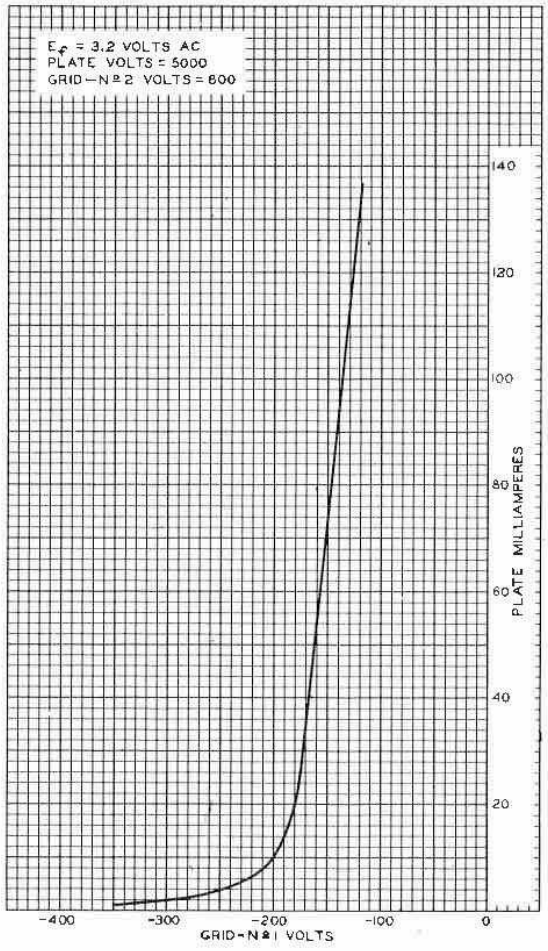



*Fig. 2 - Average Characteristic for Each Unit of Type 8D21.*

tube in case the water supply should fail. This may be done by the use of water-flow circuit breakers or interlocks which open the power supplies when the flow through any electrode is insufficient or ceases. The water flow must start before application of any voltages and preferably should continue for several seconds after removal of all voltages.

The minimum water flow required through the filament blocks, the No. 1 grids, the No. 2 grids, and the plate of each tetrode unit, together with the recommended minimum and allowable maximum pressure for such flow, is given in the tabulated data. The minimum and maximum flow obtained with a pressure of 60 pounds per square inch is also shown in the tabulated data. The use of an outlet water thermometer and a water flow meter at each of the outlets is recommended. Under no circumstances should the temperature of the water from any outlet ever exceed 70°C.

If occasion arises where any of the cooling pipes becomes clogged, the tube should preferably be removed from the circuit before attempting to dislodge the foreign material. Then, use water or compressed air at a pressure not exceeding 100 pounds per square inch to try to dislodge the foreign material in a direction opposite to that of the normal water flow through the clogged pipe. If compressed air is not available, compressed gases, such as nitrogen or oxygen, may be used provided the pressure is limited to 100 pounds per square inch. Should this procedure fail to clear the pipe, write Adjustment Dept., Radio Corporation of America, Harrison, N.J., for instructions, giving complete details.

An approximate value of the plate dissipation which should not exceed the value shown under Maximum Ratings in the tabulated data, may be calculated from the following equation

$$P_{watts} = n(t_o - t_i) \times 250$$

in which $t_i$ is the temperature of the cooling water at the inlet in degrees Centigrade, $t_o$ is the temperature of the water at the outlet in degrees Centigrade, and n is the number of gallons per minute of flow.

An *air-cooling system*, interlocked with the power supplies, is required to cool the glass envelope of the 8D21. This system consists of a blower and an air duct having a 2"-diameter nozzle. The air flow from the nozzle should not be less than 40 cubic feet per minute, and should be directed at the plate end of the tube so as to cool the area between the plate seals as well as the sides of the glass envelope. The temperature of the seals and of the bulb should not exceed 150°C at the hottest point. The temperature of the plate seals and of the bulb may be measured either with a thermocouple or with temperature-sensitive paint, such as Tempilac. The latter is made by the Tempil Corporation, 132 West 22nd Street, New York, N.Y., in the form of liquid and stick, and is stated by the manufacturer to have an accuracy of 1 per cent.

The air-cooling system should be electrically interconnected with the filament and high-voltage supplies to prevent the application of voltages to the tube without air cooling. The air flow must start with the application of plate voltage, and may be removed simultaneously with removal of the plate voltage. Precautions should be taken

to insulate the air-cooling system from the tube or circuit parts which may be at high potential.

The *thoria-coated filament* in the 8D21 is of the multi-strand type and is designed for dc or single-phase ac operation. The filament is arranged so that the strands in one leg furnish the electron emission for one tetrode unit, while those in the other leg furnish electron emission for the other tetrode unit. The strands of each leg are recessed in slots in a focusing block through which water is circulated by means of two water pipes. These two pipes are electrically and mechanically connected together by a lug which serves as the terminal for one leg of the filament. Similarly, the two pipes for the other block are connected together by a lug which serves as the terminal for the other leg of the filament. The two terminals are identified in the Outline Drawing as Filament Terminal "A" and filament Terminal "B".

The filament connectors should make firm, large-surface contact with the filament lug terminals in order to prevent heating by the high filament current. The filament-connection leads should not be taut, but should allow for some movement in order to prevent placing any strain on the filament pipes.

The filament of the 8D21 should be operated at constant voltage rather than constant current and must be allowed to reach normal operating temperature before plate and screen voltages are applied. The filament heating time is about 5 to 10 seconds depending on the type of filament starter employed. A suitable voltmeter should be permanently connected directly across the filament lug terminals so that the filament voltage will always be known.

Filament life of the 8D21 can be conserved by operating its filament at the lowest voltage which will give the desired power output. Because the filament of this tube when operated at the tabulated value of 3.2 volts provides emission usually in excess of any requirements within ratings, it is recommended that the filament voltage be reduced below 3.2 volts to a value that will give adequate but not excessive emission for any particular application. The proper operating value may be found by reducing the filament voltage, with normal modulation applied to the transmitter, until a reduction in output is observed. The filament voltage must then be increased by an amount equivalent to the maximum percentage regulation of the filament-voltage supply, and then further increased by about 0.1 volt to allow for other variations. It is suggested that the adjustment procedure be carried out daily. However, if no significant changes in the operating voltage are found necessary, the adjustment procedure can be scheduled less frequently. Good regulation of the filament voltage is in general economically advantageous from the viewpoint of tube life.

During long or frequent *standby periods*, the 8D21 may be operated at decreased filament voltage to conserve life. It is recommended that the filament voltage be reduced to 80 per cent of normal during standby operation up to 2 hours; for longer periods, the filament power should be turned off.

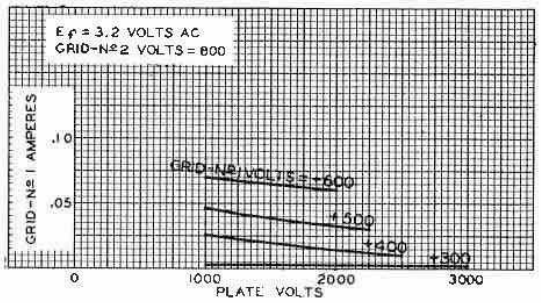



*Fig. 3 - Typical Characteristics for Each Unit of Type of 8D21.*

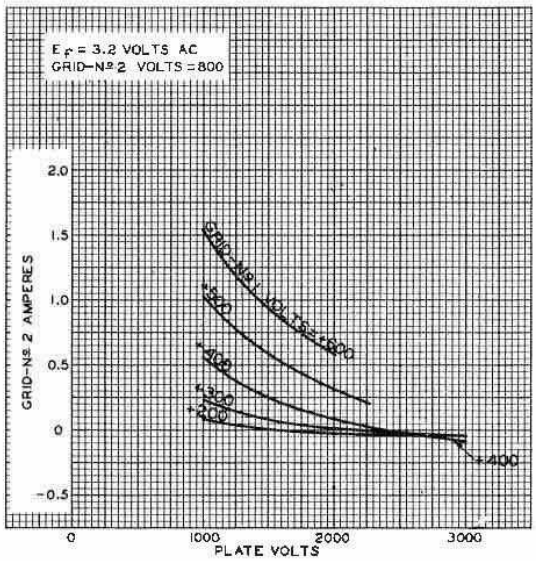



*Fig. 4 - Typical Characteristics for Each Unit of Type 8D21.*

When direct current is used, the polarity of the filament leads should be reversed every 500 hours of operation.

A *filament starter* should be used to raise the filament voltage gradually in order to limit the high initial surge of current through the filament when the circuit is first closed. The starter may be either a system of time-delay relays cutting resistance or reactance out of the circuit, a high-reactance filament transformer, or a simple rheostat. A combination of the last two methods is usually most desirable. Regardless of the method of control, it is important that the filament current never exceed, even momentarily, a value of 220 amperes.

The *grid-No.1 terminals* for the two tetrode units of the 8D21 are identified on the Outline Drawing. Electrical connection should be made to the solid end of each terminal by a suitable grip connector. Do not solder connections to these terminals.

*Circuit returns* from the No. 1 grids, the No. 2 grids (connected together within tube and brought out to a single terminal), and plates should be made to the mounting flange or to filament terminal "B" which is electrically connected to the mounting flange.

The *grid-No.2 (screen) voltage* should be obtained from a source of good regulation. The plate voltage should be applied before or simultaneously with the grid-No. 2 voltage; otherwise, with voltage on grid No. 2 only, its current may be large enough to cause excessive grid-No. 2 dissipation. A dc milliammeter should be used in the grid-No. 2 circuit so that its current can be measured and the dc power input determined.

The *grid-No.2 current* is a very sensitive indication of plate-circuit loading and rises excessively (often to the point of damaging the tube) when the tube is operated without load. Therefore, care should be taken when tuning the 8D21 circuit under no-load conditions to prevent exceeding the grid-No. 2 input rating of the tube.

The *plate-supply lead* common to both plates should be provided with a time-delay relay to delay application of plate voltage until the filament has reached normal operating temperature.

*Protective devices* should be used to protect not only the plates but also the No. 2 grids against overload. In order to prevent excessive plate-current flow and resultant overheating of the tube, the common ground lead of the plate circuits should be connected in series with the coil of an instantaneous overload relay. This relay should be adjusted to open the circuit breakers in the primary of the rectifier transformer at slightly higher than normal plate current. The time required for the operation of the relay and circuit breakers should be about 1/10 second and not more than 1/6 second.

A protective device in the grid-No. 2 supply lead should remove the grid-No. 2 voltage when the dc grid-No. 2 current reaches a value slightly higher than normal.

*When an 8D21 is first placed in service,* care should be taken to see that the water- and air-cooling systems are functioning properly. The tube should then be operated without plate or screen voltage for 5 minutes at rated filament voltage. After this initial preheating schedule, the tube should be operated at approximately one-half the usual plate and screen voltages for 15 minutes. Full plate and screen voltages may then be applied and the tube operated under normal load conditions for a period of 1 hour or more. It is recommended that spare tubes be given the preheating and initial-operation treatment every 3 months. This procedure will insure that only good tubes are carried in stock.

*When a new circuit is tried or when adjustments are made, the plate voltage and the screen voltage should be reduced to approximately one-half the rated values to prevent damage to the tube and associated apparatus.* After correct adjustment has been made with the tube operating smoothly and without excessive heating of the cooling water or the glass bulb, the plate and screen voltages may be raised in steps to the desired values. Adjustments should be made at each step for optimum operation.

*The rated plate and screen voltages of the 8D21 are extremely dangerous to the user.* Great care should be taken during the adjustment of circuits. The tube and its associated apparatus, especially all parts which may be at high potential above ground, should be housed in a protective enclosure. The protective housing should be designed with interlocks so that personnel cannot possibly come in contact with any high-potential point in the electrical system. The interlock devices should function to break the primary circuit of the high-voltage supplies when any gate or door on the protective housing is opened, and should prevent the closing of this primary circuit until the door is again locked.

## APPLICATION

The *maximum ratings* in the tabulated data for the 8D21 are limiting values above which the serviceability of the 8D21 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value for each rating below the absolute value of that rating by an amount such that the absolute value will never be exceeded under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

The 8D21 may be operated with maximum rated input up to 300 megacycles.

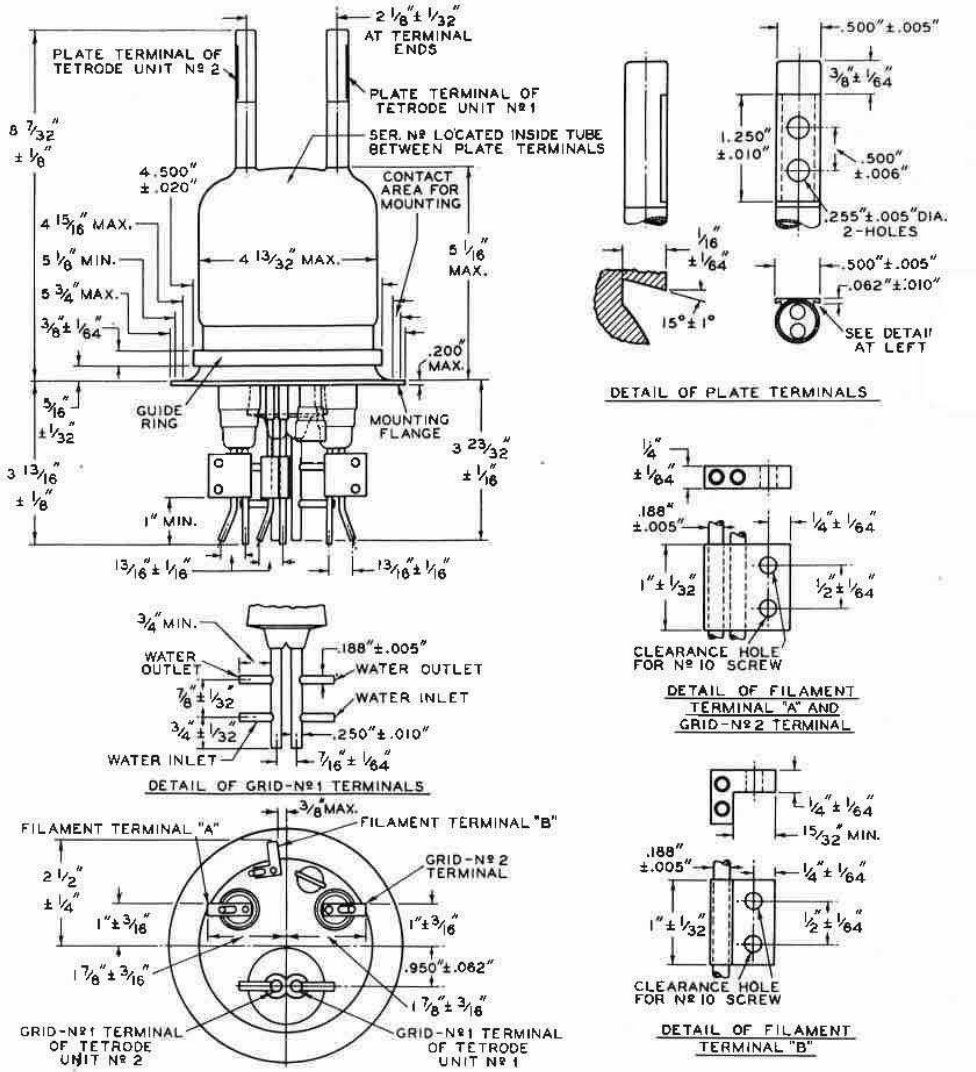
In *grid-modulated class C rf power amplifier service,* the 8D21 is supplied with unmodulated rf grid-No. 1 voltage and with a video-modulated grid-No. 1 voltage. The grid-No. 2 voltage should be obtained from a source of good regulation.

In *class C rf power amplifier service,* the 8D21 should be supplied with grid-No. 1 bias by a combination of fixed bias and a 2500- to 3000-ohm grid resistor. The grid-No. 2 voltage should be obtained from a well-regulated voltage source.

## REFERENCE

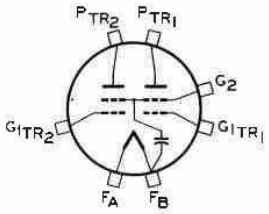
Federal Communications Commission, *"Standards of Good Engineering Practice Concerning Television Broadcast Stations"*, Superintendent of Documents, U. S. Government Printing Office Washington 25, D. C.

## DIMENSIONAL OUTLINE




## TUBE SYMBOL

**For Terminal Connections, See Outline Drawing**




$F_A$ : FILAMENT

$F_B$ : FILAMENT & MOUNTING FLANGE

$G_{1_{TR_1}}$ : GRID No. 1 OF TETRODE UNIT No. 1

$G_{1_{TR_2}}$ : GRID No. 1 OF TETRODE UNIT No. 2

$G_2$ : GRID No. 2 OF TETRODE UNITS No. 1 & No. 2

$P_{TR_1}$ : PLATE OF TETRODE UNIT No. 1

$P_{TR_2}$ : PLATE OF TETRODE UNIT No. 2

# TIPS ON USE OF THE RCA-8D21

The following material supplements the preceding instructions and data on the 8D21 tube and is compiled to help television station engineers properly utilize the RCA-8D21 Push-Pull Power Tetrode for optimum performance.

The "dos" and "don'ts" are those with which every operating engineer should be thoroughly familiar in order not to damage the 8D21 through improper operation.

## DO

*Test New 8D21's Immediately Upon Receipt*

*Give New 8D21's the Recommended "Break-In" Treatment*

*Use Care in Attaching Water Hoses and Electrical Connections*

*Use Distilled Water for Cooling*

*Be Sure That Adequate Water Flow is Maintained*

*Clean Water-Supply Filter at Regular Intervals*

*Be Sure That Air Flow to Glass Envelope is Adequate and Properly Distributed*

*Clean Blower at Regular Intervals*

*Keep 8D21's Clean*

*Allow 8D21's to Warm Up Prior to Day's Operation*

*Operate Filament at Lowest Possible Voltage*

*Blow 8D21's Free of Water and Enclose in Plastic Cover Before Placing in Storage*

*Operate Spare 8D21's Every 3 Months*

## DON'T

*Don't Handle 8D21's by the Grid-No. 1 Pipe Assembly*

*Don't Use Tap Water for Cooling*

*Don't Allow Cooling Water to Become Contaminated*

*Don't Operate 8D21's with Full Voltage on Plate and Grid No. 2, or with Full Excitation, Until Proper Loading Conditions Have Been Obtained*

## DESIGN FEATURES OF THE 8D21

RCA-8D21 has been designed specifically for use as a highly stable, high-gain, broadband television transmitting tube. It is capable of efficient operation as a linear or grid-modulated amplifier with full input at frequencies as high as 300 megacycles per second.

The 8D21 is a good broadband tube because it has an unusually high "figure of merit," i.e., ratio of filament emission current to plate-to-plate capacitance.

High emission is provided at very low heating power by a new type of electron emitter consisting of thorium oxide on tantalum ribbon.

High power capability at very high frequency is achieved through the use of a compact, high-current-density structure in which small electrodes are water cooled close to the active areas where heat is generated. The small electrodes make possible low interelectrode capacitances. As a result, operation at frequencies as high as 300 megacycles per second is readily accomplished with open-type tank circuits, and without having to "bury" the tube in a cumbersome, inaccessible, concentric-line structure.

Water cooling of the electrodes is accomplished efficiently by high-velocity water streams. The linear velocity of the water in the streams may be in the order of 25 feet per second - a

value sufficiently fast to remove instantaneously any steam or vapor bubbles that may form in the cooling ducts. The water flow required for each 8D21 is only about 2.4 gpm at the relatively low pressure of 60 psi.

The 8D21 makes possible the stability required in the modulated amplifier stage of television transmitters - stability many times greater than that required in any other type of service. The stage must not merely be kept below the point of oscillation caused by feedback; it must be kept many fold below this point to avoid severe distortion of the bandpass characteristic. Such an operating condition is achieved with the 8D21 because its pushpull tetrode construction provides: excellent internal shielding between input and output circuits; internal neutralization of the small feedback capacitance; internal bypassing of grid No. 2 to filament to maintain the rf potential of grid No. 2 at ground potential; and short internal leads with consequent low inductances. These features eliminate the major causes of input-output feedback.

Because of electron optical principles incorporated in its design, the 8D21 has high power gain, grid-current characteristics which permit video modulation of either the excitation or grid-No. 1 bias with a reasonably low value of video voltage, and a substantially linear amplitude characteristic in the synchronizing region - all necessary attributes of a good linear or modulated amplifier tube for television service.

## TESTING A NEW 8D21

Each 8D21 is thoroughly tested before shipment. However, to insure that the tube has not been damaged in transit, it should be tested (see "Break-In" Treatment) upon receipt in the equipment in which it is to be used. Should there be any evidence of damage in transit, a "bad order" report should immediately be filed with the transportation company.

After the required adjustments have been made and the tube is operating normally to give the desired output, it is suggested that the readings of the meters and flow indicators as well as the control settings be logged before the tube is placed in storage. Then, in the event of an emergency tube change, the tube can be put in service quickly.

## WATER-COOLING REQUIREMENTS

A few simple precautions will prevent the introduction of particles at some point in the water system between the filter and the tube. Inspect rubber hoses when changing tubes, for bits of rubber loosened by pipe ends that have become rough or sharp in service. When such is the case, carefully smooth the pipe ends with a fine file and/or crocus cloth.

When changing the water and before flushing the tube, use a pipe cleaner to remove any deposit from the ends of the tube pipes and the hose ends. This procedure will prevent any deposit from being carried into the tube when it is flushed. If tap water is used for flushing, always follow with a distilled-water flush to prevent any chlorine in the tap water from remaining in the tube. The presence of chlorine greatly increases the corrosion rate of the pipes and ducts in the tube. Therefore, never allow chlorinated water to enter the water system.

## TUBE CLEANLINESS

As with other high-voltage, high-frequency equipment, it is essential that the glass bulb and other external parts of the 8D21 be kept free from accumulated dirt to minimize surface leakage and the possibility of arc-over. Make it a regular practice to wipe dirt from the glass bulb and other external parts of the tube about twice a month or more frequently, if necessary, to keep the tube clean.

## "BREAK-IN" TREATMENT

Before a new 8D21 is placed in service or set aside as a spare, or after a tube has been in prolonged storage, it should be given the following treatment, preferably in the visual power amplifier:

**Step 1:** With no other voltages on tube, apply 3.0 volts to the filament for 10 minutes.

**Step 2:** Increase filament voltage to 3.2 volts, and apply about 2800 volts to the plates, 700 volts to the No. 2 grids (screens), and -600 volts bias to the No. 1 grids.

**Step 3:** Adjust the excitation to give a plate current of 100 to 200 milliamperes. Output loading should be maintained at normal broadband response.

Step 4: Decrease the grid-No. 1 bias or increase the excitation until a plate current of about 500 milliamperes is obtained. Allow tube to operate at this value for 5 minutes.

Step 5: Reduce plate current to a value between 100 and 200 milliamperes. Then apply full voltage to the plates and to the No. 2 grids, and operate at a plate current of 250 to 300 milliamperes for 10 minutes.

Step 6: Gradually increase the plate current over a period of 10 minutes until the visual "black-level" value, or the aural "carrier-level" value, is obtained. Operate the tube at this point for about 10 minutes. Modulation may then be applied.

## OPERATION WITHOUT PROPER LOADING

When the transmitter is being tuned after a tube is installed, or when major circuit adjustments are made, reduce the plate voltage, the grid-No. 2 voltage, and the excitation as much as possible consistent with the practicality of making the adjustments. After adjustment to give proper loading for the 8D21, normal operating voltages and excitation may be restored. Failure to observe this procedure may result in serious tube or circuit damage because of high peak voltages resulting from improper loading.

## GRID AND SCREEN CURRENTS

The negative grid-No. 1 and grid-No. 2 (screen) currents often observed in 8D21 operation are normal and do not indicate an inferior tube. They are caused by secondary electron emission from the No. 1 grids and the No. 2 grids. Since the magnitude of such emission is affected by slight changes in the surfaces of the No. 1 and No. 2 grids, the value of the grid-No. 1 current and the value of the grid-No. 2 current may vary considerably between individual tubes, or during the life of a tube. Accordingly, these currents should not be used for determining the proper conditions of loading, particularly when the currents are negative. Plate current and power output are the proper indicators of operating conditions.

## MICROPHONICS

While microphonics in the 8D21 are normally at a low level, it may be desirable in video service to reduce still further microphonics resulting from the tube or associated grid-No. 1 circuit. The reduction can be accomplished by increasing the amount of grid-No. 1-circuit damping and by careful tuning of the circuit. The damping should not be increased to the point where the driver tubes will operate at higher than rated plate current. It is sometimes observed that when the grid-No. 1 circuit is tuned, the point at which microphonics disappear from "white level" does not coincide with that at "black level." In such cases, tuning to achieve the desired results at "white level" will result in a good picture, since microphonics are ordinarily not observable in the darker portions of the picture.

Avoid operating the water circulating system at abnormally high pressure. Such operation will cause excessive water turbulation in the tube passages with a resultant increase in microphonics. The following readings of the pressure gauge in the transmitter will normally give adequate flow through the tube:

| Cooler Location | Pressure Gauge Reading-psi |
|---|---|
| On Floor With Transmitter..... | 70 to 75 |
| On Floor Below Transmitter..... | 65 to 70 |

## TUBES WITH DIMINISHED OUTPUT

When an 8D21 will no longer deliver adequate power output in video service, it will ordinarily be satisfactory for service in the sound transmitter. Transferring 8D21's under such conditions will greatly extend their useful life.

## STORAGE AND OPERATION OF SPARES

Before an 8D21 is placed in storage, its cooling pipes and the ducts in the tube electrodes should be blown free of water. Removing all water prevents the possibility of voltaic action in the pipes and ducts with resultant corrosion. After the tube is dry, wrap and seal it in the original wrapping material or similar plastic film to prevent any foreign matter from entering the water pipes. Then place the 8D21 in the shipping container with the plate terminals down. During storage, the tube should be protected from moisture and extreme temperature changes.

As in the case of all large power tubes, no 8D21 should remain in storage for more than 3 months. It should be operated in rotation with other 8D21's in order to keep it free from traces of gas which may be liberated during prolonged storage. This procedure of rotating 8D21's in service will insure that only good tubes are carried in stock.