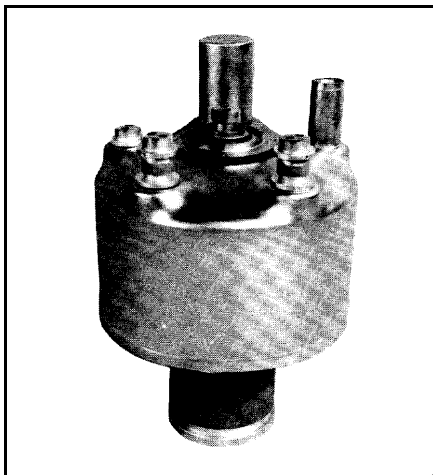


# 4648, 4648V1 Power Tube



## RF Power Amplifier Tetrode

- CW Output Up To 350 kW
- Pulsed Output Up To 1000 kW Peak
- Operation To 45 MHz
- Power Gain Up To 28 dB

The BURLE 4648 is designed to operate in a wide variety of communication, particle-accelerator, radar, and control applications. It is rated as an RF power amplifier in Class C telegraphy service, as a plate modulated amplifier in Class C telephony service, and as a power amplifier in Class B plate-pulsed service.

The 4648 is a liquid-cooled, beam power tube of ceramic-metal construction. It employs thoriated-tungsten filaments in a circular array of unit-electron-optical systems surrounding a centrally located plate to give excellent reliability and long life. It features high RF power gain with low RF drive voltage. Integral coolant ducts to each electrode assure effective cooling and good operational stability.

Accessories recommended for efficient handling and operation of the 4648 include the AJ2195 Lifting Adaptor for uncrating and installing the tube with ease and safety; the AJ2196 Plate Coolant Separator for efficient anode cooling; the AJ2198 Terminal and Coolant Connector for the filament terminal; and three AJ2197 Terminal and Coolant Connectors for the grid No. 1, grid No. 2, and filament ground terminals.

Descriptive information concerning these accessories is included. These accessories are interchangeable between 4648's and must be ordered separately.

This data sheet gives application information unique to the BURLE 4648. General information, covering the installation and operation of this tube type, is given in the "Application Guide for BURLE Power Tubes" TP-105.

Close attention to the instructions contained therein will assure longer tube life, safer operation, less equipment downtime, and fewer tube handling accidents.

The BURLE 4648V1 is a liquid cooled power tetrode of ceramic-

metal construction. It employs thoriated tungsten filaments in a circular array of unit optical systems that surround a centrally located plate electrode. Each unit filaments to be heated from an AC power source; its counterpart, the 4648 requires that the filaments be heated from a DC power force.

For further information or application assistance on this device, contact BURLE INDUSTRIES, INC., Tube Operations Application Engineering, Lancaster, PA 17601-5688

### General Data

#### Electrical

Filament: <sup>1</sup>

Type .....	Multistrand Thoriated Tungsten		
Current, DC operating .....	1650	typ.	A
	1700	max.	A
Starting current (Must never exceed even momentarily) .....	2000	max.	A
Voltage at 1650 A .....	3.8	typ.	v
Minimum heating time to reach operating voltage .....	60		s
Minimum heating time at operating voltage before applying plate voltage .....	60		s
Mu-Factor (Grid No. 2 to grid No. 1) .....	8		
Direct Interelectrode Capacitances:			
Grid No. 1 to plate .....	0.6		pF
Grid No. 1 to grid No. 2 and cathode .....	1200		pF
Plate to cathode and grid No. 2 .....	85		pF
Grid No. 2 to cathode .....	140		pF
Grid No. 2 to grid No. 1 .....	775		pF
Grid No. 1 to cathode .....	425		pF



## Tube Mounting

It is recommended that the tube be mounted with the axis vertical and either end up. In either case, support the weight of the tube on or by the indicated mounting surface shown on the tube outline drawing. Eight equally spaced 1/4-28 tapped holes on a 9.25-inch (23.5 mm) dia. bolt circle are provided in this surface for securing the tube in place.

If the tube is to be mounted with the input end up, the tube may be placed directly into the operating position with the hoist setup of Step 7 of the Uncrating Instructions. After mounting, the AJ2195 Lifting Adaptor should be removed from the tube and stored for future use.

If the tube is to be mounted with the output end up special care must be taken when turning it around. The recommended procedure is as follows:

1. Lift tube using the Lifting Adaptor AJ2195.
2. Attached a 15-inch diameter mounting plate to the tube mounting surface. This plate shall have two eyebolts 180° apart in a horizontal plane. Use all eight mounting holes. (See Figure 1.) If this plate is to be used as the filament return, make certain good electrical contact is made between the plate and the tube surface.
3. Set the tube down resting on mounting plate.
4. Remove the Lifting Adaptor AJ2195.
5. Lift tube using the eyebolts on the mounting plate. It is important that the tube be held steady while being raised.
6. Carefully turn tube end for end.
7. Set the tube down on stand so that it will be suspended from the mounting plate.

## Cooling Considerations

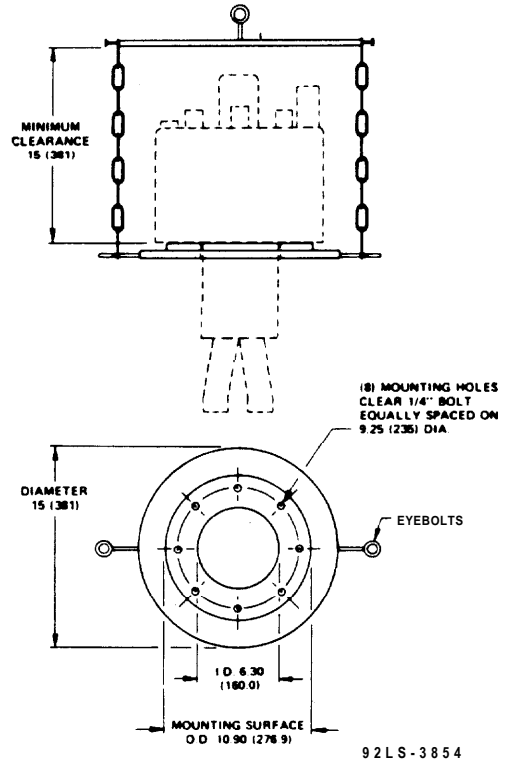
Consult TP-105 for general recommendations on liquid cooling.

The weight of the coolant hoses must be externally supported to insure against applying excessive mechanical stress to the tube.

## Anode Coolant Separator

The AJ2196 Plate Coolant Separator was designed as an accessory for the 4648 tube and must be ordered as a separate item. Unless ordered, the tube will be delivered without a water separator. The coolant separator shall be installed in accordance with the following procedure:

1. Visually inspect the coolant separator and tube anode water cavity to assure that they are clean and free of particles.  
Caution: Do not clean the anode coolant fins mechanically.
2. Place a clean, lubricant-free "O" ring (uniform size No. 237) in the moat on the anode flange.
3. Carefully insert the AJ2196 Plate Coolant separator into the anode cavity so as not to damage the anode coolant fins along the side of the anode cavity. Note: No force is required to insert the separator. After the coolant separator has been completely inserted rotate it, if necessary, to line up the clearance holes in the separator with the tapped holes in the anode flange.
4. Secure the separator in place with eight 1/4-20 NCx5/8 inch long stainless steel, binding-head screws.



Basic dimensions in inches. Parenthetical dimensions in mm for reference.

Figure 1 - Mounting Plate and Lifting Recommendation

## Coolant Course Inspection

Please contact TP-105 for instructions on "Inspection of Coolant Courses" and "Cleaning Coolant Courses". Attention is directed especially to the anode coolant fins which are soft and easily damaged. Do not attempt to clean these fins by mechanical methods.

## Electrical Considerations

Please consult TP-105 for the design of electrical connections and general electrical considerations.

Electrical requirements unique to this tube include the following items:

### A. Filament

A dc filament supply is required. Filament excitation with an ac supply may generate mechanical resonances in the cathode structure. (See Note 1.) The dc electrical filament connections must be made as follows: the positive lead is connected to the filament terminal and coolant connection on the input end of the tube using the AJ2196 connector. The negative lead is connected to the dc filament ground terminal on the output end of the tube using all eight 1/4-28 tapped holes.

### B. RF Driver

The value of drive power given under **typical operation** represents the approximate drive power required at the specified operating frequency. The driver stage should be designed to provide an excess of power over that indicated

to take care of variations in line voltage and initial tube characteristics, changes in components, and tube characteristics during life, and transmission line mismatches.

The input impedance of this tube may vary over a considerable range. The exact range is a function of the grid bias and input RF voltage swing. In instances where the input RF voltage swing exceeds the bias level, the input impedance of the tube will decrease considerably. This change in input drive impedance may limit the input drive voltage unless the circuit designer utilizes a low impedance bias supply and driver circuit. The RF input circuit should be connected between the RF-Grid-No. 1 terminal and the RF Input Cathode Terminal. Caution: The RF Input Cathode terminal is at filament potential and must never be connected directly to the grid-No. 1 terminal or ground. For drive circuit recommendations, please contact BURLE.

### C. Control Grid and Screen Grid

Due to power radiation from the filament and secondary electron emission, the control and screen grid power dissipation will be higher than that indicated by the voltage-current product for each grid. The actual dissipations must be measured calorimetrically by measuring the electrode inlet and outlet water temperatures and the coolant flow. For temperatures measured in oC and for water flow in GPM, the dissipation may be calculated using the equation:

$$\text{Power Dissipation in kW} = 0.264 (\text{GPM}) (\text{Tout} - \text{Tin})$$

#### X-Radiation Warning

X-radiation may be produced when operating this tube. For each installation, the x-radiation must be checked and shields provided if the radiation level exceeds safe limits.

### Protection Circuitry

Protection circuits serve a three-fold purpose; safety of personnel; protection for the tube in the event of abnormal circuit operation; and protection of the tube circuits in the event of abnormal tube operation.

Large power tubes require protective devices to insure against high voltage shocks, RF radiation, loss of coolant flow, inadequate warm-up, etc. A full treatment of protective requirements is covered in the "Application Guide for BURLE Power Tubes" TP-105.

### RF Power Amplifier<sup>6</sup> - Class C Telegraphy and RF Power Amplifier<sup>6</sup> - Class C FM Telephony

#### Maximum CCS Ratings, Absolute-Maximum Values

DC Plate Voltage .....	22	kV
DC Grid-No. 2 Voltage .....	1400	V
DC Grid-No. 1 Voltage .....	-400	V
DC Plate Current .....	45	A
Plate Dissipation <sup>11</sup> .....	250	kW
Grid-No. 2 Dissipation <sup>7</sup> .....	3.5	kW
Grid-No. 1 Dissipation <sup>7</sup> .....	3.0	kW

#### Typical CCS Operation

DC Plate Voltage .....	20	kV
DC Grid-No. 2 Voltage .....	1200	V
DC Grid-No. 1 Voltage .....	-200	V
Peak RF Grid-No. 1 Voltage .....	100	V
DC Plate Current .....	32	A
DC Grid-No. 2 Current .....	1.3	A
DC Grid-No. 1 Current .....	5.0	A
Driver Power (Approx.) .....	1500	W
Circuit Efficiency (Approx.) .....	95	%
Useful Power Output (Approx.) .....	350	kW

### Plate-Modulated RF Power Amplifier<sup>6</sup>

#### Class C Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0 unless otherwise indicated.

#### Maximum CCS Ratings, Absolute-Maximum Values

DC Plate Voltage .....	16	kV
DC Grid-No. 2 Voltage .....	1 100	V
DC Grid-No. 1 Voltage .....	-400	V
DC Plate Current .....	25	A
Plate Dissipation <sup>7</sup> .....	150	kW
Grid-No. 2 Dissipation <sup>7</sup> .....	2.5	kW
Grid-No. 1 Dissipation <sup>7</sup> .....	2.5	kW

#### Typical Operation

DC Plate Voltage .....	14	kV
DC Grid-No. 2 Voltage .....	1000	V
DC Grid-No. 1 Voltage .....	-250	V
Peak RF Grid-No. 1 Voltage .....	280	V
DC Plate Current .....	22	A
DC Grid-No. 2 Current .....	1.3	A
DC Grid-No. 1 Current .....	2.5	A
Driver Power Output (Approx.) .....	750	W
Output-Circuit Efficiency (Approx.) .....	95	%
Useful Power Output (Approx.) .....	200	kW

### Footnotes for Ratings

\* For circuit design assistance and recommended operating parameters, contact BURLE.

6. See TP- 105.

7. Determined by calorimeter measurements. Power specified includes intercepted power radiated from the filaments.

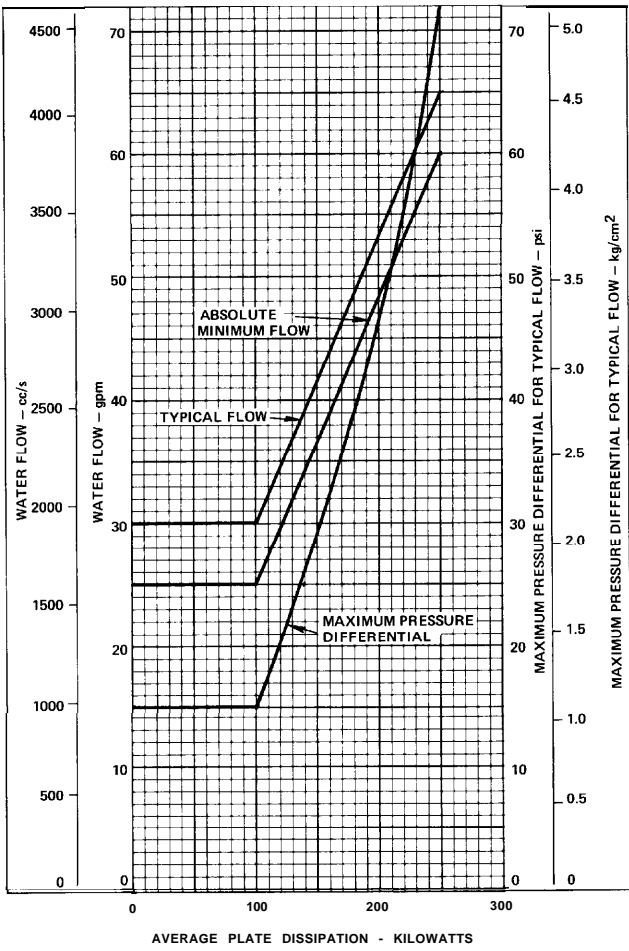


Figure 2 - Cooling Characteristics

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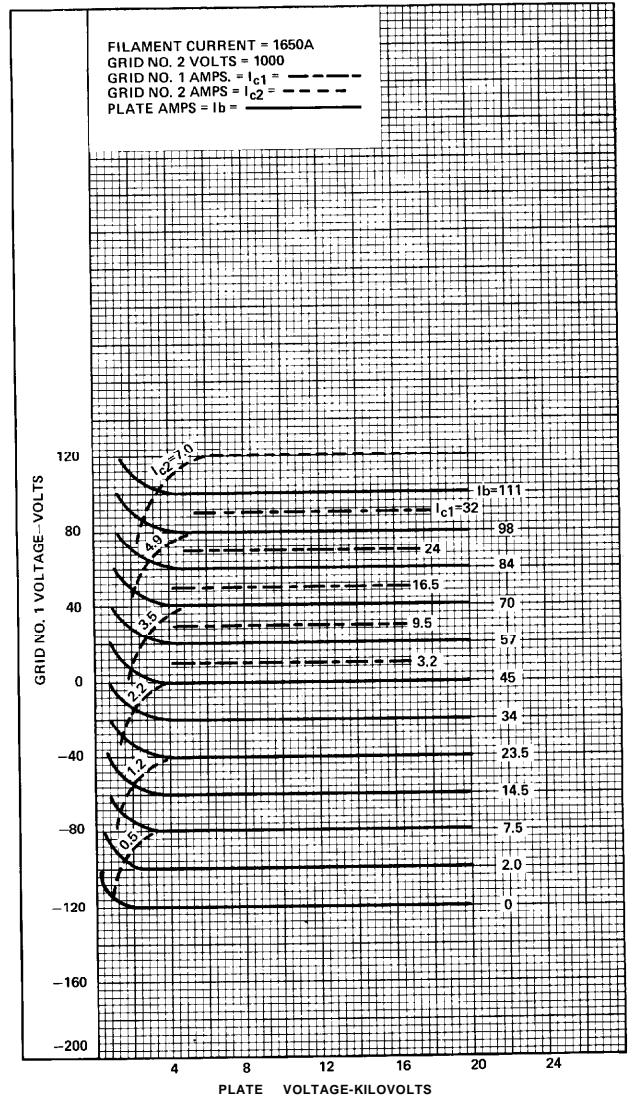


Figure 3 - Typical Characteristics ( $E_{c2} = 1000$  V)

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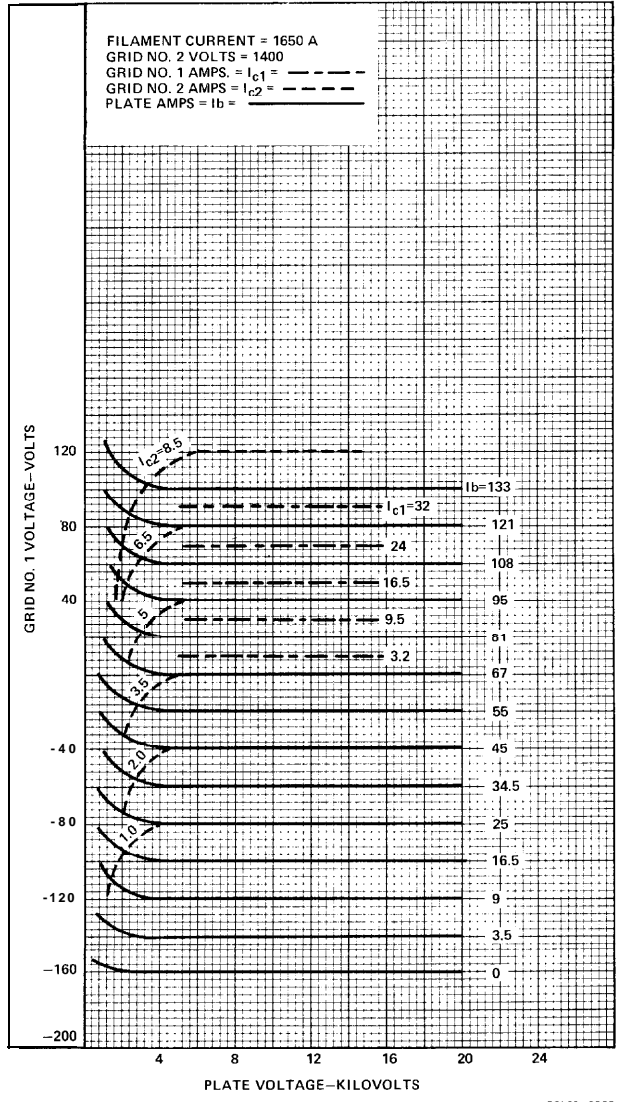
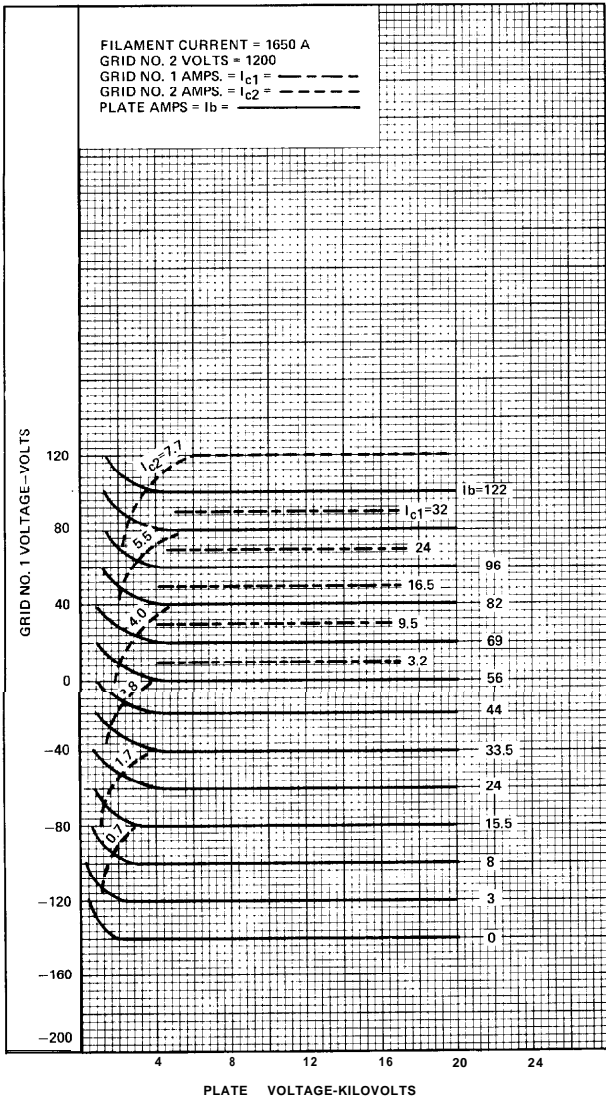


Figure 4 - Typical Characteristics ( $E_{c2} = 1200$  V)

Figure 5 - Typical Characteristics ( $E_{c2} = 1400$  V)

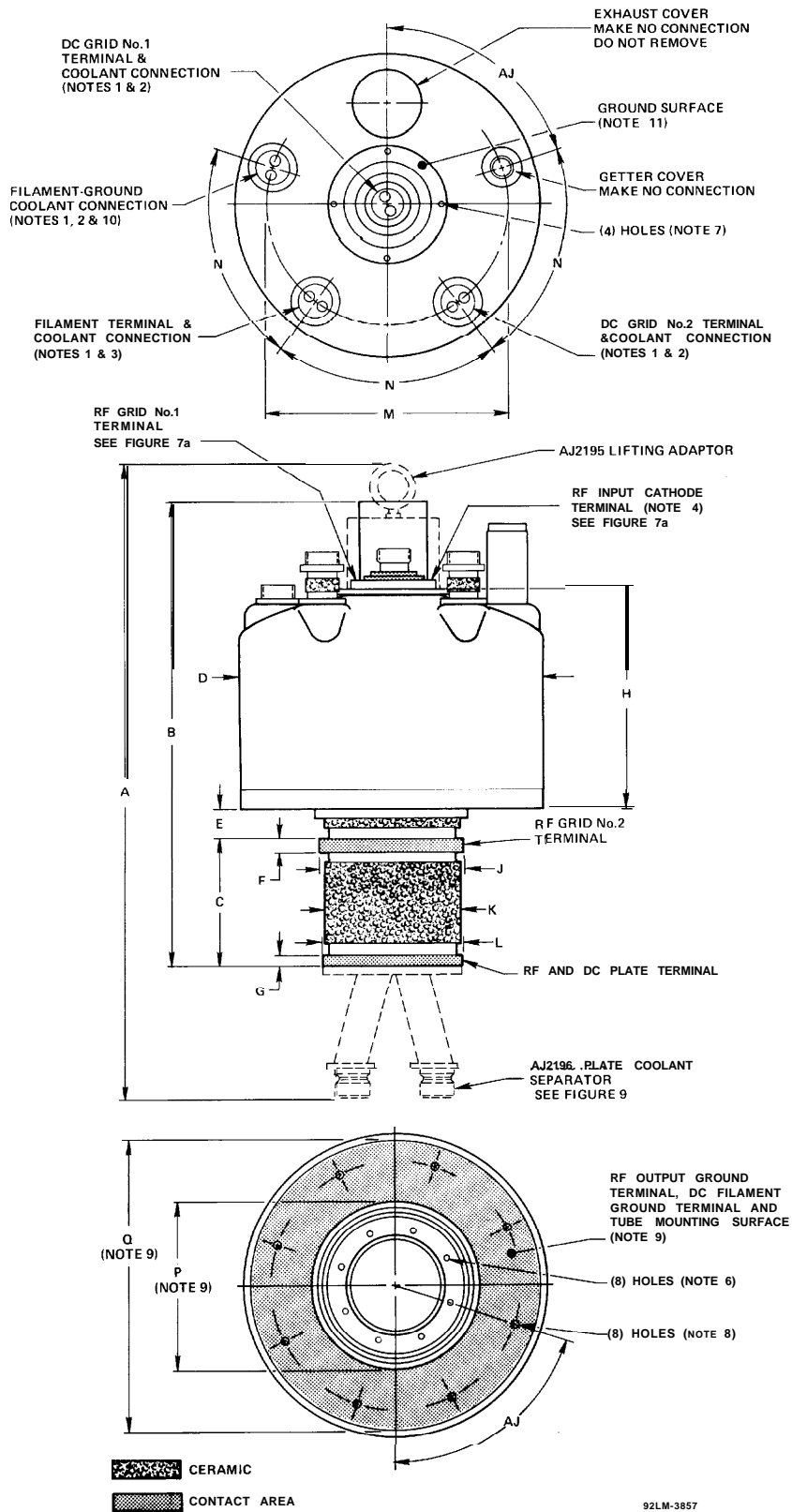
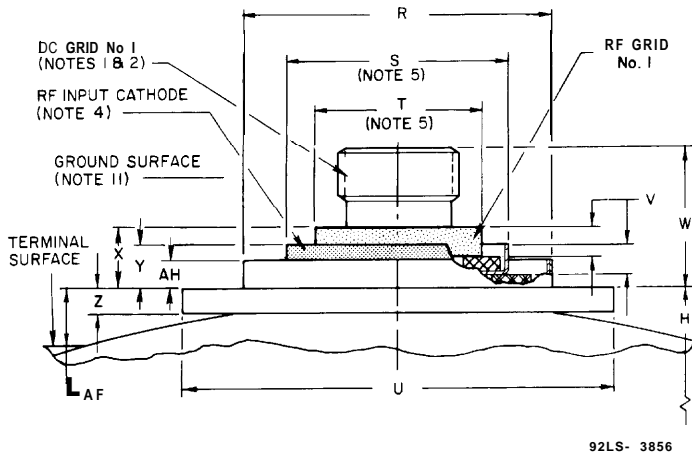


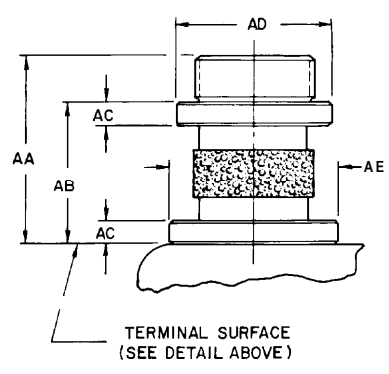
Figure 6 - Dimensional Outline



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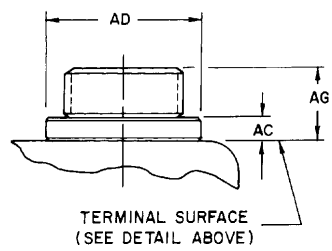
**Figure 6a - Detail of RF Input Cathode and RF Grid No. 1 Terminal, Contact Surfaces and DC Grid No. 1 Terminal**

4. The RF Input Cathode Terminal is at filament potential. Do not ground.
5. This diameter dimension is held only over length of V.
6. Eight (8) holstapped 1/4"-20 NC equallyspaced on a 4.20" (106.7 mm) diameter bolt circle.
7. Four (4) holes tapped 10-32 NF to a minimum depth of .20" (5.1 mm) equallyspaced on a 4.20" ± .03" (106.68 ± .76 mm) diameter bolt circle.
8. Eight (8) holes, tapped 1/4-28 NF to a minimum depth of .30" (7.6 mm) equally spaced on a 9.25" ± 2.03" (234.95 ± .76 mm) diameter bolt circle.
9. Contact should not be made at a diameter smaller than 6.30" (160.0 mm) nor greater than 10.90" (276.9 mm).
10. Make no electrical connections.
11. Ground surface is used to attach Lifting Adaptor AJ2195 and may be used during operation to support input circuit components at ground potential.



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**Figure 6b - Detail of Filament and DC Grid No. 2 Terminals**



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**Figure 6c - Detail of Filament Ground Terminal**

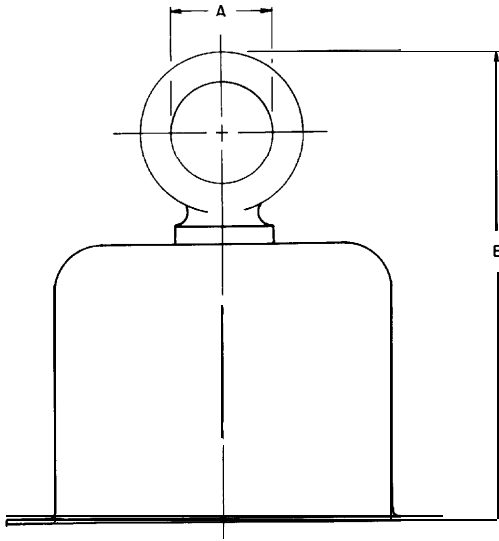
- Notes for Dimensional Outline**
1. Terminal is 1-1/4" dia. threaded 0.5" (12.7 mm) long with 16 UN Class 2A thread. It has two holes 0.312" -0.324" (7.92-8.23 mm) diameter spaced 0.531" (13.49 mm) on centers.
  2. Terminal will accept coolant connector AJ2197.
  3. Terminal will accept filament electrical and coolant connector AJ2198.

**Tabulated Dimensions\***

Dimensions	Inches	Value	Millimeters	Degrees
A	26.0 max.		660 max.	
B	18.5 max.		470 max.	
C	4.84 ± .02		122.94 ± .51	
D Dia.	11.65 max.		295.9 max.	
E	1.07 ± .03		27.18 ± .76	
F	0.52 ± .01		13.21 ± .25	
G	0.42 ± .01		10.67 ± .25	
H	8.35 ± .10		212.1 ± 2.5	
J Dia.	5.50 ± .01		139.70 ± .25	
K Dia.	5.12 ± .10		130.0 ± 2.5	
L Dia.	5.25 ± .01		133.35 ± .25	
M Dia.	9.10 ± .08		231.1 ± 2.0	
N	-		-	72° + 3°
P Dia.	6.30 max.		160.0 max.	
Q Dia.	10.90 min.		276.9 min.	
R Dia.	3.30 max.		83.9 max.	
S Dia.	2.319 ± .012		58.90 ± .30	
T Dia.	1.725 ± .015		43.82 ± .38	
U	4.50 ± .02		114.30 ± .51	
V	0.24 min.		6.1 min.	
W	1.47 ± .06		37.3 ± 1.5	
X	0.63 ± .06		16.00 ± 1.52	
Y	0.46 ± .06		11.68 ± 1.52	
Z	0.22 ± .02		5.59 ± .51	
AA	2.00 ± .05		50.8 ± 1.3	
AB	1.50 ± .04		38.10 ± 1.02	
AC	0.25 ± .02		6.35 ± .51	
AD Dia.	1.62 ± .02		41.15 ± .51	
AE Dia.	1.74 ± .02		44.20 ± .51	
AF	0.62 ± .10		15.7 ± 2.5	
AG	0.75 ± .05		19.0 ± 1.3	
AH	0.45 max.		11.4 max.	
AJ	-		-	72° ± 5°

\* Basic dimensions are in inches. Metric dimensions are derived from the basic inch dimension (1 inch = 25.4 mm).





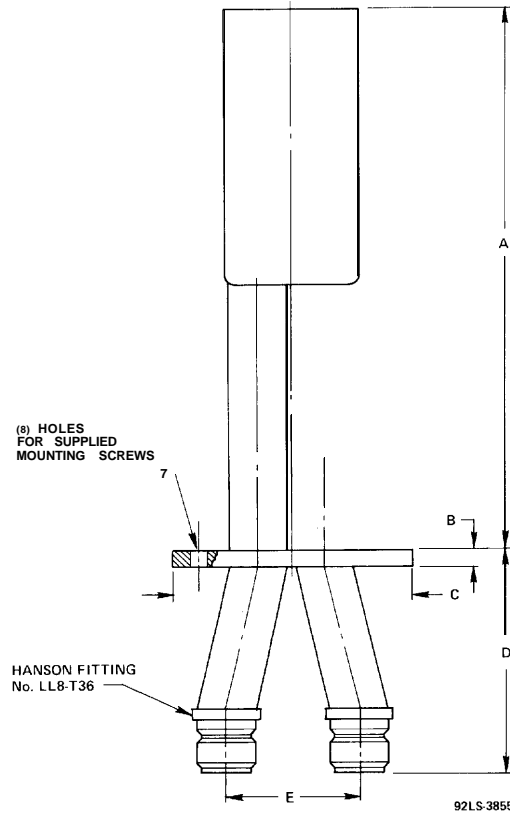
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**Tabulated Dimensions\***

Dimension	Inches	Millimeters
A Dia.	0.88 min.	22.3 min.
B	5.0 max.	127 max.

\* Basic dimensions are in inches. Metric dimensions are derived from the basic inch dimension (1 inch = 25.4 mm).

**Figure 7 - Lifting Adaptor AJ2195**

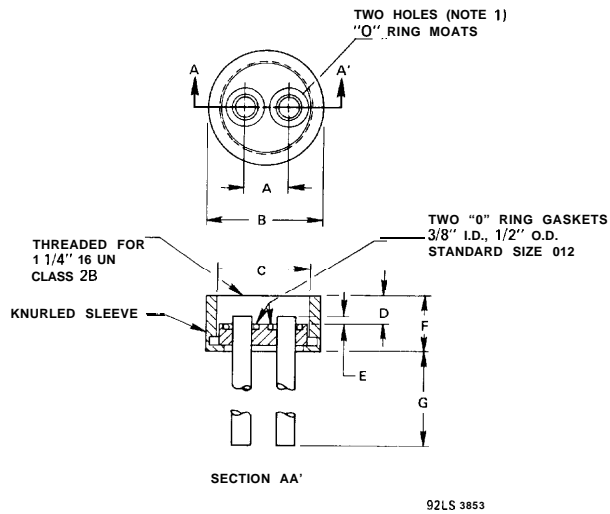


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**Tabulated Dimensions\***

Dimension	Inches	Millimeters
A	10.95 max.	278.1 max.
B	0.35 ± .02	8.89 ± .51
C Dia.	5.20 ± .01	32.08 ± .25
D	5.5 max.	139 max.
E	2.60 ± .20	66.1 ± 5.1

**Figure 8 - Plate Coolant Separator AJ2196**



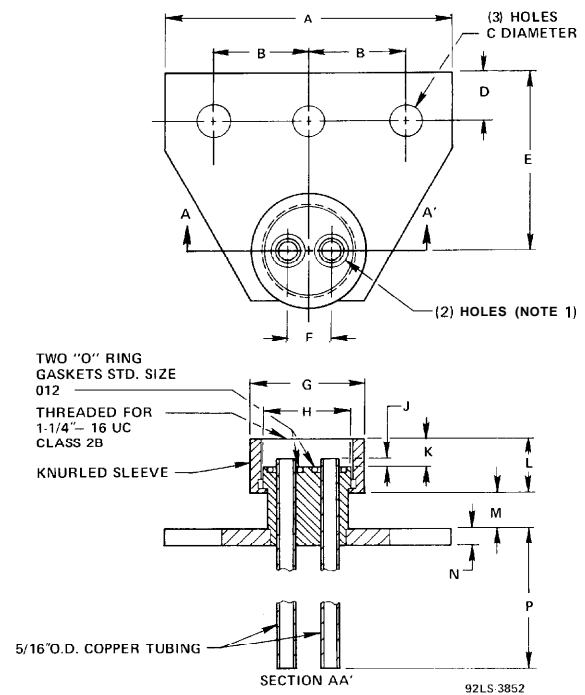
**Tabulated Dimensions \***

Dimension	Inches	Millimeter
A	0.53	13.5
B Dia.	1.50	38.1
C Dia.	1.15	29.2
D	0.38	9.6
E	0.12	3.0
F	0.69	17.5
G	3.32 min.	84.3 min.

**Note 1** - "O" Ring Moat has an OD of 0.485" (12.32 mm) and a depth of 0.05" (1.3 mm).

\* Basic dimensions are in inches. Metric dimensions are derived from the basic inch dimension (1 inch = 25.4 mm).

**Figure 9 - Coolant Connector AJ2197**



**Tabulated Dimensions\***

Dimension	Inches	Millimeters
A	3.75	95.3
B	1.25	31.7
C	0.39	9.9
D	0.62	15.7
E	2.37	60.2
F	0.53	13.5
G	1.50	38.1
H	1.15	29.2
J	0.12	3.0
K	0.38	9.6
L	0.69	17.5
M	0.69	17.5
N	0.25	6.4
P	2.62 min.	66.7 min.

**Note 1** - Moat for "O" ring has an OD of 0.485 inch (12.3 mm) and a depth of 0.05 inch (1.3 mm).

**Figure 10 - Filament Electrical and Coolant Connector AJ2198**