



# 8977 Power Tube

## Beam Power Tube

- 7 kW Aural Output Through VHF-TV Band
- 19 dB Gain
- CERMOLOX® Beam Power Tube
- Full Input to 400 MHz
- Forced-Air Cooled



The BURLE 8977 is intended specifically to meet the high gain, aural requirements of modern, reliable, VHF-TV. In VHF-TV aural service at 216 MHz, the tube will deliver a full 7.0 kW output at 19 dB gain.

Rated for full input for the VHF-TV band and for other service to 400 MHz, the tube can be readily circuited for these frequencies. The tube and available variants are also well suited for other applications such as Single Sideband CW, pulsed RF or modulator service.

Its sturdy, CERMOLOX construction and thoriated tungsten, mesh filament minimize tube inductances and feed-thru capacitances. Its coaxial, forced-air-cooled radiator reduces noise to a minimum and insures against spurious outputs. These features make possible the use of simple, economical, broadband circuit techniques in VHF and UHF operation.

This data sheet gives application information unique to the BURLE 8977. It is to be used in conjunction with the publication, "Application Guide for BURLE Power Tubes", TP-105, for general application information for tubes of this type.

Additional information of a general nature applicable to tubes of this type is given in the following publications:

- TP-105 Application Guide for BURLE Power Tubes
- TP-122 Screen-Grid Current, Loading and Bleeder Considerations
- TP-117 Handling and Operating Considerations when Using BURLE Tetrodes
- TP-118 Application Guide for Forced Air Cooling BURLE Power Tubes

Close attention to the instructions 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 Ave., Lancaster, PA 17601-5688.

### General Data

#### Electrical

All voltages referenced to cathode, unless otherwise specified.

Filamentary Cathode:

Type	Thoriated-Tungsten Mesh		
Voltage <sup>a</sup> (ac or dc)	5.7	typ.	V
	6.0	max.	V

**Caution:** For long-life expectancy, the filament voltage must be adjusted initially and throughout life as described in the procedure under 'Operating Considerations', "Filament Voltage Adjustment".

Current:

Typical value at 5.7 volts <sup>b</sup>	115	A
Maximum value for starting even momentarily <sup>c</sup>	250	A
Cold resistance	0.005	ohm
Recommended heating time		See Note d

Mu-Factor:<sup>e</sup>

(Grid No.2 to grid No.1)	20
--------------------------	----

Direct Interelectrode Capacitances:

Grid No. 1 to plate <sup>f</sup>	0.40	max.	pF
Grid No.1 to filament	75		pF
Plate to filament <sup>f</sup>	0.05	max.	pF
Grid No.1 to grid No.2	85		pF
Grid No.2 to plate	11		pF
Grid No.2 to filament <sup>f</sup>	2.5	max.	pF



## General Data (Cont'd)

### Mechanical

Operating Attitude	Vertical, either end up
Overall Length	160.02 mm (6.300 in)
Greatest Diameter	141.5mm (5.570 in)
Terminal Connections	See Dimensional Outline
Radiator	Integral part of tube
Weight (Approx.)	2.7 kg (6.0 lbs)

### Thermal

Seal Temperature <sup>g</sup> (Plate, grid No.2, grid No.1, filament-cathode and filament)	250	max.	°C
Plate-Core Temperature <sup>g,h</sup>	250	max.	°C

## RF Power Amplifier or Oscillator-Class B Telegraphy or FM Telephony

### Maximum CCS Ratings, Absolute-Maximum Values

	Up to 400 MHz		
DC Plate Voltage <sup>k</sup>	13,000		V
DC Grid-No.2 Voltage <sup>m</sup>	1650		V
DC Grid-No. 1 Voltage <sup>n</sup>	-450		V
DC Plate Current	4.0		A
DC Grid-No.1 Current	500		mA
Grid-No.1 Input	50		W
Grid-No.2 Input	100		W
Plate Dissipation <sup>p,h</sup>	6000		W

### Maximum Circuit Values

Grid-No.1 Circuit Resistance Under Any Conditions:			
With fixed bias	5000	max.	ohm
With cathode bias	Not recommended		
Grid-No.2 Circuit Impedance	See note m		
Plate Circuit Impedance	See note k		

### Calculated CCS Operation

In a cathode-drive, Class AB <sub>2</sub> , circuit at 216 MHz			
DC Plate Voltage	8200		V
DC Grid-No.2 Voltage	1000		V
DC Grid-No.1 Voltage	-40		V
Zero-Signal DC Plate Current	0.500		A
DC Plate Current	1.35		A
DC Grid-No.2 Current	30		mA
DC Grid-No.1 Current	40		mA
Drive Power Output (Approx.) <sup>q</sup>	85		W
Output Circuit Efficiency	95		%
Useful Power Output	7000		W

- a Measured at the tube terminals. For accurate data the ac filament voltage should be measured using an accurate RMS type meter such as an iron-vane or thermocouple type meter. The dc voltage should be measured using a high input impedance type meter. For high-current, low-voltage filaments such as are used in this tube, it is recommended that the filament current be monitored, since very small changes in resistance can produce misleading changes in voltage. For maximum life, the filament power should be regulated at the lowest value that will give stable performance. For those applications where hum is a critical consideration, dc filament or hum-bucking circuits are recommended. See also Application Note TP-1 17.
- b The range of current at 5.7 volts is from 106 to 126 amperes. It is recommended that an additional six amperes be available to allow for the normal reduction of filament resistance with life. Thus, the filament supply should be designed for a mean value of 132 amperes at 5.7 volts. A minimum selling is 5.4 volts.

- c Use an oscilloscope in system checkout. Systems such as auto-transformers, step transformers, shortable limiting resistors, saturable reactors, or combinations thereof must be used.
- d Recommended starting procedure for maximum stability and longest life.
- Standard: Filament heating time of 120 seconds followed by grid-No.1, plate, grid-No.2, and RF drive.
  - Emergency 1: (Power Interruption of 15 seconds or less) The tube may be brought back on the air two seconds after power restoration. Precautions must be taken so that neither the filament surge current limit nor the maximum filament voltage rating is exceeded. The sequence of voltage application after filament warm-up is as follows: grid-No.1, plate, grid-No.2, and RF drive.
  - Emergency 2: (Power Interruption of greater than 15 seconds) The tube may be brought back on the air four seconds after power restoration. Precautions must be taken so that neither the filament surge current limit nor the maximum filament voltage rating is exceeded. In order to insure that the tube does not operate in excess of typical conditions, control of the RF drive level will be required until tube temperature stability is achieved and special consideration must be given to the design of grid-No.1 circuitry. Application Engineering assistance is available from BURLE. The sequence of voltage application after filament warm-up is as follows: grid-No.1, plate, grid-No.2, and RF drive.
- e For plate voltage = 2000 V, grid-No. 2 voltage = 1375 V, and plate current = 6.0 A.
- f As measured with a special, shielded adapter. The value noted is the true tube internal capacitance and does not include external circuit or stray capacitance.
- 9 See Dimensional Outline for Temperature Measurement Points. For good contact-finger life, a maximum temperature of 180° C at the terminal is recommended when using commercially available beryllium-copper socket contacts.
- h The value of 250° C is the average of three readings taken 120° apart around the anode core. No one reading may exceed 275°C.
- j See TP-105.
- k See TP-105.
- The maximum voltage ratings must be modified for operation at altitudes higher than sea level and for temperatures in excess of 20° C in accordance with the curves of Figure 1.
- For altitude derating of the plate voltage, use the voltage difference between the plate and the grid No. 2.
- The maximum fault energy that can be dissipated within the tube is approximately 100 joules. Therefore, the energy available for a high-voltage arc or fault must be limited to this value by means of current limiting resistors or fault-protection circuitry. This is especially important in pulse service where high, stored energy and large capacitors are used. For typical TV transmitters, series resistor values are:
- Plate = 10 ohm  
Screen = 30 to 50 ohm  
Grid = 50 ohm
- For additional information see TP-105, "Application Guide for BURLE Large Power Tubes".
- m See TP-105 and TP-122. Protection devices such as spark gaps should be used.
- n See TP-105. Protection devices such as spark gaps or positive clamping diodes should be used.
- p Permitted plate dissipation is a function of cooling. For specific ratings, see Forced Air Cooling information in this data sheet.
- q Drive power output represents circuit losses in the driver output circuit and the grid input circuit in addition to the power necessary to drive the tube.

## Operating Considerations

### Filament Voltage Adjustment

The life of the filament can be conserved by adjusting to the lowest filament supply voltage that will give the desired performance. Follow the filament voltage adjustment procedure below:

1. Before the application of any other voltages to a new tube, the filament voltage should be adjusted to 5.7 volts at the tube socket. A true RMS voltmeter should be used for accurate measurement. It may be more convenient to make the measurement at other contacts in the equipment, but the value will be higher because of increased impedance such as wire loss or contact resistance.
2. Apply voltages and adjust tuning controls as necessary for proper operation as described in the appropriate instruction manual.
3. Reduce the heater voltage in 0.1 -volt increments - repeating the procedures in Step 1 and 2 - until performance degradation is noted. Then increase the heater voltage 0.1 volt above this point. Typically, depending upon the application, this voltage will be in the range of 5.4 to 5.7 volts.

During life when evidence is observed that a tube is becoming emission limited, increasing the filament voltage may extend the useful life of the tube. However, never increase filament voltage to compensate for a decrease in other circuit parameters such as RF drive.

### Safety Precautions

Protection circuits serve a threefold purpose: safety of personnel, protection of the tube in the event of abnormal circuit operation, and protection of the tube circuits in the event of abnormal tube operation.

#### Warning - Personal Safety Hazards

**Electrical Shock**- Operating voltages applied to this device present a shock hazard.

**X-Ray Warning** - This device in operation produces x-rays which can constitute a health hazard unless the device is adequately shielded for radiation.

**RF Radiation** - This device in operation produces RF radiation which maybe harmful to personnel.

Power tubes require mechanical protective devices such as interlocks, relays, and circuit breakers. Circuit breakers alone may not provide adequate protection in certain power-tube circuits when the power-supply filter, modulator, or pulse-forming network stores much energy. Additional protection may be achieved by the use of high-speed electronic circuits to bypass the fault current until mechanical circuit breakers are opened. These circuits may employ a controlled gas tube, such

as a thyratron or ignitron, depending on the amount of energy to be handled.

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 can not 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 and discharge high-voltage capacitors 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.

The screen circuit requires special attention because the heating power of the current and voltage on this electrode is not the algebraic product of the current and voltage elements as observed at the terminal. For an analysis of the circuit review the BURLE Application Note TP-122 "Screen Grid Current, Loading and Bleeder Considerations".

A time-delay relay must be provided in the grid No.2 supply circuit to delay application of this voltage until the filament has reached normal operating temperature.

An interlocking relay system should be provided to prevent application of plate voltage prior to the application of sufficient bias voltage otherwise, with insufficient bias, the resultant high plate current may cause excessive plate dissipation with consequent damage to the tube. RF load shorts or other causes of high output VSWR may also cause high dissipations, excessive voltage gradients, or insulator flashover. The load VSWR should be monitored and the detected signal used to actuate the interlock system to remove the plate voltage in less than 10 milliseconds after the fault occurs.

### Forced Air Cooling

Cooling air flow is necessary to limit the anode-core and terminal-seal temperatures to values that will assure long reliable life. A sufficient quantity of air should be directed past each of these terminals so that its temperature does not approach the absolute-maximum limit. The absolute maximum temperature rating for this tube is 275° C with a maximum average temperature around the anode of 250° C. It is recommended that a safety factor of 25° to 50° be applied, to compensate for all probable system and component variations throughout life.

The cooling air must be delivered by the blower through the radiator and at the terminal seals during the application of power and for a minimum of three minutes after the power has been removed.

To Cathode-Filament and Filament Terminals -- A sufficient quantity of air should be blown directly at these terminals so that their temperature does not approach the absolute-maximum limit of 250° C. A value of at least 60 cfm is recommended.

The Cooling Characteristic Curve indicates the air flow and pressure requirements of a system sufficient to limit the core temperature to specific values for various levels of plate dissipation.

Incoming air is at Standard Temperature and Pressure (STP) (22.5° C and 760 mm Hg). Pressure drop values are for the anode only and do not include any losses which may occur with specific sockets or cavities. When the tube base is not directly in the anode cooling air stream, special provisions must be made for separate base cooling.

Because the cooling capacity of air varies with its density, factors must be applied to the air flow to compensate for operation at altitude or in high temperature environments.

During Standby Operation -- Cooling air is required when only the filament voltage is applied to the tube.

For further information on forced air cooling, see TP-105 and also TP.118 "Application Guide for Forced Air Cooling of BURLE Power Tubes".

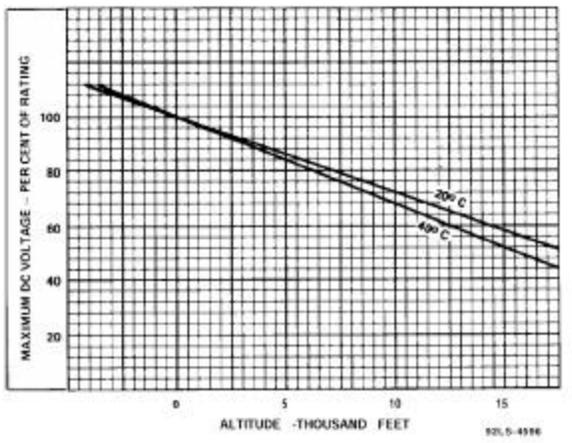


Figure 1 - Maximum DC Voltage vs Altitude

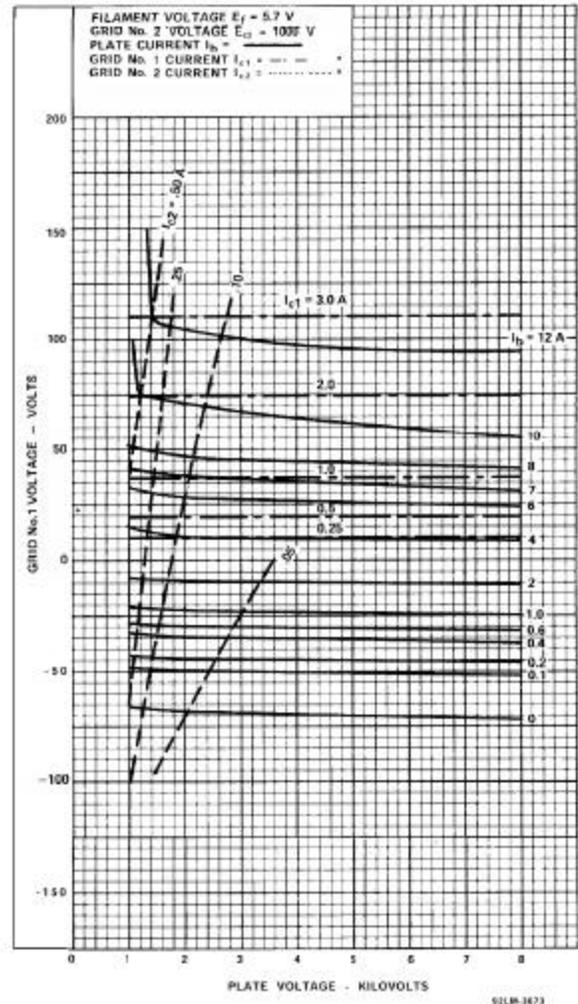


Figure 2 - Typical Constant Current Characteristics Tube Removal From Socket (Suggested Design)

The tube should not be removed from the socket by rocking the tube back and forth. This motion crushes the contact fingers and applies undue force to the internal structure of the tube. (See Figure 6.)

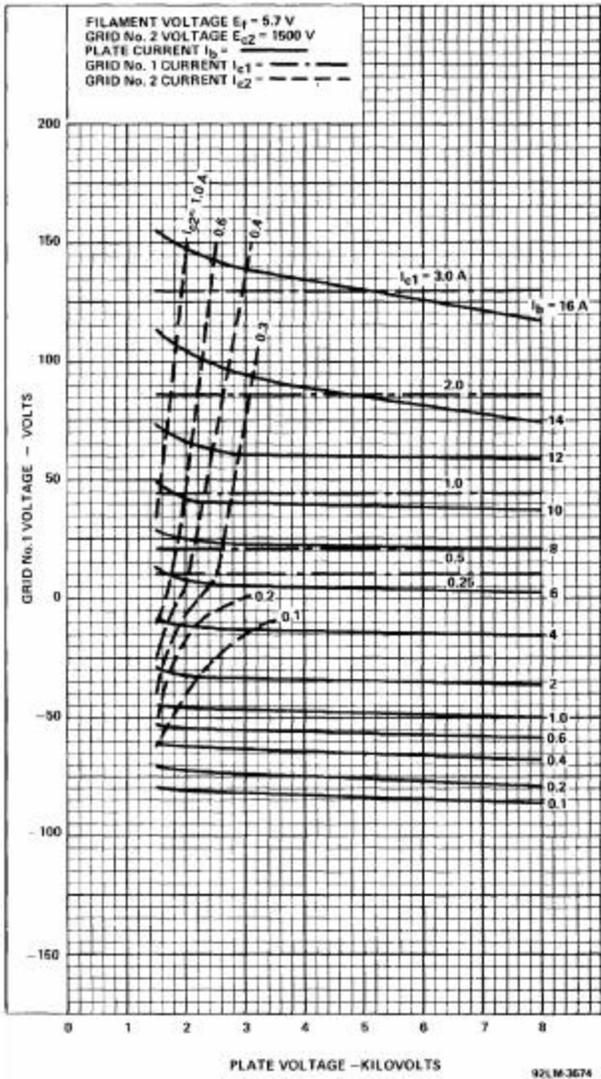


Figure 3 - Typical Constant Current Characteristics

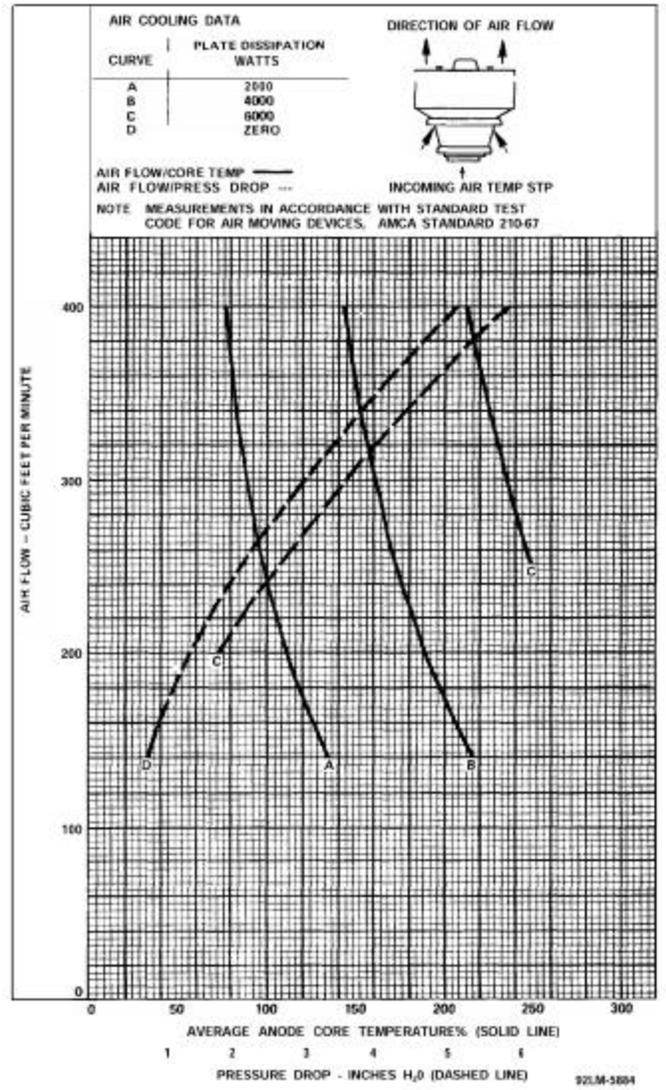


Figure 4 - Typical Cooling Characteristics

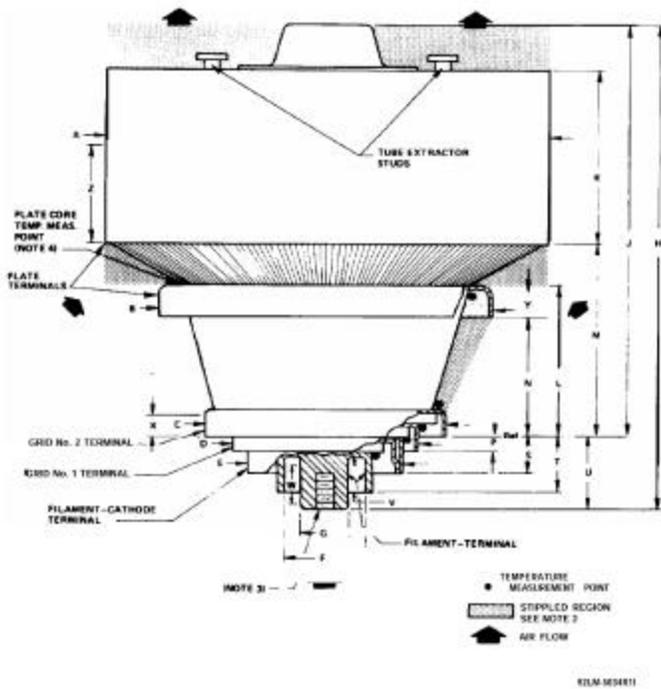
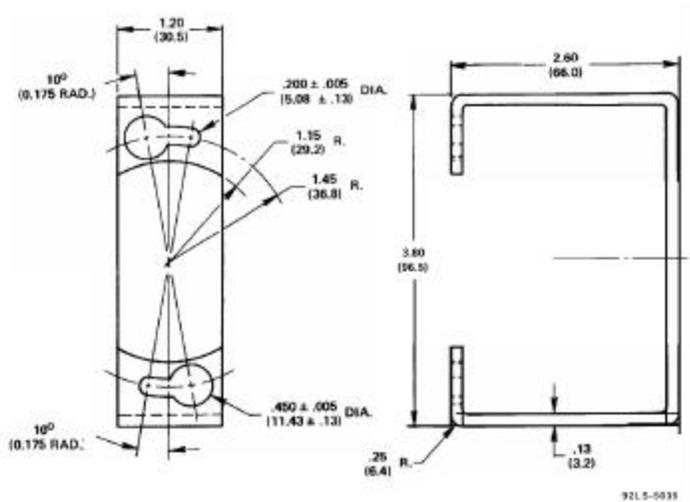


Figure 5 - Dimensional Outline

#### Tabulated Dimensions

Dimensions	Inches	Millimeters	Notes
A Dia.	5.530 ± .040	140.05 ± 1.02	1,5
B Dia.	4.188 ± .020	106.37 ± .51	1,5
C Dia.	3.028 ± .014	76.91 ± .36	1,5
D Dia.	2.319 ± .012	58.90 ± .30	1,5
E Dia.	1.850 ± .010	46.99 ± .25	1,5
F Dia.	1.200 ± .010	30.48 ± .25	1,5
G Dia.	0.617 ± .003	15.67 ± .08	1,5
H	6.300 max.	160.02 max.	
J	5.300 max.	134.62 max.	
K	2.195 ± .020	55.75 ± .51	
L	1.860 ± .030	47.24 ± .76	
M	2.390 ± .040	60.71 ± 1.02	
N	1.490 ± .020	37.85 ± .51	
P	0.200 ± .025	5.08 ± .64	
S	0.475 ± .030	12.07 ± .76	
T	0.725 ± .040	18.42 ± 1.02	
U	0.955 ref.	24.26 ref.	
V	0.250 min.	6.35 min.	1
W	0.375 min.	9.53 min.	1
X	0.220 min.	5.59 min.	1
Y	0.265 min.	6.73 min.	1
Z	1.200 min.	30.48 min.	1

- Note 1** - The diameter of each terminal is maintained only over the indicated minimum length of its contact surface.
- Note 2** - Keep all stippled regions clear. In general do not allow contacts to protrude into these annular regions. If special connectors are required which may intrude on these regions, contact BURLE Power Tube Application Engineering, Lancaster, PA 17601.
- Note 3** - Tapped 1/4 - 20 NC x 0.5" (12.7 mm) deep. May be used for attaching additional heat sink for seal temperature control if required.
- Note 4** - Plate core temperature measurement point is located on the plate itself and not at the fins.
- Note 5** - With the plate terminal and the cathode-filament terminal used as reference, the other terminals will measure less than 0.040" (1.02 mm) total indicator run-out (TIR).



- Note 1** - Material 1/8" thick cold rolled steel
- Note 2** - Round all edges
- Note 3** - Slot between holes

**Figure 6 – Tube Extractor (Suggested Design)**