Beam Power Tube

2 MEGAWATTS PEAK POWER OUTPUT IN SHORT-PULSE SERVICE AT 425 Mc

PULSE LENGTH TO 15 MICROSECONDS

LOW FILAMENT POWER FOR AIRBORNE USE

LIQUID COOLED

For Grid-Driven, Plate-Pulsed Amplifier Applications at Frequencies from 174 to 600 Mc

Electrical:

Filamentary Cathode, Multistrand, Matrix-Type, Oxide-Coated:

Voltage:

- Maximum, with dc or 60 cps ac excitation... 1.00 volt
- Maximum, with 400 cps ac excitation... 1.05 volts
- Typical, with dc or 60 cps ac excitation... 0.95 volt

Current:

- Typical operation value at 0.95 volt, with 60 cps excitation... 495 amp
- Minimum time to reach operating filament voltage... 30 seconds
- Minimum time at normal operating filament voltage before other voltages are applied... 90 seconds

Mu-Factor, Grid No.2 to Grid No.1... 7

Direct Inter electrode Capacitances:

- Grid No.1 to plate... 0.15 max. pf
- Grid No.1 to grid No.2 and cathode... 500 pf
- Plate to cathode and grid No.2... 30 pf
- Grid No.2 to cathode (including bypass capacitors)... 18000 max. pf

Mechanical:

Operating Position... Tube axis vertical, either end up

Overall Length... 8.62" ± 0.31"

Maximum Diameter... 11.25"

Weight (Approx.)... 38 lbs

Terminal Connections (See Dimensional Outline):

- F - Insulated Filament Terminal and Coolant Connection
- \( F_R \) - uninsulated Filament Terminal for DC Circuit Returns and Coolant Connection
- \( G_1 \) - RF Grid-No.1 Terminal Contact Surface
- \( G_{1W} \) - DC Grid-No.1 and Coolant Connection
- \( G_2 \) - DC Grid-No.2 and Coolant Connection
- \( K_R \) - RF Cathode Terminal Contact Surface for Circuit Returns
- P - RF Plate Terminal Contact Surface
- \( P_W \) - DC Plate and Coolant Connection

\( \rightarrow \) Indicates a change.
Thermal:

Ceramic-Insulator Temperature.................. 150 max. °C
Metal-Surface Temperature...................... 100 max. °C
Minimum Storage Temperature,
without cooling liquid in
coolant ducts............................... -65 min. °C
External Gas Pressureb......................... 60 max. psia

Air Cooling for Insulators and Contact Areas:
It is important that the temperature of any external part
of the tube not exceed the value specified. In general,
forced-air cooling of the ceramic insulators and the adjacent
contact areas may be required if the tube is used in a
confined space without free circulation of air. Under such
conditions, provision should be made for blowing an adequate
quantity of air across the ceramic insulators and adjacent
terminal areas to limit their maximum temperature to the
value specified.

Liquid Cooling:
Liquid cooling of the filament block, dc cathode block,
grid-No.1 block, grid-No.2 block, and plate is required.
When tube operation under low ambient temperatures is re-
quired, the recommended coolant is inert liquid FC75 (made
by the Fluorochemical Division, Minnesota Mining and Manu-
facturing Co., 900 Bush Avenue, St. Paul 6, Minnesota) but
ethylene glycol mixed with water in the proportion of 60%
ethylene glycol to 40% water by weight can be used. When
the environmental temperature permits, the coolant may be
water; the use of distilled water or filtered deionized
water is essential. The liquid flow must start before
application of any voltages and preferably should continue
for several seconds after removal of all voltages. Inter-
locking of the liquid flow through each of the cooled
elements with all power supplies is recommended to prevent
tube damage in case of failure of adequate liquid flow.

Flow:
Liquid Pressure at any outlet.................. 100 max. psi
Water Flow:

<table>
<thead>
<tr>
<th>Absolute Min. Flow</th>
<th>Typical Flow</th>
<th>Max. Pressure Differential for Typical Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>gpm</td>
<td>gpm</td>
<td>psi</td>
</tr>
<tr>
<td>Through Filament block... 0.5</td>
<td>0.8</td>
<td>8</td>
</tr>
<tr>
<td>Through dc cathode block... 0.5</td>
<td>0.8</td>
<td>8</td>
</tr>
<tr>
<td>Through grid-No.1 block... 0.5</td>
<td>0.8</td>
<td>6</td>
</tr>
<tr>
<td>Through grid-No.2 block... 0.5</td>
<td>0.8</td>
<td>8</td>
</tr>
</tbody>
</table>

Through plate:
For plate dissipations up
to 5 kw (Av.)........... 5 7 5
For plate dissipations of
5kw to 8 kw (Av.)...... 8 10 10
Resistivity of Water at 25°C......... 1 min. megohm-cm
Water Temperature from any outlet ....... 70 max. °C
Storage Temperature ......... See footnote d

FC75 Flow:
Through filament block .... 1.0 1.2 20
Through dc cathode block .... 1.0 1.2 20
Through grid-No.1 block .... 1.0 1.2 14
Through grid-No.2 block .... 1.0 1.2 20

Through plate:
For plate dissipation up to 5 kw (Average) ....... 10 12 20
For plate dissipation of 5 kw to 8 kw (Average) .... 20 24 80
Outlet-Liquid FC75 Temperature from any outlet ....... 70 max. °C
Storage Temperature with liquid FC75 in Coolant Courses ......... -65 min. °C
Liquid FC75 Temperature for Tube Operation ......... -25 min. °C

Ethylene-Glycol-Water Solution Flow:
Through filament block .... 1.0 1.2 18
Through dc cathode block .... 1.0 1.2 18
Through grid-No.1 block .... 1.0 1.2 12
Through grid-No.2 block .... 1.0 1.2 18

Through plate in direction shown on Dimensional Outline:
For plate dissipation up to 5 kw (Average) ....... 6 8 7
For plate dissipation of 5 kw to 8 kw (Average) .... 16 18 40
Outlet-Solution Temperature from any outlet ....... 60 max. °C

Min. Plate-Solution-Column Resistance at 250°C ......... 10 min. megohms
Storage Temperature with Solution in Coolant Courses ......... -45 min. °C
Solution Temperature for Tube Operation ......... -20 min. °C

PULSED RF AMPLIFIER

For frequencies from 174 to 600 Mc, and a maximum "ON" time as specified in any 3000-microsecond interval.

Maximum Ratings, Absolute-Maximum Values:

"ON" Time 15 µsec 70 µsec
Peak Positive-Pulse Plate Voltage* ....... 55000 max. 30000 max. volts
Peak Positive-Pulse
  Grid-No.2 Voltage \( f_g \) \( \ldots \) 2200 max. \( \ldots \) 7200 max. volts
DC or Peak Negative-Pulse
  Grid-No.1 Voltage \( \ldots \) 400 max. \( \ldots \) 400 max. volts
Peak Plate Current \( \ldots \) 80 max. \( \ldots \) 30 max. amp
Peak Grid-No.2 Current \( \ldots \) 15 max. \( \ldots \) 3 max. amp
Peak Rectified
  Grid-No.1 Current \( \ldots \) 15 max. \( \ldots \) 3 max. amp
DC Plate Current \( \ldots \) 0.320 max. \( \ldots \) 0.500 max. amp
DC Grid-No.2 Current \( \ldots \) 0.060 max. \( \ldots \) 0.060 max. amp
DC Grid-No.1 Current \( \ldots \) 0.060 max. \( \ldots \) 0.060 max. amp
Plate Input (Average) \( \ldots \) 16000 max. \( \ldots \) 9000 max. watts
Plate Dissipation (Average) \( \ldots \) 8000 max. \( \ldots \) 5000 max. watts

Typical Plate-Pulsed Operation:

In Class B service at 425 Mc with a rectangular waveshape pulse.

<table>
<thead>
<tr>
<th>Pulse width</th>
<th>Duty factor</th>
<th>Plate Voltage</th>
<th>Grid-No.2 Voltage</th>
<th>Grid-No.1 Voltage</th>
<th>Plate Current</th>
<th>Grid-No.2 Current</th>
<th>Grid-No.1 Current</th>
<th>DC Plate Current</th>
<th>DC Grid-No.2 Current</th>
<th>DC Grid-No.1 Current</th>
<th>Peak Driver Power</th>
<th>Useful Peak Power Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 ( \mu )sec</td>
<td>0.004</td>
<td>50000</td>
<td>1800</td>
<td>325</td>
<td>75</td>
<td>10</td>
<td>0.3</td>
<td>0.03</td>
<td>0.04</td>
<td>2000000</td>
<td>225000</td>
<td></td>
</tr>
<tr>
<td>60 ( \mu )sec</td>
<td>0.018</td>
<td>19000</td>
<td>1700</td>
<td>250</td>
<td>25</td>
<td>0.5</td>
<td>0.45</td>
<td>0.02</td>
<td>0.01</td>
<td>2000</td>
<td>2000</td>
<td></td>
</tr>
</tbody>
</table>

\( a \quad \text{Because the filament, when operated near the maximum voltage value, provides emission in excess of any requirements within tube ratings, during operation of the tube, the filament voltage should be reduced to a value that will give adequate but not excessive emission. Careful attention to maintaining the value of filament voltage consistent with adequate emission will conserve tube life. The filament voltage should be measured at the filament liquid coolant connections on the tube side of the threads. This procedure is essential for accurate measurement of the filament voltage. At 400 cycles some heating of the filament leads and rf cathode terminal (cathode header) occurs; this condition is not detrimental to tube operation or tube life.} \)

\( b \quad \text{This pressure is related to the output-cavity pressurization as required to prevent corona or external arc-over.} \)

\( c \quad \text{Measured directly across cooled element for the indicated typical flow.} \)

\( d \quad \text{The tube coolant ducts must be free of water before storage or shipment of the tube to prevent damage from freezing.} \)

\( e \quad \text{The magnitude of any spike on the plate voltage pulse should not exceed its peak value by more than 4000 volts, and the duration of any spike when measured at the peak-value level should not exceed 10% of the maximum "ON" time. The output cavity must be pressurized as required to prevent corona or external arc-over at the ceramic insulator.} \)
The magnitude of any spike on the grid-No. 2 voltage pulse should not exceed its peak value by more than 250 volts, and the duration of any spike when measured at the peak-value level should not exceed 10% of the maximum "ON" time.

A negative dc voltage of 300 volts maximum may be applied to grid No. 2 to prevent any tube conduction between pulses.

The grid-No.1 voltage may be a combination of fixed and self bias obtained from a series grid resistor.

**CHARACTERISTICS RANGE VALUES**

<table>
<thead>
<tr>
<th>Note</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filament Current</td>
<td>j</td>
<td>460</td>
</tr>
<tr>
<td>Input Strap-Resonant Frequency</td>
<td>k</td>
<td>222</td>
</tr>
<tr>
<td>Output Strap-Resonant Frequency</td>
<td>k</td>
<td>230</td>
</tr>
<tr>
<td>Direct Interelectrode Capacitances:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grid No.1 to plate</td>
<td>m</td>
<td>-</td>
</tr>
<tr>
<td>Grid No.2 to cathode</td>
<td>-</td>
<td>10000</td>
</tr>
</tbody>
</table>

j At filament voltage of 0.95 volt and ac filament excitation at 60 cps.

k The frequency range of the sweep generator is varied to produce the resonance curve observed on the oscilloscope and the UHF Marker Oscillator frequency is varied so that the pip is observed at the peak of the resonance curve. The resonant frequency is read on the frequency meter.

m Measured with special shield adapter.

**COOLING CONSIDERATIONS**

System

The liquid-cooling system consists, in general, of a source of cooling liquid, a liquid regeneration loop, a heat exchanger, a feed-pipe system which carries the liquid to the filament section blocks, to the filament common-point connection, to the grid-No.1 block, to the grid-No.2 block, and to the plate connections of the tube, and provision for interlocking the liquid flow through each of the cooling courses with the power supplies.

It is essential that the insulating tubing between the cooling-system piping and each of the cooling courses have good insulating qualities and be of sufficient length to minimize leakage currents and/or electrolysis effects. The minimum plate liquid column resistance should be 10 megohms at 25° C.

The piping system must be arranged so that direction of coolant flow through the plate coolant connection is in accord with the markings on the plate coolant connection (see *Dimensional Outline*) to insure adequate cooling. Through each of the other coolant connections, the liquid flow may be in either direction. Series or parallel arrangement of the coolant ducts is permissible so long as the specified flow, pressure, and outlet temperature ratings are observed. Caution: The feed-pipe system should be so designed that all of the cooling liquid indicated by the flow meter at each outlet passes through the associated coolant duct within the tube, and is not shunted inadvertently by any other path.
A test as to proper design and functioning of the feed-pipe system can be made by plugging the inlet and outlet holes of the fitting at each cooling connection.

Under these conditions, and with all voltages removed from the tube, no liquid flow should be indicated by the flowmeter for any connection when the coolant valve is fully opened.

Precautions

Proper functioning of the coolant system is of the utmost importance. Even a momentary failure of the liquid flow will damage the tube. In fact, without coolant, 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 tube in case the coolant supply should fail. This may be done by the use of coolant-flow interlocks which open the power supplies when the flow through any element is insufficient or ceases. The coolant flow must start before application of any voltages and preferably should continue for several seconds after removal of all voltages.

The absolute minimum coolant flow required through the filament section blocks, the filament common-point connections, the grid-No.1 block the grid-No.2 block, and to the plate together with pressure differentials across the cooled elements, is given in the tabulated data. The use of an outlet coolant thermometer and a coolant flow meter at each of the outlets is recommended. Under no circumstances should the temperature of the coolant from any outlet ever exceed the maximum value given for the coolant in the tabulated data.

In spite of the usual precautions taken to eliminate contamination of the coolant by oil, dust, etc., some impurities are likely to enter the fluid. The use of a strainer with at least 60-mesh screen is recommended in the coolant supply line as near to the tube as possible to trap any foreign particles likely to impair the coolant flow through the tube ducts. Also, a regeneration loop followed by a submicron filter should be employed. For example, a regeneration loop having a 10-to-20-gallon-per-hour capacity will ordinarily be adequate for use with a cooling system containing about 20 gallons.

When the tube is used in equipment under conditions such that the ambient temperature is below 0°C, precautions should be taken to prevent freezing of the water in the tube ducts.

FOR ADDITIONAL INFORMATION ON THIS TYPE INCLUDING INPUT AND OUTPUT CAVITY DRAWINGS, WRITE FOR TECHNICAL BULLETIN AVAILABLE FROM:

Commercial Engineering
Electronic Components and Devices
Radio Corporation of America
Harrison, New Jersey
SIMPLIFIED DIMENSIONAL OUTLINE

INDEX HOLE

DO NOT MAKE CONNECTION TO SCREWS

COOLANT OUTLET

COOLANT INLET

INDEX PIN

OUTPUT END

INDICATES CERAMIC BUSHING

DC PLATE & COOLANT CONNECTION

RF PLATE TERMINAL CONTACT SURFACE

EXHAUST CAP
MAKE NO CONNECTION
DO NOT REMOVE

RF GRID-IA TERMINAL CONTACT SURFACE

COOLANT-CONNECTION NUT

INSULATED FILAMENT TERMINAL & COOLANT CONNECTION
92CL-9656VIA

A detailed Dimensional Outline and associated Gauge Drawings are given in the Technical Bulletin available upon request.
TYPICAL CONSTANT-CURRENT CHARACTERISTICS

$E_1 = 0.95$ VOLT
$I_{C1} =$ GRID-N°1 AMPERES
$I_{C2} =$ GRID-N°2 AMPERES
GRID-N°2 VOLTS = 1800

RADIO CORPORATION OF AMERICA
Electron Tube Division
Harrison, N. J.