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S94000E
Power Tube
High-Voltage, Beam Tetrode Regulator Tube For High-Power, Very-Long Pulse Switch and Regulator Applications

- **200 kV Hold-Off**
- **90A**
- **Multisecond Pulse Capability**
- **Full Regulation to 2 Megawatts of Anode Dissipation**
- **Negative-Grid Operation**
- **Liquid Cooled**

The BURLE S94000E is designed especially for high-power, very-long pulse switch and regulator applications. It is a liquid-cooled, ceramic-metal beam power tetrode that utilizes thoriated-tungsten filaments in a circular-array of unit electron-optical systems surrounding a centrally located anode. The tube has the capability of supplying high current to a uniquely designed anode structure with negative voltage applied to grid No.1.

This bulletin gives information unique to the BURLE S94000E tube, in addition, accessories for the installation of the tube are available from BURLE. General information, covering the installation and operation of this tube is given in “Application Guide for BURLE Power Tubes”, TP-105 and “S94000E Installation and Operating Instructions”.

Close attention to the data and information contained in these publications will assure longer tube life, safer operation, less equipment downtime, and fewer tube handling accidents. For copies of these publications, contact your BURLE Representative or write BURLE INDUSTRIES, INC., 1000 New Holland Avenue, Lancaster, PA 17601-5688.

General Data

Electrical

Filament

Type…….	Multistrand Thoriated Tungsten		
Current, DC……..	4200	typ.	A
Current, DC……..	4700	max.	A
Starting Current (must never exceed)……..	5000	max.	A
Voltage at 4200A…….	3.5	typ.	V
Minimum time to reach operating voltage	2	min.	
Mu-Factor, (Grid No.1 to Grid No.2)……..	9	typ.	
Direct Interelectrode Capacitances:			
Grid No.1 to anode……..	0.7		pf
Grid No.1 to grid No.2 and cathode (input)	2000		pf
Anode to grid No.2 and cathode (output)	80		pf
Grid No.2 to cathode ……..	1700		pf

Mechanical

Operating Attitude……	Tube Axis Vertical
Operating Environment…….	Above 125 kV the anode terminal and ceramic insulator must be immersed in oil or pressurized gas
Overall Length (Typ.) ……..	0.914 m (36 in)
Maximum Diameter (Typ.)……	0.565 m (22.25 in)
Weight (Typ.)	
Uncrated……	147 kg (325 lbs)
Crated……	394.625 kg (870 lbs)
Dimensions and Terminal Connections……..	See **Outline Drawing**

Thermal

Maximum Ceramic Temperature ……	150	°C
Maximum Metal Temperature……	150	°C
Minimum Storage Temperature[1] ……	-65	°C
Maximum External Gas Pressure, Absolute……..	(2.1 bars) 30	PSI

Switch/Regulator Service

For a maximum "On" time of 10 seconds in any 1 minute interval.

Maximum Ratings, Absolute-Maximum Values

See **Figure 1**).

DC Anode Voltage……..	200	kV
Peak Anode Current……	90	A
Anode Dissipation……	2000	kW
Dc Grid No.1 DC Voltage……	-1000	V
DC Grld-No.2 Voltage……	2.0	kV
Peak Grld-No.2 Current……	8.0	A
Grid-No.1 Dissipation [2,3] ……	10	kW
Grld-No.2 Dissipation[2,3] ……	10	kW

Typical Operation

Switch-Tube Service

Pulse Length = 10 seconds. Repetition Rate = 1 per minute.

DC Anode Voltage……	190	120	kV
Peak Anode Current ……	90	65	A
DC Grid-No.2 Voltage……	1.5	1.5	kV
Peak Orid-No.2 Current……	3.5	1.0	A
DC Grid-No.1 Voltage……	-500	-500	V
Grid-No.1 Voltage During Pulse……	-35	-60	V
Output (Load) Voltage During Pulse….	180	112	kV

Regulator Service

DC Anode Voltage Range……....	175 to 182	105	kV
Peak Anode Current……	90	65	A
DC Grid-No.2 Voltage……..	1.5	1.5	kV
Peak Orid-No.2 Current……...	3.0	1.0	A
DC Grid-No.1 Voltage……..	-500	-500	V
Grid.-No.1 Voltage During Pulse…..	-35	-60	V
Output (Load) Voltage During Pulse.	160	90	kV

Cut-Off Conditions

DC Anode Voltage……..	200	kV
DC Anode Current……..	10	mA
DC Grid-No.2 Voltage……	1.0	kV
DC Grid-No.1 Voltage……	-200	V

Electrical Considerations

Filaments

A DC filament supply is required. Filament excitation with an AC supply may generate mechanical resonances in the filament structure. A three-phase, full-wave rectifier supply is recommended.

Protection Circuitry

Protection circuits are necessary to protect the tube in the event of a flash-arc within the vacuum enclosure when the tube is handling high energy.

All power supplies that are capable of supplying more than 5 Joules of energy to the tube terminals should be equipped with high-speed fault protection. A full explanation of fault protection requirements is covered in "Application Guide for BURLE Power tubes", TP-105. In addition, a spark gap is required between grid No.2 and the cathode.

Ion Pump

Pumping Speed…….. 8 liter/sec

Controller Unit….. Varian No. 9210015, or equivalent

Cooling[4]

Liquid Cooling

Liquid cooling of the filament, grid No.1, grid No.2, filament ground, and the anode are required prior to the application of power to the filament. Interlocking of coolant flow through each element is required.

Normal procedure is to allow the coolant flow to remain flowing for approximately one minute after all voltages have been terminated from the tube. Under emergency conditions, the coolant flow and tube voltages may be terminated simultaneously.

Liquid Pressure Data

Any Inlet Except Mode ……..	(6.9 bars)	100 max.	psi
Anode Inlet ……..	(7.6 bars)	110 max.	psi
Anode Outlet ……..	(1.4 bars)	20 min.	psi
Resistivity of Water at 25ºC……	1.5	min.	Mohm cm
Water Temperature at Any Outlet…….	70	min.	°C
Water Temperature at Anode Inlet……	35	max.	°C

Filament, Grid No.1, Grid No.2, Filament Ground, and Anode Flow vs. Pressure Drop for Water

Coolant Course	Minimum Flow (l/m) gpm	Typical Flow (l/M) gpm	Maximum Diff'r'l Pressure at Typical Flow (bars) psi
Anode: To 1 Mega W Dissipation	(567.8) 150	(605.6) 160	(1.4) 20
To 2 Mega W Dissipation	(946.2) 250	(984.1) 260	(4.1) 60
Filament	(10.6) 2.8	(11.3) 3	(2.1) 30
Filament Ground	(6.8) 1.8	(7.6) 2	(2.1) 30
Grid No.1[5]	(6.8) 1.8	(7.6) 2	(2.1) 30
Grid No.2	(6.8) 1.8	(7.6) 2	(2.1) 30

Anode-Ceramic Cooling

In applications where the anode ceramic is not immersed in oil, a flow of air or gas such as SF6 at a rate of 20 cfm (0.0094 m^3/s) may be required to maintain ceramic temperature below 150 °C.

Notes

1. The tube cooling channels must be free of water before storage.
2. Peak dissipation during the pulse.
3. The power specified includes the filament power that is absorbed by the grids. The grid-No.1 absorbs approx. 40% and grid-No.2 absorbs approx. 20% of the filament power.
4. For additional information on liquid cooling, refer to "Application Guide for BURLE Power Tubes", TP-105.
5. The grid No.1 coolant course should not be connected in series with any other electrode coolant course.

Accessories

The accessories tabulated below and depicted on page 4 for operating the S94000E switch tube are available from BURLE. These accessories can be fabricated by the user from detailed Specifications given in the Application Guide, "S946000E Installation and Operating Instructions".

Accessory (See Figure 4)	Quantity Required	BURLE Order Number	Manufacturer and Number
Coolant Fittings for:			
Grid No.1, grid No.2, and filament ground:			
Fitting……	3	C94804E	-
Clamp……	3	-	Aeroquip Marman No.24502-150
O-Ring……	6	-	Parker No.2-Oil, Compound N674-70
Filament:			
Fitting……	2	C94801E	-
Clamp……	2	-	Aeroquip Marman No24502-200
O-Ring……	2	-	Parker No.2-227, Compound N674-70
Anode:			
Fitting……	2	C94802E	-
Clamp……	2	-	Aeroquip Marman No.24502-225
O-Ring……	2	-	Parker No.2-229, Compound N674-70
Mounting Plate/Filament Return (Ground) for Tube:			
Plate……	1	*	
O-Ring……	1	-	Parker No.2-468, Compound N674-70
Pressure Sealing Sleeve for Mode (Not Required for All Applications):			
Sleeve……	1	C94803E	Parker No.2-364, Compound N674-70
Stand for Mounting Tube Accessories:			
Stand ……	1		

* For information on this accessory, contact BURLE Power Applications Engineering, Lancaster, PA 17601-5688.

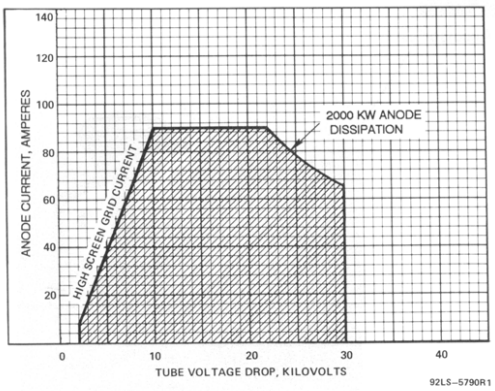
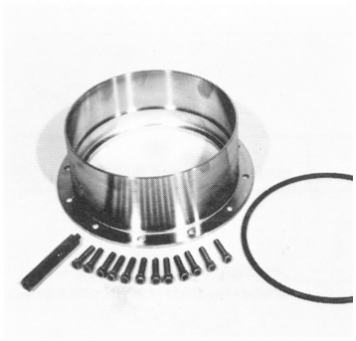


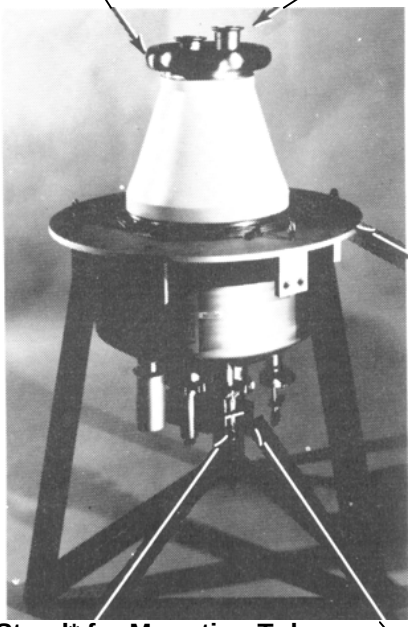
Figure 1 - Operating Region for S94000E Switch Tube

Warning - Personal Safety Hazards
Electrical Shock - Operating voltages applied to this device present a shock hazard.
X-Ray Warning - This device in operation may produce X-rays which can constitute a health hazard unless the device is adequately shielded for radiation.

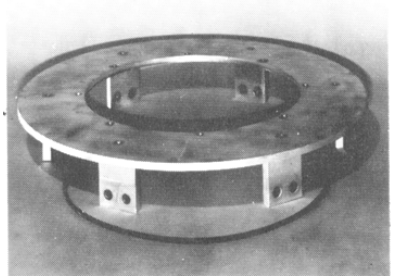


Pressure Sealing Sleeve
(Not shown on assembly, not required for all applications)

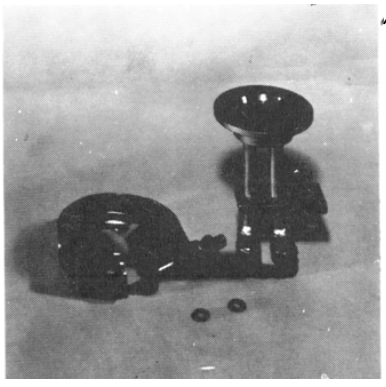
Coolant Fitting for Plate
(Not shown on assembly)



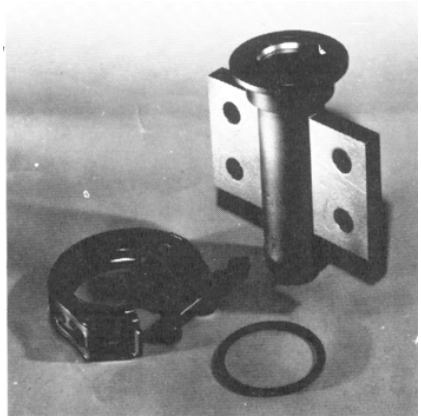
Stand* for Mounting Tube Accessories



Mounting Plate/Filament Return (Ground)*



Coolant Fitting for Grid No. 1, Grid No. 2, and Filament Ground



Coolant Fitting for Filament

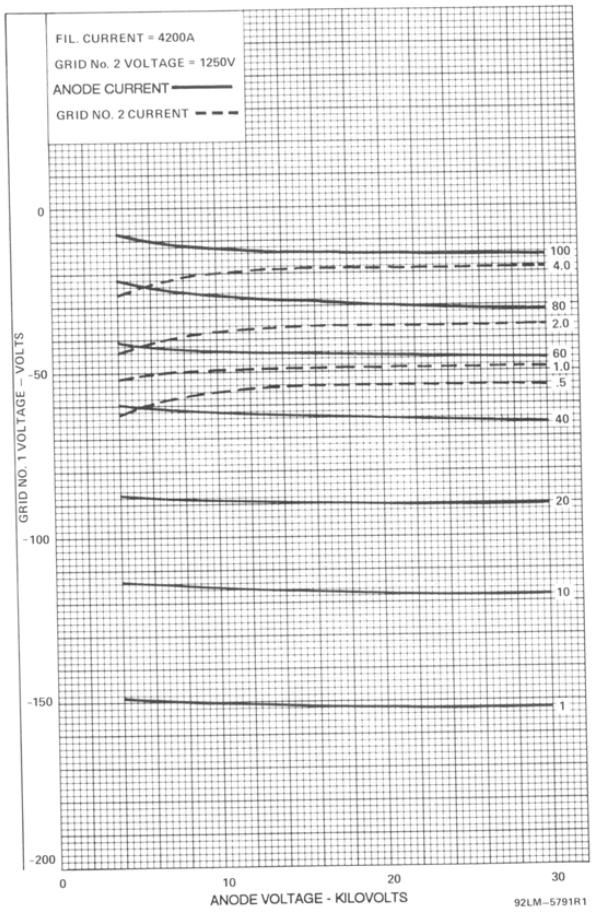


Figure 2 - Typical Constant Current Characteristics (E_{c2} = 1250V)

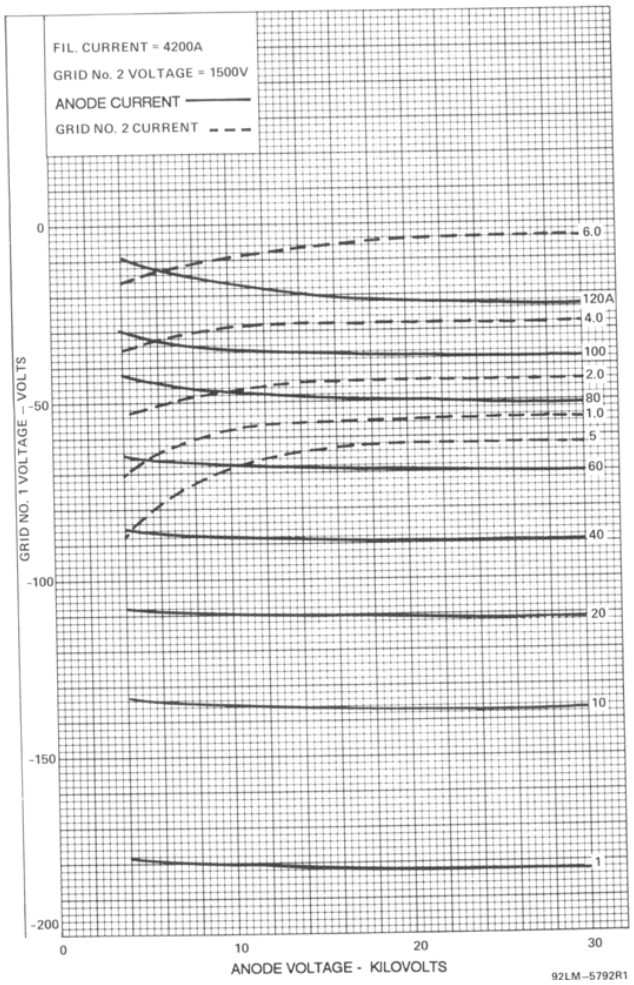
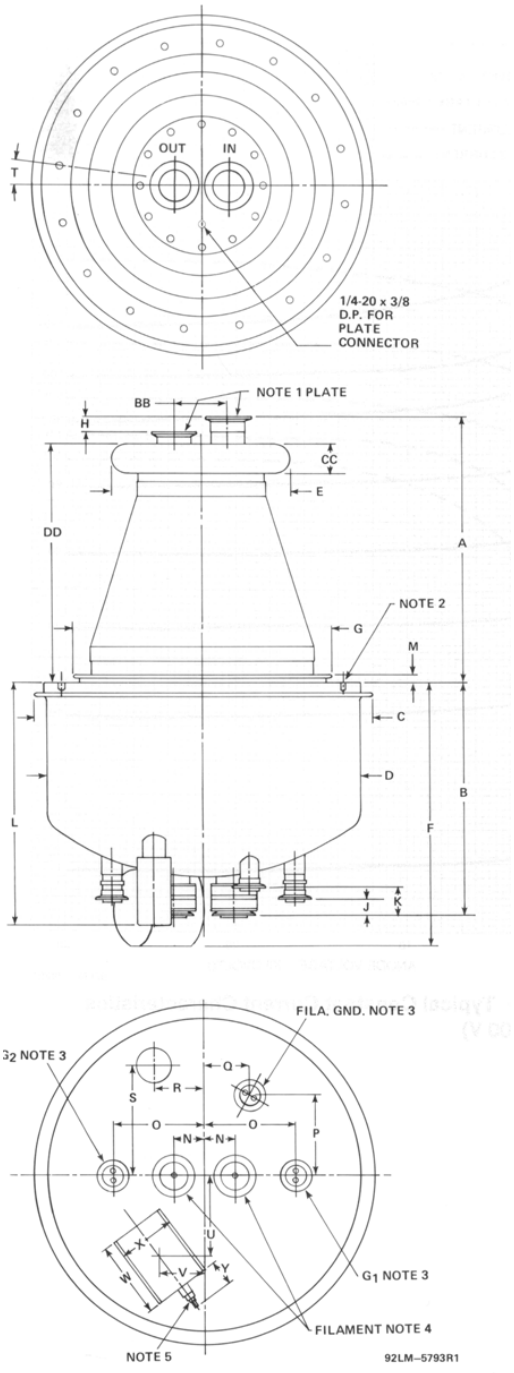


Figure 3 - Typical Constant Current Characteristics (E_{c2} = 1500 V)



Note 1 - Mating flange Aeroquip Marman No.4560-225, O-Ring Parker No.2-229, Clamp Aeroquip Marman No.24502-225, suggested connector BURLE No.C94802E.
Note 2- (16)3/8-16 x 3/8 deep tapped holes, equally spaced on 18.5 ± 0.02 (469.9 ± 0.37 mm) B.C
Note 3- Clamp Aeroquip Marman No.24502-150S, O-Ring Parker No.2-Oil, suggested connector BURLE No.C94804E.
Note 4-Clamp Aeroquip Marman No.24502-200, O-Ring Parker No.2-227, suggested connector BURLE No.C94801E.
Note 5 - Mates with Varian/NRC cable model No.924-0750, Power Supply Varian/NRC Model No.921-0015 or equivalent.

Tabulated Dimensions	Dimensions Inches	Millimeters	
A	17.81± 0.2	(452.37 ± 5.08)	
B	15.07± 0.2	(382.78 ± 5.08)	
C Dia.	22.25	(565.15)	Max.
D Dia.	20.5± 0.2	(520.7 ± 5.08)	
E Dia.	11.62±0.1	(295.15±2.54)	
F	18.18± 0.2	(461.77 ± 5.08)	
G Dia.	17.12	(434.85)	Max.
H	1.00	(25.4)	Ref.
J	0.98	(24.89)	Ref.
K	1.83	(46.48)	Ref.
L	15.9± 0.2	(403.86 ± 5.08)	
M	1.25	(31.75)	Max.
N	2 ± 0.1	(50.8 ± 2.54)	
0	6 ± 0.1	(152.4 ± 2.54)	
P	5.25± 0.1	(133.35 ± 2.54)	
0	3 ± 0.1	(76.2 ± 2.54)	
R	3.25± 0.1	(82.55 ± 2.54)	
S	7.25± 0.1	(184.15 ± 2.54)	
T	7.5º	7.5°	Ref.
U	5.25± 0.1	(133.35 ± 2.54)	
V	3 ± 0.1	(76.2 ± 2.54)	
W	5	(127)	Ref.
X	3.75	(95.25)	Ref.
Y	1.62	(41.15)	Ref.
BB	3.5	(88.9)	Ref.
CC	2 ± 0.06	(50.8 ± 1.52)	
DD	16.08± 0.15	(408.43 ± 3.81)	

Figure 4 - Dimensional Outline