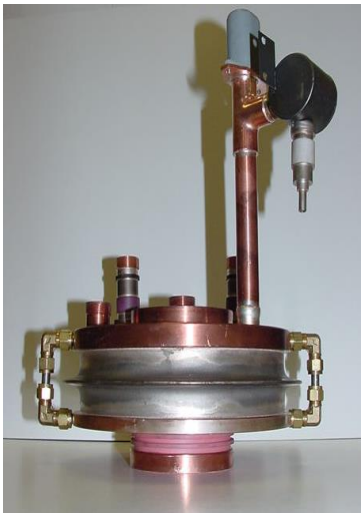
94402E
Power Tube



Super-Power Beam Power Tube

-**Pulse Length to 125 Microseconds**[1]

-**200 Kilowatts from 600 Mc to 799 Mc**

-**175 Kilowatts from 800 Mc to 1000 Mc**

-**Low Filament Power for Airborne Use**

PHOTONIS-94402E is a water-cooled super-power beam power tube of the ceramic-metal type intended for use as an RF-pulse amplifier at frequencies primarily between 600 and 1000 Mc.

The 94402E features low filament power requirements made possible by the use of a matrix-type, oxide-coated filamentary cathode. This cathode provides high emission, long life, and economical operation. The filament voltage is rated to 400 cps for use in airborne and light-weight portable equipment.

Ratings and typical operation are established for the 94402E as a pulsed amplifier in pulsed communications applications. When operated at a pulse duration of 10 microseconds and a duty factor of 0.01 the S94402E can achieve useful peak power output of 200 kilowatts at frequencies of 600 Mc to 799 Mc and useful peak power output of 175 kilowatts at frequencies of 800 Mc to 1000 Mc.

The mechanical structure of the tube consists of a symmetrical array of unit electron-optical systems surrounding a centrally located plate. Integral capacitors effectively bypass the grid No.2 to cathode. Integral water ducts to all electrode areas provide effective cooling of the tube structure.

These outstanding advantages and features of the 94402E permit its use in a wide variety of applications. For further information on extended frequency use or requested services, contact PHOTONIS DEFENSE, Inc.,1000 New Holland Avenue, Lancaster, PA, 17601-5688.

This bulletin is to be used in conjunction with publication, TP-105 -- Application Guide for PHOTONIS Power Tubes.

PHOTONIS
Defense

General Data

Electrical

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

Voltage:[2]			
Maximum, with dc or 60 cps ac excitation	0.80		V
Maximum, with 400 cps ac excitation	0.85		V
Typical, with dc or 60 cps ac excitation	0.75		V
Current:			
Typical operation value at 0.95 volt, with 60 cps excitation	475		amp
Minimum time to reach operating filament voltage	30		sec
Minimum time at normal operating filament voltage before other voltages are applied	90		sec
Mu-Factor, Grid No.2 to Grid No.1	7		
Direct Interelectrode Capacitances:			
Grid No.1 to grid No.2 and cathode	350		pF
Plate to cathode and grid No 2	30		pF
Grid No.2 to cathode (including bypass capacitors)	15,000	max	pF

Mechanical

Operating Position	Tube axis vertical, either end up
Overall Length (w/out Ion Pump)	8.12 ± 0.30 in
Maximum Diameter	11.25 in
Terminal Connections	See Dimensional Outline
Weight (Approx.)	32 lbs

Thermal

Ceramic-Insulator Temperature	150	max.	ºC
Metal-Surface Temperature	100	max.	ºC
Minimum Storage Temperature[3]	-65	min.	ºC

Air Cooling:

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 will 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.

Water Cooling:

Water cooling of the filament block, dc cathode block, grid-No.1 block, grid-No.2 block, and plate is required. The water flow must start before application of any voltages in order to purge the system of bubbles and should continue for several minutes after removal of all voltages. Interlocking of the water flow through each of the cooled elements with all power supplies is recommended to prevent tube damage in case of failure of adequate water flow. The use of distilled water or filtered deionized water is essential.

Water flow:

	Absolute Minimum Flow gpm	**Typical Flow gpm**	**Maximum Pressure Differential For Typical Flow[4] psi**
Through filament block	0.8	1.2	18
Through dc cathode block	0.8	1.2	18
Through grid-No.1 block	0.8	1.2	14
Through grid-No.2 block	0.8	1.2	18
Through plate:			
For plate dissipations up to 10 kw (Av.)	12	14	30
For plate dissipations of 10 kw to 30 kw (Av.)	20	22	60

Resistivity of Water, at 25 ºC	1	min.	megohm-cm
Water Temperature from Any Outlet	70	max.	ºC
External Gas Pressure[5]	60	max.	psia
Water Pressure at Any Inlet	100	max.	psi

Pulsed RF Amplifier

For frequencies from 600 to 1000 Mc, and a maximum "ON" time of 125 microseconds in any 3125-microsecond interval.

Maximum Ratings, Absolute-Maximum Values[6]

Maximum Duty Cycle of	**0.04**	
	At 980 Mc	
DC Plate Voltage[14]	25,000	V
Peak Positive-Pulse Grid-No.2 Voltage[7,8]	2,200	V
DC or Peak Negative-Pulse Grid-No.1 Voltage[9]	400	V
Peak Plate Current	50	amp
Peak Grid-No.2 Current	5	amp
Peak Rectified Grid-No.1 Current	5	amp
DC Plate Current	2.0	amp
DC Grid-No.2 Current	0.2	amp
DCGrid-No.1 Current	0.2	amp
Plate Input (Average)	50,000	W
Plate Dissipation (Average)	32,000	W

Typical Screen-Pulsed Operation

In Class B service at the frequencies shown with a rectangular waveshape pulse of 10 microseconds and a duty factor of 0.01.

	At 750 Mc	**At 980 Mc**	
DC Plate Voltage[14]	20,000	23,000	V
Peak Positive-Pulse Grid-No.2 Voltage[7]	2,000	2,200	V
Negative Grid-No.1 Voltage[9]	230	225	V
Peak Plate Current	33	43	amp
Peak Grid-No.2 Current	3.7	2.5	amp
Peak Rectified Grid-No.1 Current	2.4	1.0	amp
DC Plate Current	0.33	0.43	amp
DC Grid-No.2 Current	0.037	0.025	amp
DC Grid-No.1 Current	0.024	0.010	amp
Peak Driver Power Output (Approx)	6,300	5,400	W
Useful Peak Power Output	250,000	190,000	W

Maximum Circuit Values

Grid-No.1 Circuit Resistance	500	max.	ohms

Characteristics Range Values

	Min.	**Max.**	
Filament Current[10]	428	523	amp.
Input Strap-Resonant Frequency[11, 12]	300	320	Mc
Output Strap-Resonant Frequency[11,13]	710	730	Mc
Direct Interelectrode Capacitances:			
Grid No.2 to cathode	12,000	15,000	pF

1. Operating at pulse lengths greater than 125 microseconds has resulted in electron beam cutting of the copper anode. Continuous operation at long pulse lengths will accelerate the anode cutting and may jeopardize the vacuum integrity of the tube.
2. Because the filament voltage, when operated near the maximum value, provides emission in excess of any requirements within tube ratings, during life the filament voltage should be reduced to a value that will give adequate but not excessive emission. Careful attention to maintaining the value consistent with adequate emission will result in conserving the life of the tube. The filament voltage should be measured at the respective 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.
3. The tube coolant ducts must be free of water before storage or shipment of the tube to prevent damage from freezing.
4. Measured directly across cooled element for the indicated typical flow.
5. This pressure is related to the output-cavity pressurization as required to prevent corona or external arc-over.
6. In accordance with the Absolute Maximum rating system as defined by the Electronic Industries Association Standard RS-239A, formulated by the JEDEC Electron Tube Council.
7. The magnitude of any spike on the grid-No.2 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.
8. A negative dc voltage of 300 volts maximum may be applied to grid No.2 to prevent any tube conduction between pulses.
9. The grid-No.1 voltage may be a combination of fixed and self bias obtained from a series grid resistor.
10. At filament voltage of 0.75 volt and ac filament excitation at 60 cps.
11. Measurements were taken with a Hewlett Packard 8752C Network Analyzer.
12. See **Figure #** for input cavity. (Currently Not Available)
13. See **Figure #** for output cavity. (Currently Not Available)
14. High speed fault" protection must be used with all grid-pulsed applications and with all plate-pulsed applications where the pulse length exceeds 20 microseconds.

Definitions

"ON" Time -- **The** sum of duration of all individual pulses which occur during the indicated interval.

Pulse Duration -- The time interval between the two points on the pulse at which the instantaneous value is 70% of the peak power value.

Peak Value -- The maximum value of a smooth curve through the average of the fluctuations over the top portion of the pulse. Duty Factor-- Ratio of "ON" time to indicated interval.

For considerations common to all BURLE (PHOTONIS) power beam power tubes, see Application Guide for BURLE Power Tubes, TP-105. Additional considerations specifically for the 94402E follow.

Mechanical Considerations

Connections

Flexible connectors of the spring-contact type are required for the RF grid-No.1 terminal and the RF plate terminal. A compressible metal-braid gasket may be used for connection between each RF cathode terminal contact surface and its associated cavity.

To prevent excessive stress on the ceramic-metal seal of the filament and grid-No.2 coolant connections, the two flat edges of the coolant-connection nut should be gripped firmly with a 15\16-inch open-end wrench when removing or tightening the fitting.

Cooling Considerations

Inspection of Cooling Courses

The 0-ring in the moat of the plate assembly in the 94402E may be replaced by a uniform size 230, Buna-N material made by Parker Seal Co., or equivalent.

Electrical Considerations

Mode of Operation

The operating mode of the 99402E and its associated input coaxial cavity is defined as the TEM mode (transverse electromagnetic mode). Difficulty with spurious internal modes can be avoided in the frequency range where operation is desired. A circumferential $TE_{1,1}$ mode may be encountered in the vicinity of 520 Mc. The subscripts 1,1 indicate the order and number of the mode, respectively (see Reference 1). In order to avoid this mode, special care must be taken to obtain a symmetrical TEM-mode excitation of the input electrodes. Because of the unique arrangement of input electrodes in the #-gun array of the tube, the frequency of the first-order circumferential mode is lower than a calculated value based on the average diameter of the array. When the input circuit of the tube is tuned so that the desired operating TEM-mode frequency is near the $TE_{1,1}$ mode frequency and driven at the TEM-mode frequency, existence of the circumferential mode is evidenced by low power output, excessive grid-No.1 current, and excessive plate current at normal driving power.

Driver

The value of driver power output given under Typical Operation represents approximately the actual driving power required at the specified frequency. At higher frequencies, more driving power may be necessary because of increased tube and circuit losses. In all cases, however, the driver stage should be designed to provide an excess of power over that indicated under the typical operating conditions to take care of variations in line voltage, in components, in initial tube characteristics, and in tube characteristics during life.

References

1. L.L. Koros, "A Novel Ultra-High-Frequency High-Power-Amplifier System", RCA Review, Vol. XVI, No. 2, June, 1955.
2. W.P. Bennett, "A Beam Power Tube for Ultra-High-Frequency Service", RCA Review, Vol. XVI, No. 3, Sept., 1955.
3. R.W.P. King, H. R. Mimno, and A. H. Wing, "Transmission Lines, Antennas, and Wave Guides". Published by McGraw-Hill Book Company, Inc.
4. G. N. Glasoe and J. V. LeBacqz, "Pulse Generators'\" M.I.T. Radiation Laboratory Series, Vol. 5, (1948). Published by McGraw-Hill Book Company, Inc.

94402E Input Tuning Curves

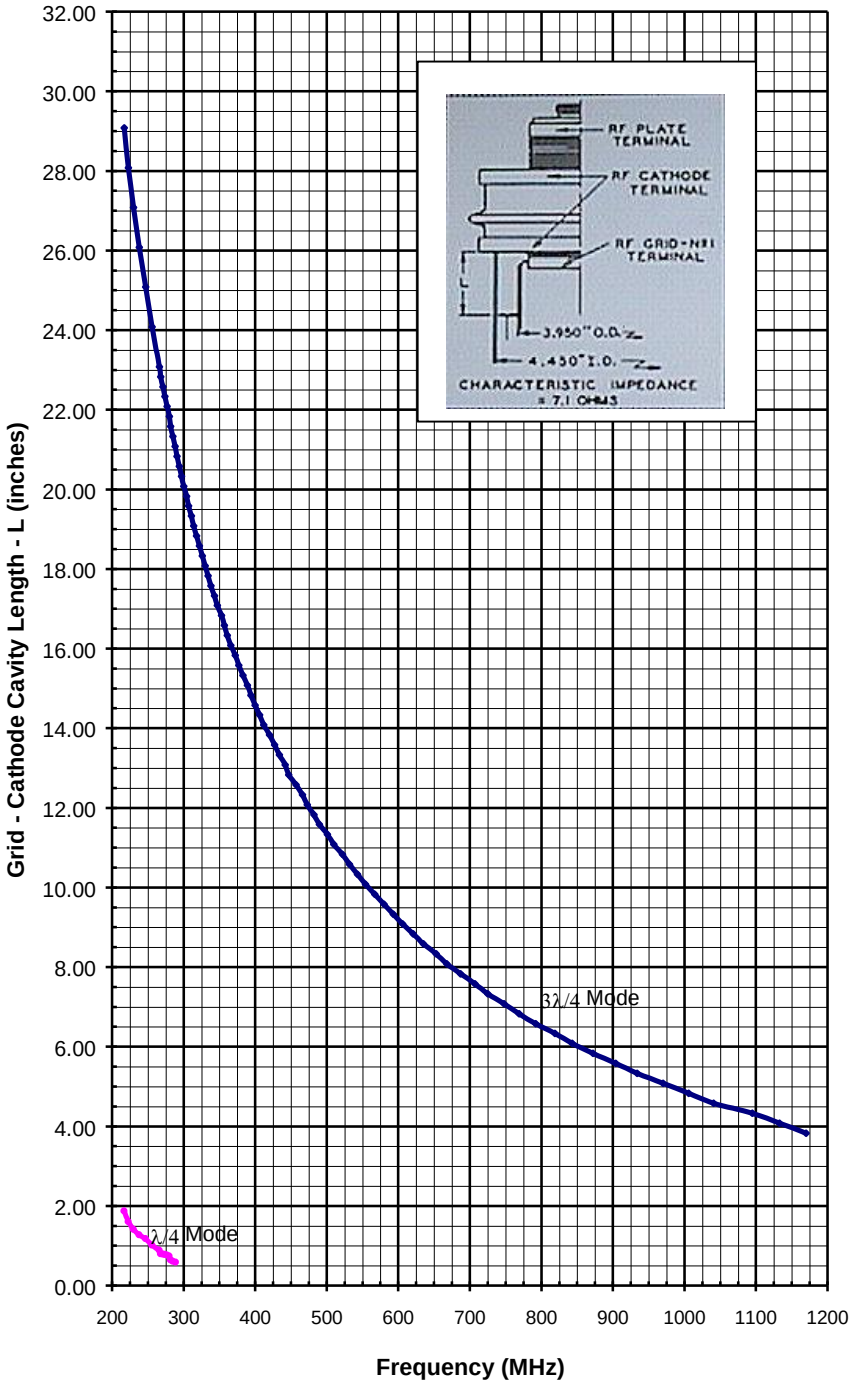


Figure 1 – Input Tuning Curves for Type 94402E Operating in Indicated Modes

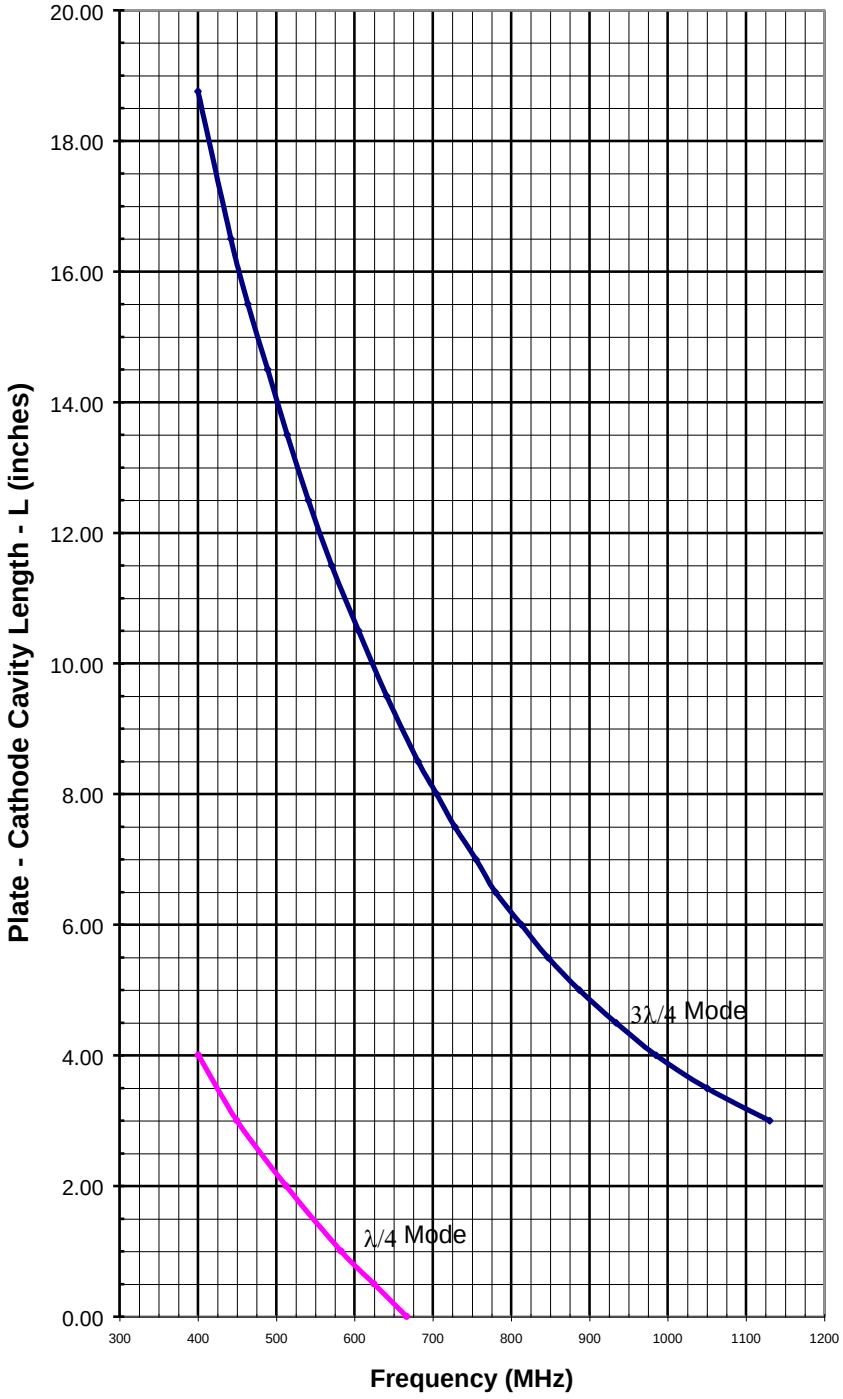


Figure 2 – Output Tuning Curves for Type 94402E Operating in Indicated Modes w/ Zo = 7.1 Ohms.

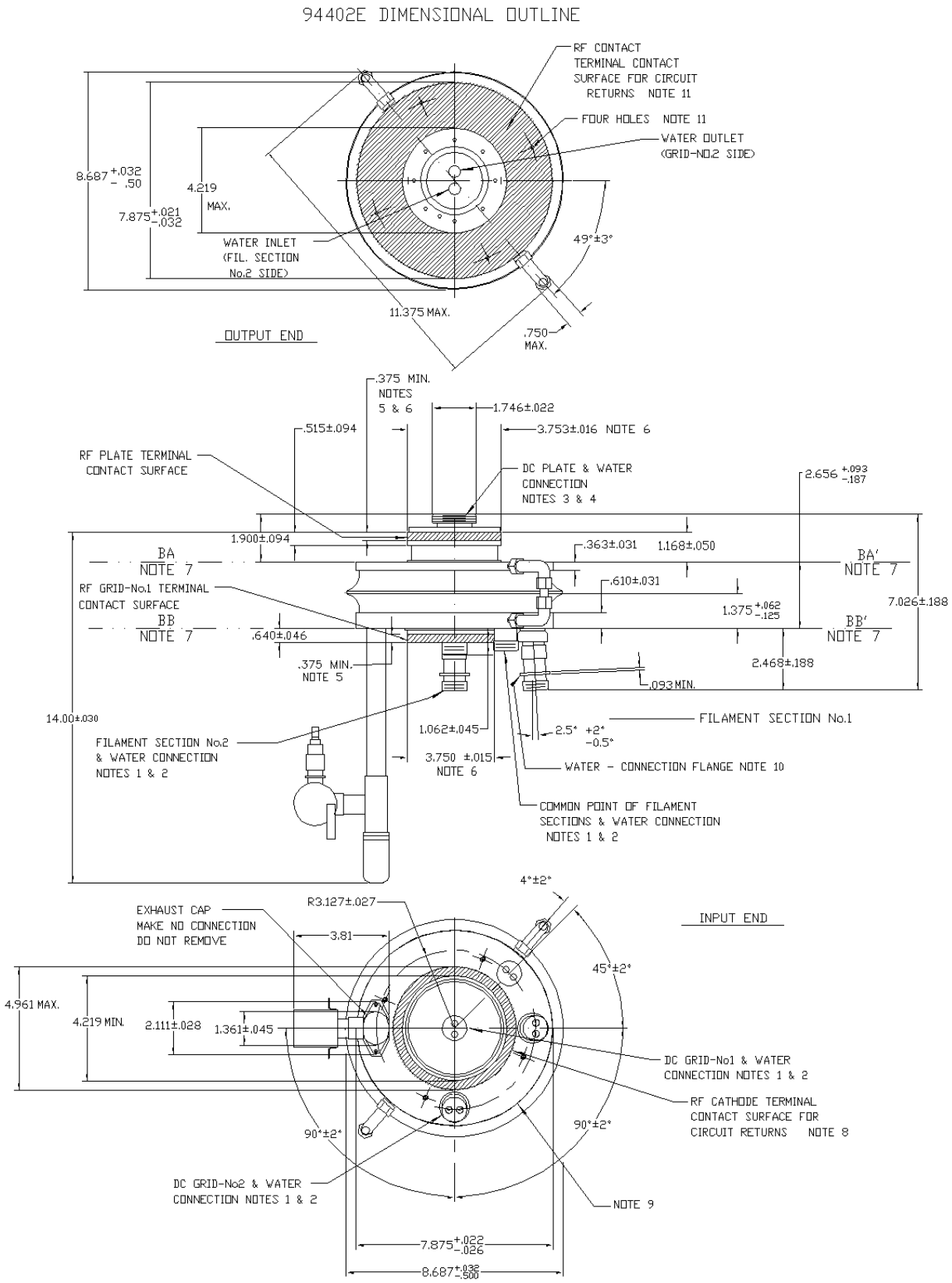


Figure 8 - **Dimensional Outline**

Note 1: Terminal has 1"-16 unified thread, Class 2A fit, 0.38”long and 2 holes 0.258"-0.270”diameter spaced 0.438” on centers.

Note 2: The holes in the filament, grid-No.1 and grid-No.2 coolant terminal connections will accept the pins of the plug-and-cylinder combination gauge G_1.

Note 3: Terminal has 1-3/4"-16 unified extra fine thread, Class 2A fit, 0.38”long, 2 holes 0.508-0.522”diameter spaced 0.688”on centers and an index hole 0.160” maximum diameter spaced 0.344”from the center of the terminal.

Note 4: The holes in the plate coolant connection will accept the pins of the plug-and-cylinder combination gauge G_2.

Note 5: Pressure from circuit contacts should be exerted only over 0.38” maximum length of designated contact area of the plate or grid-No.1 terminal.

Note 6: This diameter dimension is held only over the indicated length of 0.38” minimum.

Note 7: The contact surfaces BA-BA’ and BB-BB’ of the RF cathode terminals are parallel within 0.06”

Note 8: Contact on the input-end of the RF cathode terminal should not be made at a diameter smaller than 4.06," nor greater than 4.95".

Note 9: Serial number is located on this surface between DC grid-No.2 and insulated filament terminal.

Note 10: To prevent excessive stress on the ceramic seal, a 15/16” open end wrench must be used to permit gripping the terminal when removing or tightening the coolant connectors.

Note 11: Contact of the output-end RF cathode terminal should not be made at a diameter smaller than 6" The pressure exerted for this RF contact should be limited to that necessary for good electrical contact. The mechanical force for the cavity support and pressure seal should be made at a diameter not less than 6". On the output-end RE cathode terminal, there are four equally spaced 0.188"- diameter holes on a circle having diameter of 6.75". These holes are for tube manufacturing purposes only, Attention is called to the existence of these holes so that equipment designers can avoid making a pressure seal or electrical contact at points which are coincident with these holes. Mechanical clamping devices for the output cavity should be designed so as to exert their clamping force across the outer edge of the output header flange.