QUALITY IONIZATION VACUUM SENSORS, FILAMENTS AND COMPONENTS

Hot cathode ionization gauges such as the triode, Schulz-Phelps, Bayard-Alpert and the extractor gauge have the same basic operating principle.

Electrons emitted from a hot filament at constant rate are accelerated towards a positively charged electron collector. In the space between the filamentary electron emitter and the ion collector these electrons collide with gas molecules, ionizing them. The positive ions thus formed are collected on the ion collector. The number of gas molecules ionized at a fixed electron flux is proportional to the gas density and, hence, to the gas pressure. We can define a proportionality constant S such that: **S (Sensitivity) = Ion collector current / (Electron collector current)(Pressure)** where the currents are in amperes and the pressure in Torr.

The sensitivity defined in this manner is independent, over a wide range, of the electron current and dependent only to the gauge geometry and the gas species. Thus, if you know the sensitivity (from the manufacturer's data) and the ion current at a known electron current, the pressure can be computed.

Ionization gauges have different relative sensitivities for different gases and, thus, will only give true pressure measurements if the gas composition is known. Table 1 gives the relative sensitivity of certain common gases. Thus, gauges, which are usually calibrated for nitrogen, can be used for other gases.

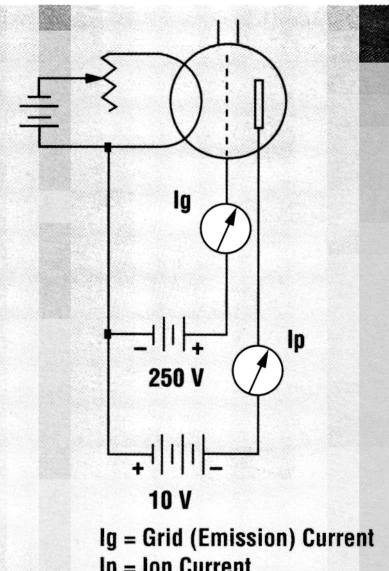
Table 1– Average Ionization Gauge Sensitivity Ratios for Various Gases Normalized for Nitrogen

Gas	He	Ar	H_2	N_2	O_2	Dry air	CO	CO_2
	0.13	1.47	0.42	1.00	0.77	0.90	1.01	1.09

Essentially, the different types of hot cathode gauges are determined by the shapes, sizes, and distribution of the three basic elements (electron emitter, electron collector and ion collector).

TRIODE

The earliest configuration was that of a simple triode vacuum tube. It was soon learned that if the functions of the grid and anode of the tube were interchanged so that the grid became the electron collector and the anode the ion collector, a higher sensitivity could be achieved. In this case electrons leaving the filament are attracted to the positively charged electron collector (grid). Due to the open nature of the grid, most of the electrons miss the grid and are repelled by the negatively charged ion collector and return to the grid. A significant fraction miss again, so that the electrons transit the grid-to-ion-collector space several times before finally striking the grid. This greatly increases the probability that an electron will ionize a gas molecule and that the resulting ion will strike the ion collector.



Typical Triode Configuration

Triode gauges of small dimensions or of unusual configurations are well suited to measurements of relatively high pressure approaching 10^{-1} Torr. However, they are limited at low pressures to 10^{-6} Torr, or in some configurations, 10^{-8} Torr.

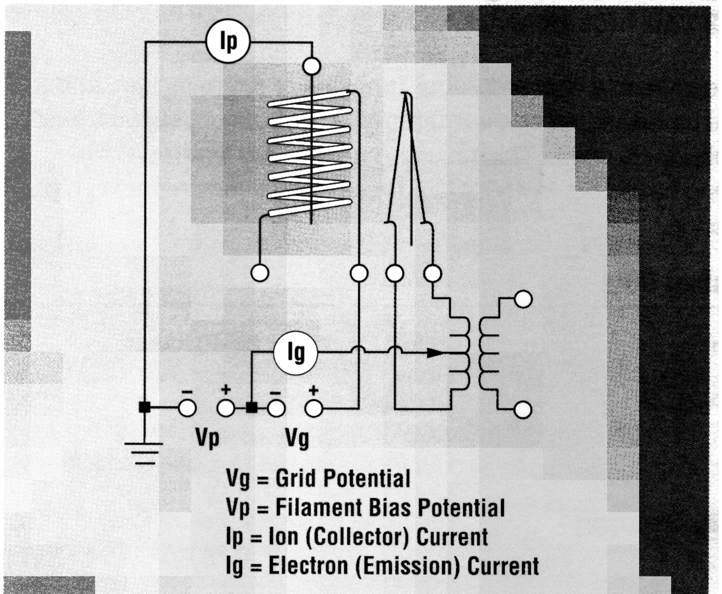
X-RAY LIMIT

It was learned that the low-pressure limit of the triode gauge was caused by energetic electrons striking the electron collector and producing soft X-rays. A fraction of these X-rays strike the ion collector releasing photoelectrons. An electron current leaving the ion collector is indistinguishable from an ion current arriving at the ion collector, thus setting a limit to the lowest pressure that can be measured.

BAYARD-ALPERT (BA) GAUGES

The Bayard-Alpert Gauge is essentially a triode reconfigured so that only a small fraction of the X-rays discussed above are able to strike the collector.

To achieve this reconfiguration, the filamentary electron emitter wa moved outside the grid and the massive ion collector was replacec by a fine wire in the center of the grid. The improved performance at lower pressures requires some sacrifice of high-pressure perfor· mance. The range of measurement of glass Bayard-Alpert Gauge is nominally from the 10^{-3} Torr scale to the 10^{-10} Torr scale. Nude Bayard-Alpert Gauges operate from 10^{-3} to 10^{-11} Torr. Special designs are under development to extend the low-pressure limit



Typical Bayard-Alpert Configuration

to less than 10^{-12} Torr.

Electron-Stimulated Ion Desorption

The Electron-Stimulated Ion Desorption (ESID) effect in Bayard-Alpert gauges is caused by ionization of adsorbed gas molecules on the electron collector by the arriving electrons. These ions then are driven by the internal electric fields in the gauge to the collector, along with the ions formed from the gas phase. The result is a falsely high apparent pressure measurement which gets proportionally worse as the pressure falls. ESID errors exhibit themselves as false high pressures or prolonged/inconsistent pump-down times and are noticeable at pressures as high as 10^{-7} Torr.

General Vacuum Practice

To insure that the measured pressure accurately mirrors the system pressure, several factors should be considered. The gauge should be well de-gassed, especially when measuring very low pressures. The gauge should be baked under high vacuum for one hour at a temperature of at least 250˚C or as high as is practical up to the maximum set by the particular gauge specification. The internal electrodes are de-gassed by heating them to a temperature of about 900˚C for approximately 15 minutes. The electrode heating is accomplished by either electron bombardment (EB) or by passing a high current at low voltage (I^2R) through the grid. Gauges equipped with squirrel-cage grids or those where the grid wire is welded, brazed or swaged to the support wire at multiple locations are usually only de-gassed by electron bombardment. The collector in present designs can only be de-gassed by electron bombardment. Grids consisting of a helix or double helix with both ends having external connections can be de-gassed by either the EB or high current I^2R method. Care must be taken to have a heavily grounded gauge circuit and to avoid touching exposed electrodes especially during EB de-gas when higher voltages are present.

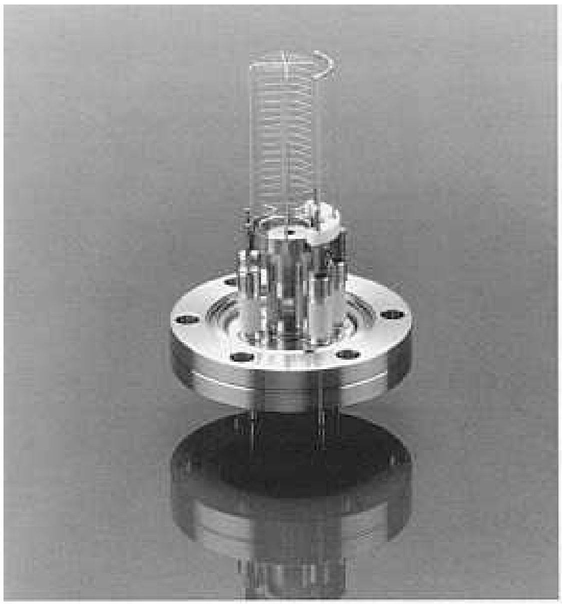
The ionization gauge has a certain pumping capacity due to both chemical and electrical effects. Chemical pumping is due, in general, to reactions on the hot filament and the adsorption of gases on very clean surfaces. As the surface becomes saturated the pumping decreases. Pumping due to electronic phenomena continue as long as voltages are applied.

The vacuum connection between the ionization gauge and the rest of the system can have a great effect on the measuring ability and life of the gauge. If the tubulation has too small a diameter or is connected by long plumbing to the vacuum system, the gauge reading may differ from the system pressure by as much as a factor of ten. This difference is most pronounced when system pressures change rapidly and the system is at low pressures. It is wise to select the largest diameter tubulation possible or even use a nude gauge in the vacuum system. A glass gauge with 3/4-inch tubulation has adequate conductance for use down to the 10^{-8} Torr scale. A gauge with 1-inch tubulation can be used down to the 10^{-10} Torr.

When considering gauge placement and tubulation size, a number of factors can come into play. If the application is one where material is evaporated or sputtered, care must be taken to keep the material out of the gauge. Contamination of the gauge can severely limit life and lead to grossly inaccurate measurements. Also, operations taking place in the 10^{-2} to 10^{-4} Torr range, with relatively high voltage and current, can lead to long path arc discharge. A simple right-angle connector has been shown to lessen both the long path arc and evaporation problems, but with some sacrifice of conductance.

Manufacturer's Cross Reference

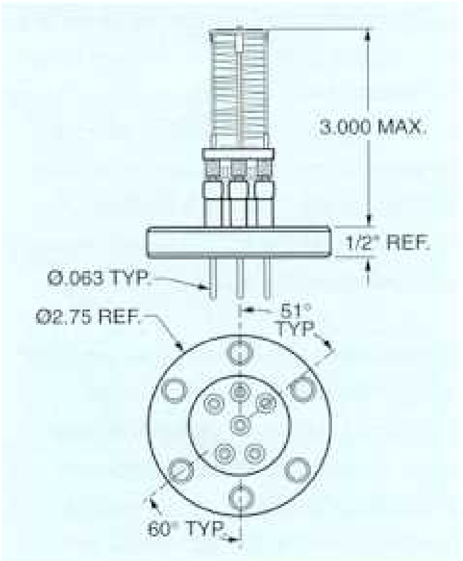
Each manufacturer's gauge is made to custom requirements and, therefore, generic gauges purchased from unknown "second sources" should be approached with caution. In some cases, generic material or approximate tolerances are used. These generic gauges may not perform as intended by the original manufacturer or are of inferior quality. It is, therefore, recommended that you contact the original manufacturer of the gauge to assure that complete operational specifications are met. In the cases where the original manufacturer no longer provides this gauge, they can best guide you to a reliable source of gauges. Several companies, no longer in operation, have made arrangements with ETI to provide gauges that meet the exact original specifications. If you are uncertain about the source of your replacement gauges, please contact ETI.



Nude Ionization Gauge Type 8130, 8130T, 8150 and 8150T

The ETI Nude Ionization Gauge is a high-sensitivity gauge covering the vacuum range of 1 x 10^{-3} to 2 x 10^{-11} Torr (Argon).

This tube features replaceable filaments, dual Tungsten or single iridium, and a small diameter-cage tantalum grid on platinum-clad, molybdenum support rods. A .005"-diameter collector is used. This results in a low X-ray limit, sensitive tube, capable of being baked out to 450° C for those applications requiring high-temperature processing.



8130 Physical Data

Connection	2-3/4" Conflat or KF40 flange
Envelope	None
Mounting Position	Vertical
Collector	.005" Tungsten
Filament	Replaceable Thoria-Coated Iridium or Dual Tungsten (8130)**
High Stability Geometry*	Available in Single Iridium Only
Grid	Tantalum and Pt/Moly support squirrel cage

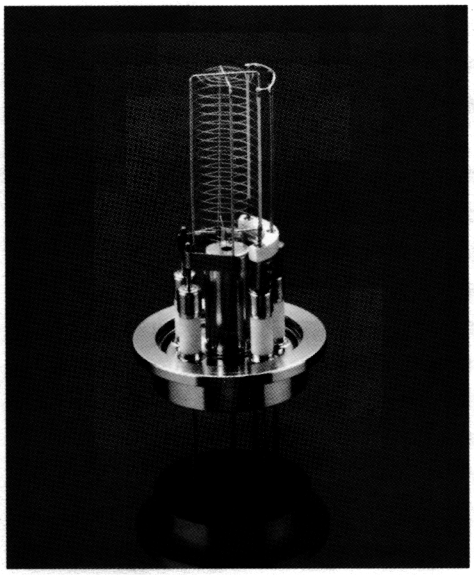
**See Special Gauges*
***Also available in Dual Irridium*

Operating Data

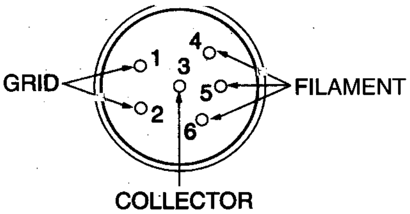
Sensitivity for N_2	25/Torr
X-ray limit	2 x 10^{-11} Torr
Operating Pressure	2 x 10^{-11} to 1 x 10^{-3} Torr
Electron Bombardment De-gas	40 Watts @ 500 volts
Resistance Heated De-gas	n/a
Bake-out Temperature	450° C

Recommended Electrical Operating Parameters

Collector Potential	0 volts
Shield Potential	n/a
Grid Potential	150 to 180 volts
Filament Current	4 to 6 amps
Filament Voltage	3 to 5 volts
Filament Potential to Ground	30 volts



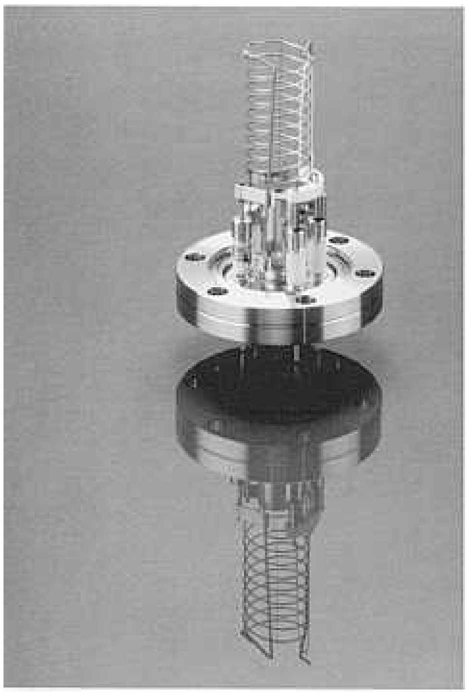
8130 Single Iridium		8130T Dual Tungsten		8150 Dual Tungsten/ Iridium
Pin #1	Grid	Pin #1	Grid	8150 provides modified pin geometry to mate with unique connector. Call factory for details.
Pin #2	Grid	Pin #2	Grid	
Pin #3	Collector	Pin #3	Collector	
Pin #4	Filament	Pin #4	Filament #1	
Pin #5	Filament	Pin #5	Common	
Pin #6	Not Used	Pin #6	Filament #2	



Nude Ionization Gauge Type 8140

The ETI 8140 Nude Ionization Gauge is a flange-mounted, Bayard-Alpert type for the range of 1 x 10^{-3} to 4 x 10^{-10} Torr. It is equipped with a bonded thoria, replaceable filament. The grid is of bi-filar construction. A .005"-diameter tungsten collector is provided for a low X-ray limit.

The ETI 8140 is suited to either the I^2R or the electron bombardment method of electrode de-gassing, making it compatible with either type of controller. This gauge may be baked to 450° C.

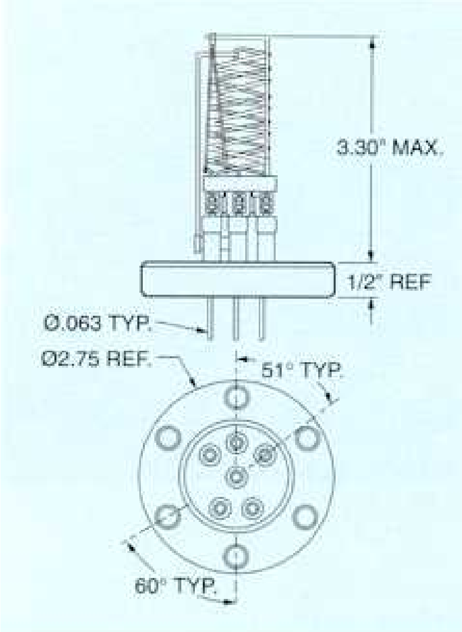


8140 Physical Data

Connection	2-3/4" Conflat or KF40 flange
Envelope	None
Mounting Position	Vertical
Collector	.005" Tungsten
Filament	Replaceable Thoria-Coated Iridium or Dual Tungsten
High Stability Geometry*	Available in Iridium Only
Grid	Tungsten helix configuration

Operating Data

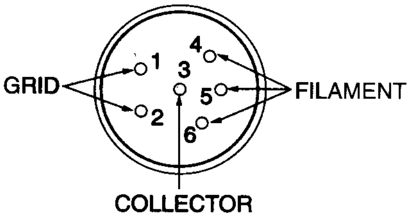
Sensitivity for N_2	10/Torr
X-ray limit	4 x 10^{-10} Torr
Operating Pressure	4 x 10^{-10} to 1 x 10^{-3} Torr
Electron Bombardment De-gas	70 Watts
Resistance Heated De-gas	6.3 to 7.5 volts @ 10 amps
Bake-out Temperature	450° C

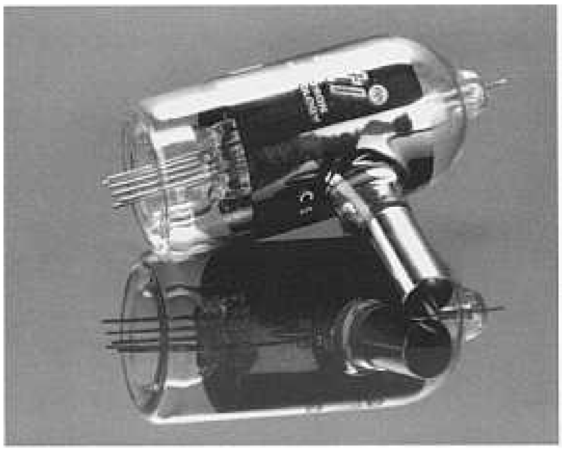


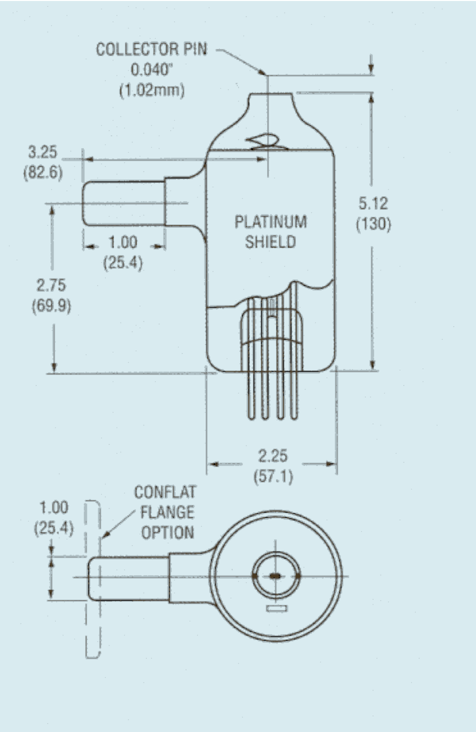
Recommended Electrical Operating Parameters

Collector Potential	0 volts
Shield Potential	n/a
Grid Potential	150 to 180 volts
Filament Current	4 to 6 amps
Filament Voltage	3 to 5 volts
Filament Potential to Ground	30 volts

8140 Single Iridium		8150/8150T	
Pin #1	Grid	Pin #1	Grid
Pin #2	Grid	Pin #2	Grid
Pin #3	Collector	Pin #3	Collector
Pin #4	Filament	Pin #4	Filament #1
Pin #5	Filament	Pin #5	Common
Pin #6	Not Used	Pin #6	Filament #2







Ionization Gauge Type 8142

Type 8142 is a versatile gauge constructed with a rugged bi-filar grid and a thoriated iridium filament. The interior of the tube is platinum-coated, shielding the gauge components from electrostatic and static charges which can occur in various operating conditions. This gauge contains a burn-out resistant, thoriated iridium filament. It is also available in a rugged, long-life design described in the special gauge section.

8142 Physical Data

Tubulation	3/4", 1" Pyrex or Nonex Glass or 3/4", 1" Kovar, flanges are available
Envelope	Nonex, platinum-coated interior
Mounting Position	Vertical*
Collector	.005" Tungsten
Filament	Thoriated Iridium
High Stability Geometry	Available
Grid	Tungsten helix configuration

*See Special Gauges

Operating Data

Sensitivity for N_2	10/Torr
X-ray limit	2×10^{-10} Torr
Operating Pressure	2×10^{-10} to 1×10^{-3} Torr
Electron Bombardment De-gas	70 Watts
Resistance Heated De-gas	6.3 to 7.5 volts @ 10 amps
Bake-out Temperature	250° C

Recommended Electrical Operating Parameters

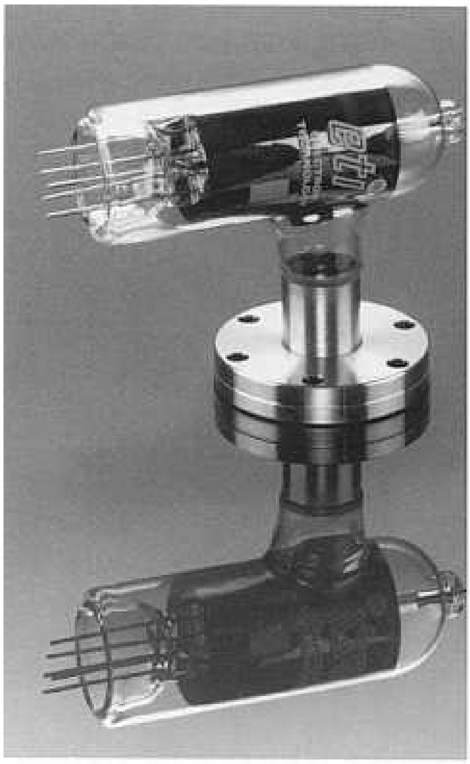
Collector Potential	0 volts
Shield Potential	Connected to filament return
Grid Potential	150 to 180 volts
Filament Current	4 to 6 amps
Filament Voltage	3 to 5 volts
Filament Potential to Ground	30 volts

8142 Single Iridium

Pin #1	Grid (G)
Pin #2	Filament (F)
Pin #3	Filament *Platinum Coating connected to this pin (F)
Pin #4	Grid (G)

IONIZATION GAUGE TYPE 8136

The ETI 8136 is a broad range Bayard-Alpert gauge. The special fabricated gauge elements and burn-out resistant, thoria-coated iridium filament enable this gauge to operate up to 1 x 10^{-1} Torr. This gauge is likewise available in a long-life version that is position independent.



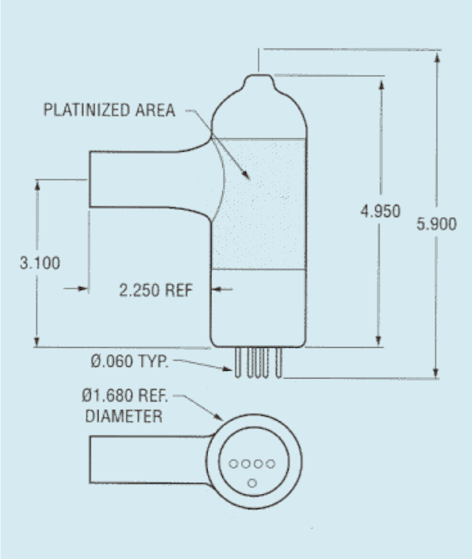
8136 Physical Data

Tubulation	3/4", 1" Pyrex or Nonex Glass or 3/4", 1" Kovar, flanges are available
Envelope	Nonex, platinum-coated interior
Mounting Position	Vertical*
Collector	.005" Tungsten
Filament	Thoria- Coated Iridium
High Stability Geometry	Available
Grid	Tungsten helix configuration

Note: **See Special Gauges*

Operating Data

Sensitivity for N_2	8/Torr
X-ray limit	4 x 10^{-10} Torr
Operating Pressure	1 x 10^{-10} to 1 x 10^{-1} Torr
Electron Bombardment De-gas	70 Watts
Resistance Heated De-gas	6.3 to 7.5 volts @ 10 amps
Bake-out Temperature	250° C

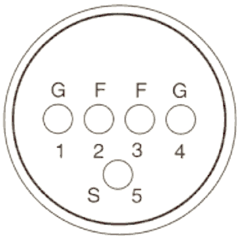


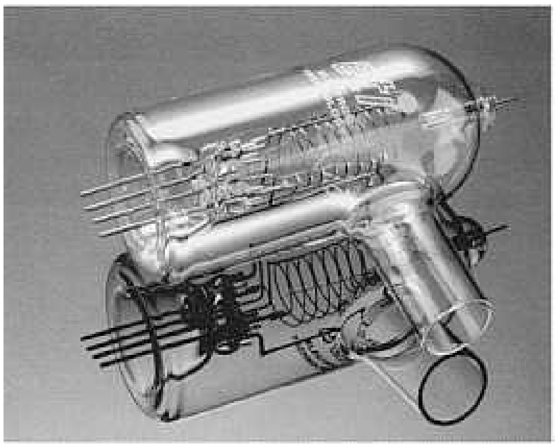
Recommended Electrical Operating Parameters

Collector Potential	0 volts
Shield Potential	0 volts
Grid Potential	150 to 180 volts
Filament Current	4 to 6 amps
Filament Voltage	3 to 5 volts
Filament Potential to Ground	30 volts

8136 Pin Configuration

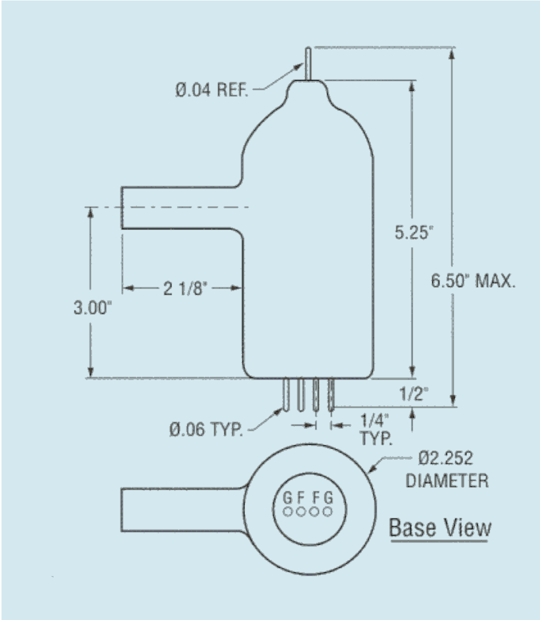
Pin #1 Grid (G)
Pin #2 Filament (F)
Pin #3 Filament (F)
Pin #4 Grid (G)
Pin #5 Shield (Platinum Coating) (S)





Ionization Gauge Type 4336 and 8135

The ETI 4336 Series of Ionization Gauges are Bayard-Alpert gauges available either with a burn-out-resistant, iridium-coated filament, or two tungsten filaments. ETI was the first to incorporate a bi-filar design grid in its Bayard-Alpert gauges. Through this design, only one-half of the grid weight is suspended on each support, thereby making it more "sag resistant" during frequent outgassing conditions.



4336 Physical Data

Tubulation	3/4", 1" Pyrex or Nonex Glass or 3/4", 1" Kovar, flanges are available
Envelope	Nonex 7720 Glass
Mounting Position	Vertical*
Collector	.005" Tungsten
Filament	Thoria-Coated Iridium or Tungsten
High Stability Geometry	Available*
Grid	Tungsten helix configuration

**See Special Gauges*

Operating Data

Sensitivity for N_2	10/Torr
X-ray limit	2×10^{-10} Torr
Operating Pressure	2×10^{-10} to 1×10^{-3} Torr
Electron Bombardment De-gas	70 Watts
Resistance Heated De-gas	6.3 to 7.5 volts @ 10 amps
Bake-out Temperature	250° C

Recommended Electrical Operating Parameters

Collector Potential	0 volts
Shield Potential	n/a
Grid Potential	150 to 180 volts
Filament Current	4 to 6 amps
Filament Voltage	3 to 5 volts
Filament Potential to Ground	30 volts

Type 4336

4336 Single Iridium Pin Configuration

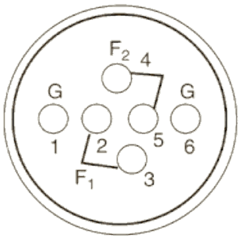
Pin #1 Grid (G)
Pin #2 Filament (F)
Pin #3 Filament (F)
Pin #4 Grid (G)

Single Iridium

Type 4336 T

4336T Dual Tungsten Pin Configuration

Pin #1 Grid (G)
Pin #2 Filament #1 (F_1)
Pin #3 Filament #1 (F_1)
Pin #4 Filament #2 (F_2)
Pin #5 Filament #2 (F_2)
Pin #6 Grid (G)



Dual Tungsten filament type

Type 8135

8135 Dual Tungsten Pin Configuration

Pin #1 Filament #1 (F_1)
Pin #2 Grid (G)
Pin #3 Filament Common (F_c)
Pin #4 Grid (G)
Pin #5 Filament #2 (F_2)

Dual Tungsten 5 pin in-line header

Ionization Gauge Type 8138/29D20

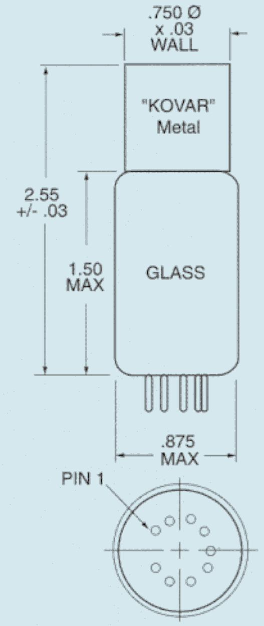
The 8138/29D20 is a directly heated triode ionization gauge intended for the continuous measurement of vacuum in the range of 10^{-1} to 10^{-7} Torr. Short-term readings of up to 1 Torr can be monitored. Accidental exposure to atmosphere at normal operating temperature will not damage the gauge. The use of a thoria-coated iridium filament makes this possible. In coating these filaments, great care must be exercised in controlling the cataphoritic process for the application of the thoria.

8138/29D20 Physical Data

Tubulation	7/8" Glass/ .750 Kovar
Envelope	7052/7056
Mounting Position	Any
Collector	.005" Nickel Mesh
Filament	Thoriated Iridium

Operating Data

Sensitivity for N_2	5.5/Torr
Operating Pressure	1 x 10^{-7} to 1 x 10^{-1} Torr
Electron Bombardment De-gas	700 volts

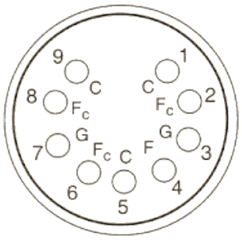


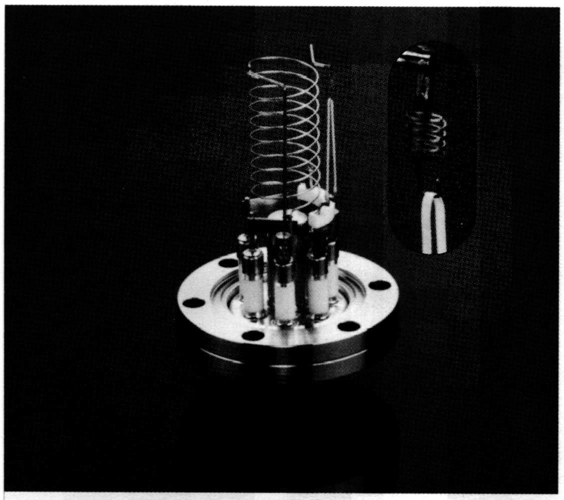
Recommended Electrical Operating Parameters

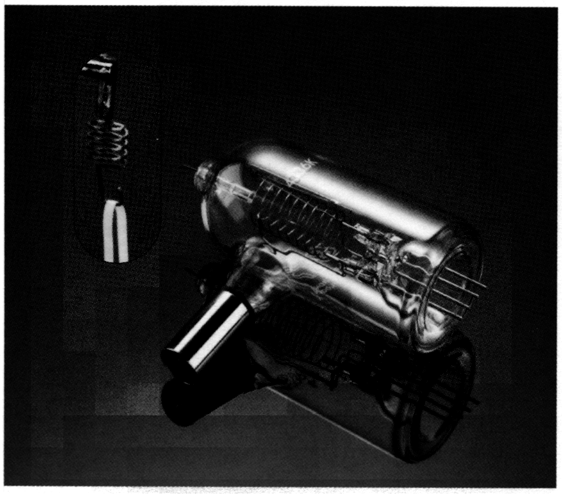
Collector Potential	-20 to -50 volts
Grid Potential	120 to 250 volts
Filament Current	1.5 amps
Filament Voltage	1.5 to 3.5 volts
Filament Potential to Ground	+20 volts

Pin Configuration

Pins #1, 5, 9	Collector (C)
Pins #3, 7	Grid (G)
Pins #2, 6, 8	Filament Common (F_c)
Pin #4	Filament (F)







High Stability Gauges

Selected ETI gauges can be ordered with high stability "S" option. These gauges are manufactured with a spring-tensioned, burn-out resistant, thoriated iridium filament, improved supports, and gold-plated connector pins. This improved design significantly reduces any variation in the filament to grid spacing which, in turn, affects gauge sensitivity. Filament sag is totally eliminated and allows the user to mount the gauge in any position. Special materials are also used to minimize or eliminate ESID. The resultant benefit is a gauge that has double the useful life over the traditional gauges. Erroneous pressure readings due to physical/sensitivity changes are eliminated. Gold-plated pins assure that the gauge tube can be easily removed from the connector after extended use.

The improved "S" gauges can be used with all manufacturers' gauge controller electronics and, in turn, will improve system measurement stability and accuracy without having to invest in a new gauge controller.

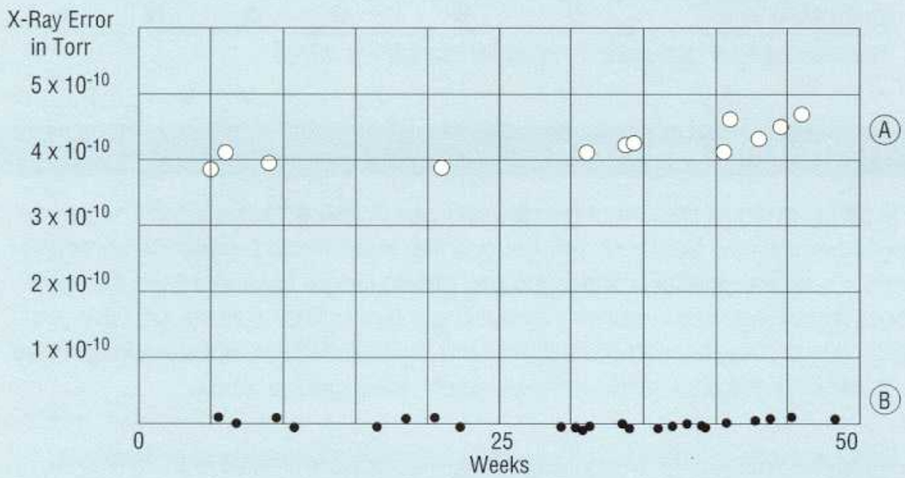
Flux Monitor

The Flux Monitor is a variant of the ETI 8130 Nude Ionization Bayard-Alpert gauge. Its unique construction positions the ionization gauge further into the chamber to avoid “wall-effect outgassing”. This phenomenon is especially prevalent in large chambers that are frequently exposed to atmosphere or which are used with gases that tend to be adsorbed to the chamber. Wall-effect error can add up to two decades of pressure error. This error can adversely affect product quality. The Flux Monitor Gauge is custom built to your length requirements. Please contact the factory for additional details.

Ultra-High and Extreme Ultra-High Vacuum Gauges– Patent Applied For

X-ray induced emission of electrons from the ion collector of a Bayard-Alpert gauge is recognized as a cause of falsely high readings at low pressures and is a characteristic of all Bayard-Alpert gauges. The error in the UHV range can exceed 50% with a conventional Bayard-Alpert gauge. The patented ETI gauge essentially eliminates the x-ray error by use of high stability materials and a patented x-ray cancellation technique. This is a high-performance gauge that requires a special gauge controller, which provides an auxiliary signal and an improved electrometer to take full advantage of the extended range (1 x 10^{-12} Torr).

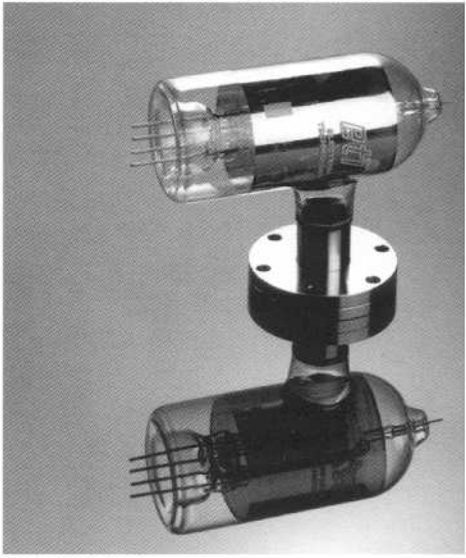
The gauge is available in two configurations: all metal gauge or glass enveloped. The unique features of this gauge also provide the benefits of electrical shielding, cooler running and improved stability at high pressures.

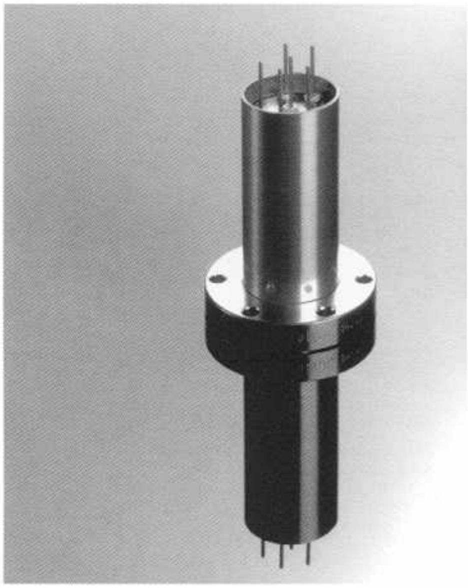


Pressure Error (Torr) due to X-Ray induced emission measured at 1 x 10^{-10} Torr

Ⓐ – No Correction

Ⓑ – With Patented Correction





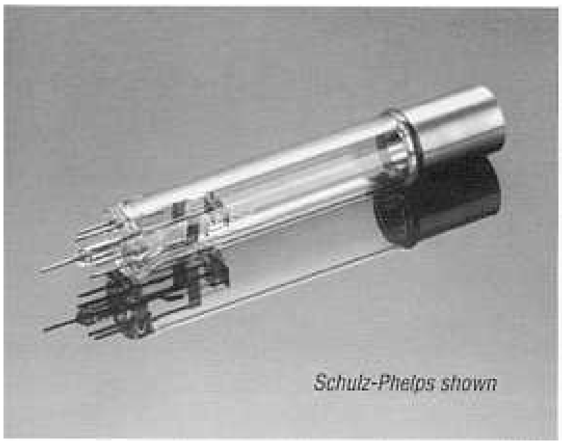
Configurations of Standard Gauges

Standard Features of All ETI Gauges

All ETI gauges are made to the strictest manufacturing standards using precision tooling and the purest materials available. Gauges manufactured by ETI are date coded or serialized assuring complete traceability of the manufacturing process and materials used.

Model	4336	8135 & 4336T	8142	8136	8130	8140
3/4" glass tubulation	●	●	●	●		
1" glass tubulation	●	●	●	●		
1/2" glass tubulation		●				
3/4" Kovar	●	●	●	●		
1" Kovar	●	●	●	●		
2 3/4" Flange	●	●	●	●	●	●
KF Flange 25	●	●	●	●		
KF Flange 40	●	●	●	●	●	●
Sealed at $1x10^{-5}$ Torr	●					
Spring-tensioned filament*	●		●	●	●	●
Gold-plated pins*	●	●	●	●	●	●

**Ordered together, add suffix "S" to model number e.g. 4336S*



Schulz-Phelps shown

Earlier Model Gauges

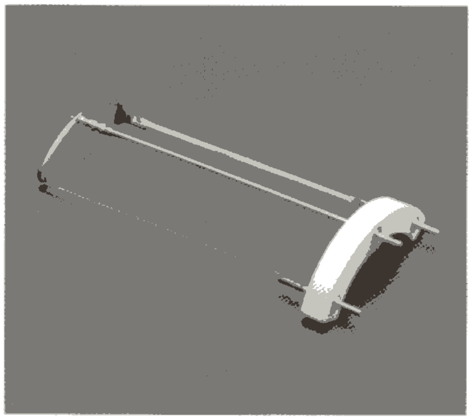
ETI can provide replacement gauges such as Schulz-Phelps, triode, miniature Bayard-Alpert and Septar-based gauges that were made popular on some systems. In some situations, these gauges are no longer available from the traditional source and are becoming exceedingly rare to find. In turn, valuable processing equipment is scrapped due to the unavailability of replacement gauges, or is expensively re-engineered to eliminate these gauge tubes.

ETI can provide gauge tubes that meet original manufacturer specifications, extend the useful life of process equipment, and save valuable engineering resources. Please call ETI with your requirements.

Replacement Filament Assemblies for 8130, 8140 and 8150 Gauges

Single Iridium

Dual Tungsten



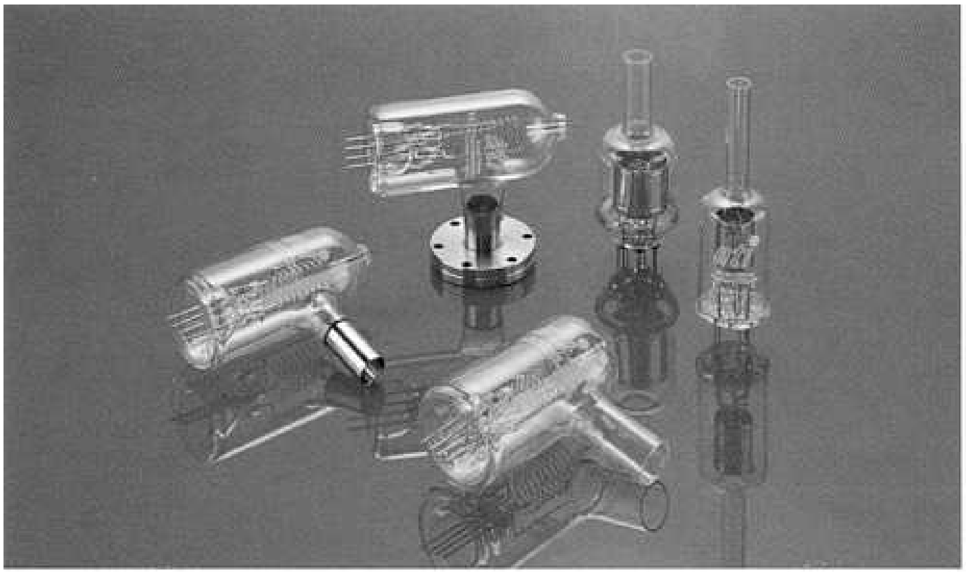
Dual Iridium

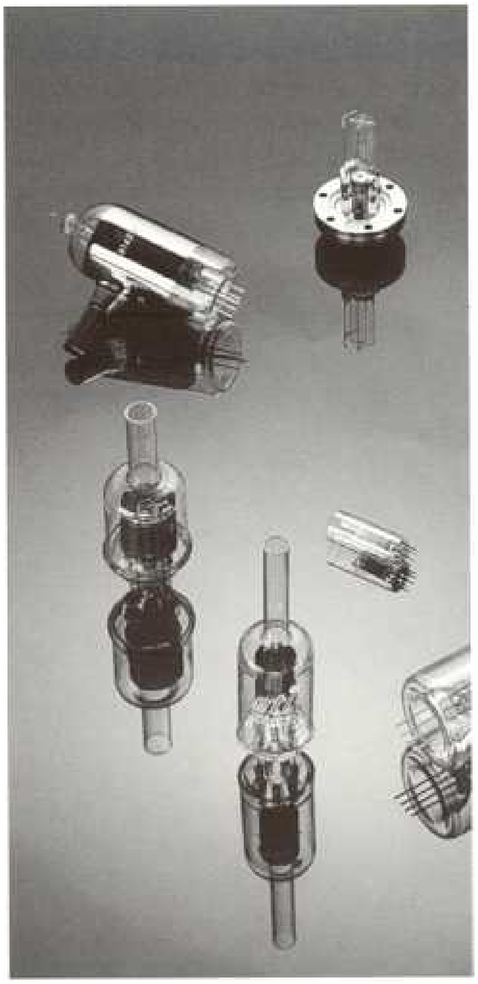
OEM

ETI welcomes your OEM applications. We specialize in developing the most appropriate sensor or component for your product requirements. Our quality manufacturing techniques assure a product that will be consistently repeatable to your required specifications.

Custom Designs

Call on ETI for any specialized UHV ionization product you require. We have wide experience in developing and customizing products to your particular requirements. We will address your specialized need with an intensive search for the best product solution. Challenge us with your most exacting custom requirements.





ETI Custom Filaments

ETI offers custom-designed filaments or completed assemblies. Filaments are fabricated from tungsten, rhenium or iridium. Coatings with thoria or yttria are also available. These coatings are designed to offer the advantages of a burn-out resistant base metal and a low-work function coating which enhances the operation of the filament in a variety of operating conditions.

Configurations Available

Filaments are available in two basic forms, ribbon or wire. In addition, they may be further described as to form, namely straight, hairpin, "V" shape, spiral or special.

Finally, filaments are made up with either plain ends or with platinum tabs for ease of welding. Complete welded and packaged assemblies can be provided on a custom holder.

Standard Sizes

Ribbon– available in .002" thick x .027" wide in any length up to 3.00" long. Other widths and lengths can be supplied on special order.

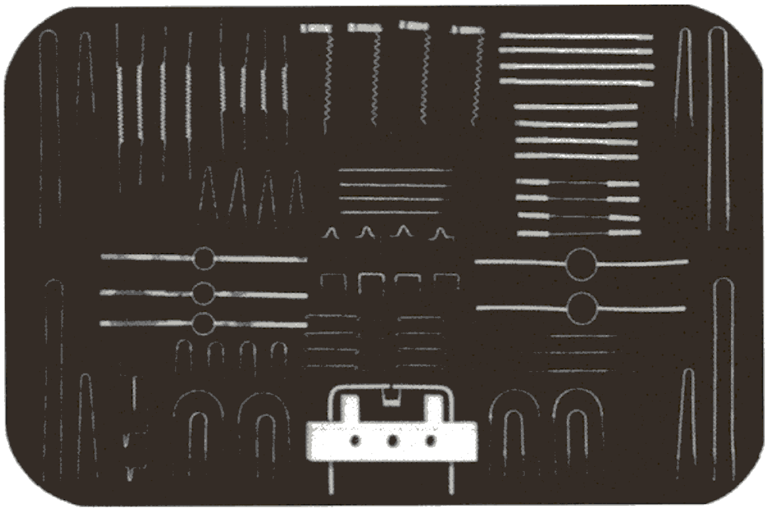
Wire– available in .005", .008" and .010" diameter in any length and configuration. Special diameters are available on special order. However, there are limits as to the diameters that certain metals can be drawn.

Ordering Information

In ordering, please supply sketch or drawing of configuration required.

Ribbon filaments should specify thickness, width, length of “active area”, configuration (whether straight, hairpin, etc.), whether tabs are required and overall length.

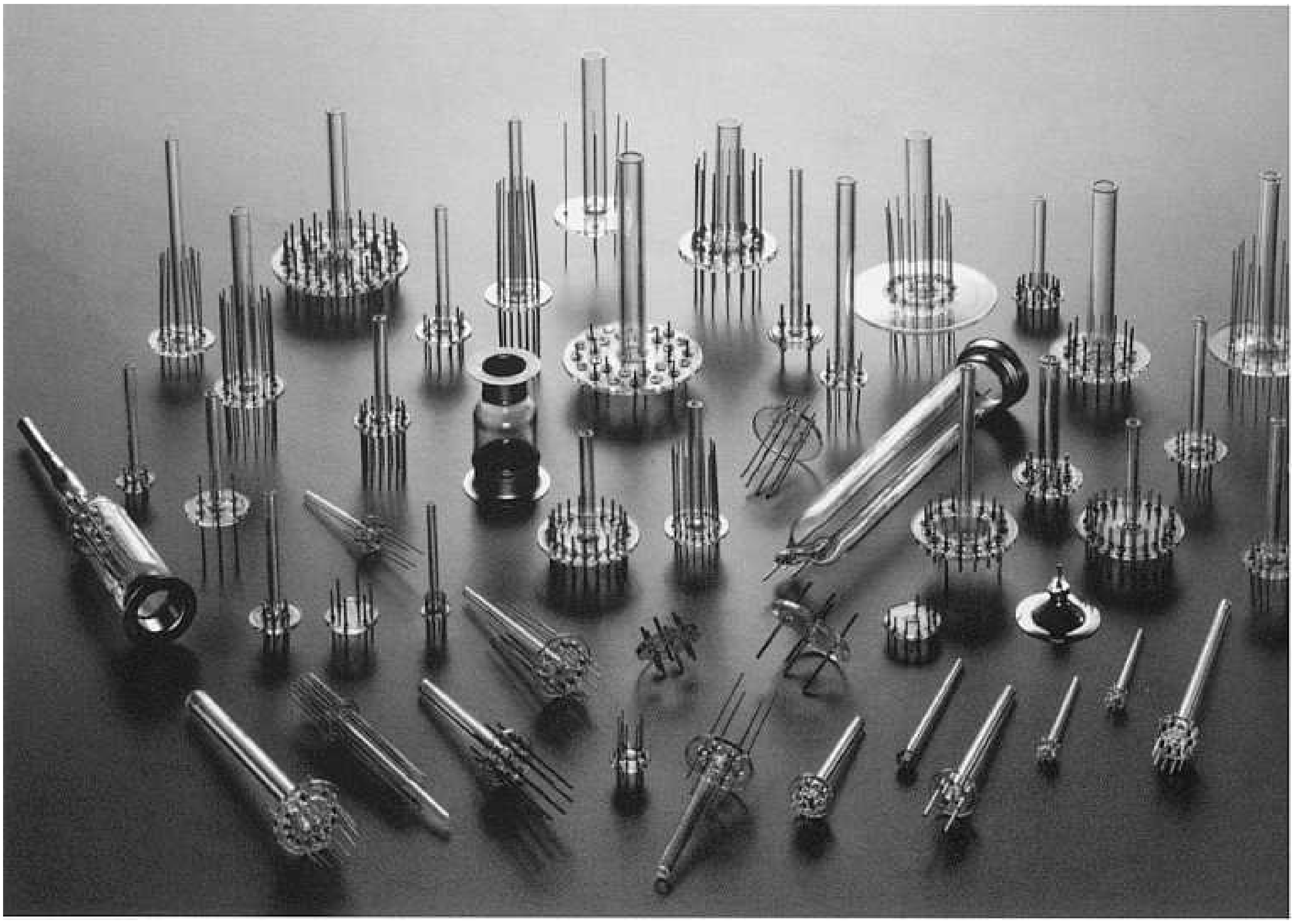
Wire filaments should specify wire diameter, configuration, and length of “active area”. On spiral designs, show radius I.D. of spiral, turns per inch, number of turns, length of spiral, length of “pigtails” and overall length.

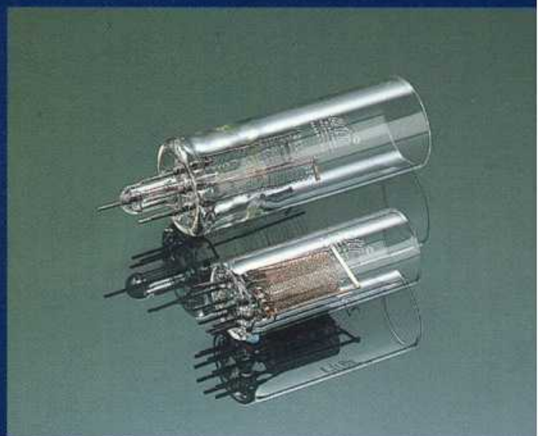


ETI Stems

Stem assemblies are used in sophisticated glass products such as cathode ray tubes, X-ray tubes, image intensifiers, laser and infrared detectors and photo-multipliers, along with other components for electronic devices. Stem assemblies consist of a glass wafer containing a series of hermetically sealed leads and, as required, glass tubulation.

Glass header assemblies are critical components used in the evacuation and getter-firing of electron and power tubes. ETI offers an unlimited variety of press stems with various diameters and pin configurations. Materials often specified for this glass sealing include kovar, tungsten, Sylvania #4, Kulgrid and molybdenum.





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