KJL4500

Ionization Gauge Controller
Instruction Manual

Kurt J. Lesker Company

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SAFETY

WARNING: ALL SAFETY REQUIREMENTS AND PROCEDURES MUST BE THOUROUGHLY AND COMPLETELY REVIEWED PRIOR TO OPERATION OF UNIT BY ALL PERSONS WHO MAY OPERATE UNIT.

Danger – High Voltage

Dangerous voltage is present during the operation of this ion gauge controller. Any and all safety procedures normally attendant with the use of high voltage must be adhered to with the operation of this controller.

The following precautions must be stringently adhered to at all times:

Do not open the controller cabinet.
Do not touch any cable connections. +180 volts is present in the gauge during operation. Do not touch the ion gauge tube, ion gauge connector, or tube connectors while the controller is in operation.
Under no circumstances whatsoever shall the controller be serviced and/or repaired by any person, company, or entity other than the manufacturer.
Operator must ensure that the proper voltage is used with the appropriate unit. Under no circumstances should the operator use voltage other than that specified on the unit's back panel next to the voltage receptacle.
Follow safe procedures to avoid electrical shock hazards.

If needed, contact the Kurt J. Lesker Co. for repair.

Explosive Gases

Ionization gauge filaments in ion gauge tubes operate at high temperatures. Do not use this controller to measure the vacuum pressure of explosive, combustible, corrosive, or unknown gases because the high temperature of the filament could ignite the gas.

Grounding

Any and all ion gauges used in connection the this unit must be grounded. The ground screw on the back of the KJL4500 must be directly connected to the ion gauge flange and vacuum chamber. Use an ohmmeter to ensure that the ion gauge and vacuum chamber are at ground potential.

Any questions concerning the operation of this unit must be directed to the Kurt J. Lesker Co.

RECEIVING - DAMAGED / MISSING PARTS

Confirm that the shipped controller is the same as listed on the packing list and that it includes all the materials and options that were ordered. If materials are damaged, the carrier that delivered the carton or cartons must be notified in accordance with the Interstate Commerce Commission regulations - normally within 15 days. A damage claim must be filed with the carrier, do not call the manufacturer to file a claim, as all claims must be made by the recipient through the delivering carrier. Kurt J. Lesker Co. will be happy to help with shipping identification numbers, routing and/or shipment tracing.

Any damaged materials including all shipping containers, boxes and packing materials should be kept for the carriers inspection.

If the shipment is not identical to the packing list or not what was ordered.
Contact the manufacturer:

Kurt J. Lesker Co.
1515 Worthington Ave.
Clairton, PA 15025
412-387-9200 Phone

International Shipments

Inspect all materials received for shipping damage. Check to be certain your shipment includes all materials and controller options ordered. Any items damaged must be reported to the carrier making the delivery to the customs broker within 15 days of delivery.

WARRANTY

The Kurt J. Lesker Co.~~,~~ KJL4500 Ionization Gauge Controller is guaranteed for **three years** against defects in parts, materials and workmanship. Any misuse or attempts to reprogram the controller during the warranty period will void the warranty. No other warranties are expressed or implied. If the unit malfunctions during the warranty period, contact the Kurt J. Lesker Company for return instructions. Please include a written statement of the problem along with a contact name and number.

KJL4500 SPECIFICATIONS

Power Requirements :	95 - 125 VAC (50/60 Hz), 185 Watts 200-250 VAC (50/60 Hz),185 Watts - OPTIONAL
Size:	3 ½" H (90mm), 15" W (381mm), 10.5" D (267mm) 19" W (483mm), with Rack Mount
Weight:	14 Lbs. (6.4 Kg)
Temperature Range :	0 - 40° C
Thermocouple Tubes :	
Type	KJL-6000 or Compatible
Range	1 to 1.0 x 10^{-3} Torr
Ion Gauge :	
Type	Bayard - Alpert
Range	9.9 x 10^{-4} to 1.0 x 10^{-10} Torr
Sensitivity	Adjustable, 1/Torr to 64/Torr (Factory set to 10/Torr)
Emission Current	Adjustable, 1.0 mA to 20.0 mA (Factory set to 10.0 mA)
Collector Potential	0 VDC
Grid Potential	+180 VDC
Filament Potential	+30 VDC
Degas	I^2R, 7V, 8A max; Adjustable timer from 1 to 60 min.
Display:	
Ion Gauge	Main Display; Scientific notation, 2 significant digits (Torr)
TC1	Main Display; Scientific notation, 2 significant digits (Torr) 30 segment bar graph (Millitorr)
TC2	30 segment bar graph (Millitorr)
Sensitivity	Main Display; 2 digits (/Torr)
SP1	Main Display; Scientific notation, 2 significant digits (Torr)
SP2	Main Display; Scientific notation, 2 significant digits (Torr)
SP3	Main Display; Scientific notation, 2 significant digits (Torr)
SP4	Main Display; Scientific notation, 2 significant digits (Torr)
Emission Current	Main Display; 3 digits (Milliamps)
Degas Time	Main Display; 2 digits (Minutes) If Degas is on, then remaining time is also displayed
Accessories:	
Recorder Output	0-10V; Logarithmic, 1 V/decade
Setpoint Outputs	SPDT relay output; 3 Amp @ 115 VAC

KJL4500 INSTALLATION

Thermocouple Installation

Connect the gauge tube to a clean, dry vacuum system with the open end pointing down so as to be self-draining should any vapors condense in it. Thread metal tubes into 1/8" female NPT threads. Allow the tube to outgas in the vacuum system for approximately 24 hours before operating with the controller.

Connect the Thermocouple (TC) Cable to the TC tube base. The plastic base of the tube might break off if force is used and the plug is not properly lined up with the tube. Plug the other end of the cable into the TC1 Connector on the back of the KJL4500. (Or TC2 Connector if TC1 is already installed) Route the TC Cables so that they won't get tripped on or pulled.

Ionization Gauge Installation

WARNING - Connect the IG Cable to the glass tube before it is under vacuum. Accidental bending of the tube pins, while under vacuum, could cause the tube to crack and implode.

Use only a **Standard Bayard-Alpert Ion Gauge** tube with this controller. This controller has resistive degas and is not designed to be used with an Ultra High Vacuum Tube. Using this controller with a UHV tube, that requires E Beam degas, will damage the unit and **void the warranty**.

Mount the ionization gauge in a central location in the vacuum system. The ion gauge reading will read a higher vacuum if mounted near the vacuum pumps. The reading will be lower if mounted near a gas inlet or source of contamination. If your vacuum system has an electron beam source the tube should have a shield around it to keep any spurious charged particles out of it.

Connect the IG cable to the tube; don't force the cable head onto the tube. The pins on the tube can bend easily. Connect the collector plug onto the collector pin on the top of the tube. Plug the other end of the cable into the ion gauge connector on the back of the KJL4500. Also connect the BNC plug into the ion collector connector next to the ion gauge connector.

Controller Installation

Place the controller in a secure place, or mount into an equipment rack with the rack mount kit. The unit comes from the factory, wired for either 115 or 230 VAC, check the back panel for input voltage type and connect the power cord to the appropriate voltage.

Grounding

Make sure the KJL4500 and the vacuum chamber are properly grounded to each other and to all vacuum instrumentation being used. See GROUNDING on page iii.

OPERATION

Controller Layout

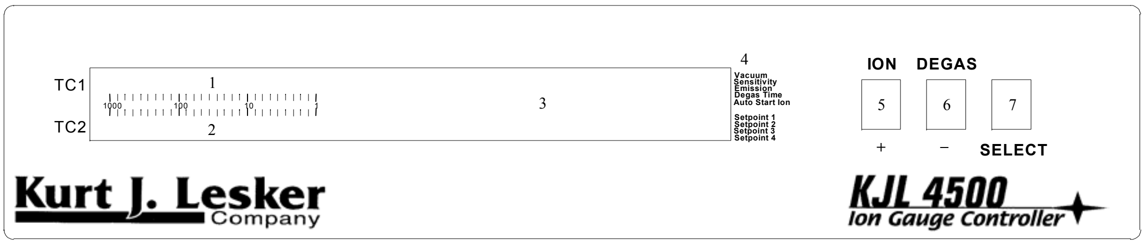


Figure 1

1. Thermocouple 1 Bar Graph
2. Thermocouple 2 Bar Graph
3. Main Display
4. Mode & Setpoint indicators
5. Ion Gauge On/Off switch
6. Degas On/Off switch
7. Select mode switch

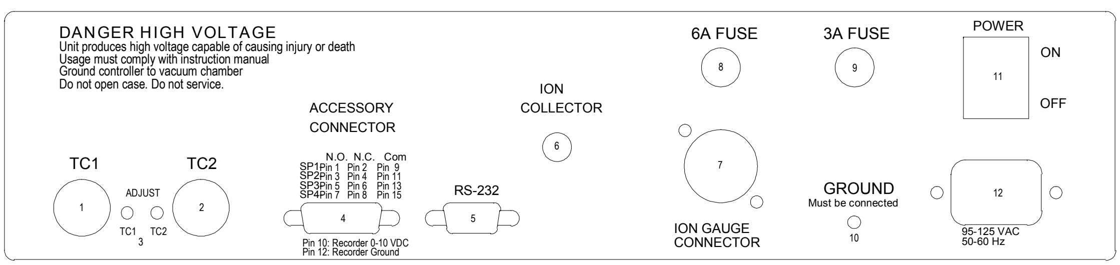


Figure 2

1. Thermocouple 1 connector
2. Thermocouple 2 connector
3. Thermocouple Adjust
4. Accessory connector
5. RS-232 connector
6. Ion Collector BNC connector
7. Ion Gauge connector
8. Ion filament fuse
9. Main power fuse
10. Ground Screw
11. Power switch
12. Power connector

READ THE SAFETY PAGE BEFORE PROCEEDING

Follow the instructions in the installation chapter and install the tubes and cables. Turn on the power switch on the back panel. The main display will be reading the TC1 gauge or if no tube is connected you will see 5 dashes.
Press the ION Switch on the front panel, the ion indicator will light. Wait a few seconds for the controller to display the pressure. To turn off the ion gauge, press the switch again.
The controller may automatically start the ion gauge tube. For this to happen, the Auto Start Ion is "on" and the vacuum on the TC tube is greater than 1.0×10^{-3}.

ION Switch

The Ion switch turns the on and off the ion tube in the vacuum mode. In the other modes it is used to adjust the values.

DEGAS Switch

The KJL4500 uses resistive heating for degassing the ion gauge tube. Before degassing, the ion gauge tube must be on and in a good vacuum (i.e. 9.9×10^{-4} or higher). The degas cycle is started by pressing the Degas Button, the degas indicator should come on to indicate degassing. Degas will only start if the controller is in the vacuum mode and the ion gauge is turned on. The KJL4500 will degas for the amount of time set on the timer.
There are 3 ways to shut off the degas cycle, first the degas timer can run out and the controller will turn off the degas, second you can press the degas button again, or you can turn off the ion gauge tube and the degas will also shut off.
In the other modes the degas switch is used to adjust the values.

SELECT Switch

The KJL4500 has 9 different modes of operation. They are accessed by pressing the Select Switch and are displayed on the main display.

Here is a list of the modes and what they do:

Mode	Operation
Vacuum	Displays the current vacuum
Sensitivity	Display & adjust sensitivity
Emission	Display & adjust emission
Degas Time	Display & adjust degas time
Auto Start Ion	Allows crossover between Ion gauge and TC gauge
Setpoint 1	Display & adjust setpoint 1
Setpoint 2	Display & adjust setpoint 2
Setpoint 3	Display & adjust setpoint 3
Setpoint 4	Display & adjust setpoint 4

Vacuum

This is the primary mode and displays readings from the three gauges. The controller will not display the vacuum reading from the gauges in any of the other modes. Refer to the mode indicator lights on the right of the main display to confirm the “Vacuum” mode.

Sensitivity Adjustment

Press the Select switch to the "Sensitivity" position. The sensitivity value is displayed on the main display. The range of adjustment is from 1 to 64 /Torr.

There are two factors in ion gauges that have a sensitivity value. The first is the sensitivity of the gauge tube and the second is the sensitivity of the gas in the vacuum system. These two values should be multiplied together to form the sensitivity value. For more information on sensitivity see page 14.

Sensitivity = Tube Sensitivity x Gas Sensitivity

Emission Adjustment

Press the Select switch to the "Emission" position. The emission current value will be displayed on the main display. The range of adjustment is from 1 to 20 milliamps.

The emission may need adjustment to accommodate different tubes or filaments. Do not use the emission adjustment to correct for different sensitivity. The KJL4500 has its own sensitivity adjustment and that should be used to change sensitivity.

Degas Time

Press Select switch to the "Degas Time" mode. The degas time value is displayed on the main display. The range of adjustment is from 1 to 60 minutes.
To see how much time is left on the degas timer, press the Select Switch to the "Degas Time" mode. The number on the left of the main display is the remaining time.

Auto Start Ion

The Kurt J. Lesker Co. ion gauge controller features automatic pumpdown tracking (Auto Start Ion). If "Auto Start Ion" is turned on, it will monitor the thermocouple output and automatically start the ion gauge when the vacuum system reaches the correct crossover pressure. The thermocouple reads the vacuum system from 1 torr to 1.0 x 10^{-3} torr. At the 1.0x10^{-3} torr crossover pressure, the controller will attempt to automatically starts the ion gauge. Because the ion gauge filament could oxidize or burnout at vacuum levels in the 1x10^{-3} torr range the controller will not allow the ion gauge tube to be operated in these ranges. The system pressure must be 9.9x10^{-4} torr or lower before the KJL4500 controller will allow the filament to be kept on. If this vacuum has not been reached, the controller shuts off the power to the ion gauge tube for 60 seconds. The controller is programmed to try and turn on the tube every 60 seconds thereafter, until the vacuum reaches 9.9x10^{-4} torr or greater. After this pressure is reached the controller continually tracks the system pressure during the high vacuum pumpdown; changing scales automatically as the vacuum increases. The highest vacuum that can be read with the KJL4500 is 1.0x10^{-10} torr.

Press the Select switch to the "Auto Start Ion" position. This feature maybe turn on or off.

Setpoints

The KJL4500 has four process control setpoints. They are activated by the vacuum pressure. To display or adjust the setpoints, press the Select Switch to the desired setpoint. The setpoint value is displayed on the main display. The range of adjustment is from 9.9 x 10^{-1} to 1.0 x 10^{-10} torr.

Depending on the setpoints value, the setpoint relays will be assigned to one of the three tubes.

If the adjusted value is between 9.9 x 10^{-4} and 1.0 x 10^{-10} torr, the setpoint relay will be automatically be assigned to the ion gauge tube.

If the adjusted value is between 9.9 x 10^{-1} and 1.0 x 10^{-3} torr, the relay will be assigned to one of the thermocouple tubes. The thermocouple tube must be connected and reading vacuum to trigger the setpoint relay.

A setpoint may be assign to either TC1 or TC2. The TC bargraphs will indicate which TC is selected. The following procedure switches between TC1 and TC2:

Press the Select Switch to the desired setpoint.
Press and hold the Select switch for five seconds, the assigned TC will be displayed on the main display and bargraph.
Use the Ion or Degas buttons to switch between TC1 and TC2.
Press the Select switch again to return to setpoint adjust.

The output of the setpoints are two pole relays rated at 3A @ 115 Vac. They can be connected to external equipment via the Accessory Connector.

ACCESSORIES

Accessory Connector

Pin Number	Setpoint	Operation
1	SP1	N.O.
2	SP1	N.C.
3	SP2	N.O.
4	SP2	N.C.
5	SP3	N.O.
6	SP3	N.C.
7	SP4	N.O.
8	SP4	N.C.
9	SP1	Com
10	Recorder Output	Positive DC
11	SP2	Com
12	Recorder Output	Ground
13	SP3	Com
15	SP4	Com

Analog Recorder Output

The recorder output of the KJL4500 is a 0 to 10 VDC signal accessible through the accessory connector. Pin 10 is the positive DC signal and Pin 12 is ground. It is a representation of what vacuum is displayed on the main display(TC or Ion Gauge). The output is a linear 1 volt per decade.

The formula for the recorder output is:

Vout = (-*Vac. Exponent* x 1.0 VDC) + (1 - (*Vac. Mantissa* / 10))

Examples:

4.4×10^{-1}	=	1.56 VDC
1.0×10^{-3}	=	3.90 VDC
3.5×10^{-5}	=	5.65 VDC
9.9×10^{-8}	=	8.01 VDC
5.0×10^{-6}	=	6.50 VDC

Remote Operation (RS-232 Interface)

The KJL4500 Ion Gauge Controller has a full functioning remote computer port. All aspects of the KJL4500 can be controlled via the RS-232 interface by sending simple commands to the controller. Any computer or terminal with a serial RS-232 port can be connected to the KJL4500. If the controller is connected when the power is turned on the software version name will be sent to the computer.

The RS-232 interface uses a standard 9 pin serial port. The port specifications are listed in table 1 below. The Pin out of the controllers RS-232 port is listed in table 2, you can get by with only the TX, RX & Ground wires connected. The DTR is connected internally to the DSR and the RTS to the CTS.

Interface Type	RS-232
Interface Mode	DTE
Baud Rate	2400
Stop Bits	1
Data Bits	8
Parity Bits	None
Flow Control	None
Voltage of Logic 0	+12 VDC
Voltage of Logic 1	-12 VDC

Table 1

Pin	Function
1	NC
2	TX (Transmit Data)
3	RX (Receive Data)
4	DTR
5	Ground
6	DSR
7	RTS
8	CTS
9	NC

Table 2

Software Commands

All commands must terminate with a <CR>
The controller will echo back the characters received (unless disabled).
Standard ASCII is used
"n, nn, nn.n" refer to a numerical value
"m.m" refer to a mantissa value
"ee" refer to an exponent

COMMAND	RESPONSE	DESCRIPTION
=X	<prog V xx>	Reset Program
=RA	A=On	Read AutoStart
=SA:1	A:Ok	Set AutoStart
=RS	S=sens	Read Sensitivity
=SS:nn	S:OK	Set Sensitivity
=RE	E=emis	Read Emission Current
=SE:nn.n	E:OK	Set Emission Current
=RT	T=nn	Read Degas Time
=ST:nn	T:OK	Set Degas Time
=R1	1=t:m.msee	Read Setpoint 1
=S1:t:m.m-ee	1:OK	Set Setpoint 1
=R2	2=t:m.msee	Read Setpoint 2
=S2:t:m.m-ee	2:OK	Set Setpoint 2
=R3	3=t:m.msee	Read Setpoint 3
=S3:t:m.m-ee	3:OK	Set Setpoint 3
=R4	4=t:m.msee	Read Setpoint 4
=S4:t:m.m-ee	4:OK	Set Setpoint 4
=R#	<prog name> SN: serial number	Read Serial Number
=RV1	V=m.m-ee	Read Vacuum from IG
=RV2	V=m.m-ee	Read Vacuum from TC1
=RV3	V=m.m-ee	Read Vacuum from TC2
=RV	V=m.m-ee	Read Vacuum from Main Display
=R*	*=123456	Read Status b1=Ion On b2=Degas On b3=SP1 b4=SP2 b5-SP3 b6=SP4
=SF1	F=On	Turn On Filament
=SF0	F=Off	Turn Off Filament
=SD1	D=On	Turn On Degas
=SD0	D=Off	Turn Off Degas
	Error 1	Syntax Error
	Error 2	Number Out of Range
	Error 3	Operation Not Allowed
	Error 4	Tx Buffer Overflowed

Setpoint Format t:m.msee t = type 0 = TC1, 1 = TC2 m.m = Mantissa ee = Exponent

THERMOCOUPLE GAUGE TUBE

Operating Principles

The thermocouple sensing mechanism consists of a tube with an internal filament, which is heated by an electrical current. A thermocouple filament is welded to the center of this heated filament. The heat transfer between the filaments varies with the vacuum pressure. The thermocouple filament generates an output voltage as it is heated. Thermocouple tubes can be slow to respond as the heat transfer within the tube is not an instantaneous process.

Controller Interface

The KJL4500 Ion Gauge Controller has provisions for two thermocouple tubes. Thermocouple 1 is for use in monitoring the vacuum system pressure and is displayed on a bargraph located on the front panel of the controller. Thermocouple 1 is also displayed on the main display when the ion gauge is off and the controller is in the vacuum mode. Thermocouple 2 is usually used to measure a secondary vacuum such as a foreline, roughing pump or insulation vacuum. TC2 is displayed on a bargraph of its own.

The output of both thermocouple 1 and thermocouple 2 are amplified by a precision OP AMP circuit for an accurate reading. The signals are sent to the microprocessor via an A/D Converter. The microprocessor then converts the voltage to a vacuum pressure, using a lookup table located in the microprocessor.

Calibration of Thermocouple Tubes

The KJL-6000 thermocouple tubes are designed with close tolerances between tubes, for this reason if the tubes are switched or replaced, there maybe no need to recalibrate KJL4500 Controller.

If you wish to recalibrate the TC tubes the following procedure should be used:

1. Attach the new TC tube to a known vacuum in the 10^{-3} torr range.
2. Connect the tube to the KJL4500 Ion Gauge Controller
3. Allow the controller and tube to warm up for one hour.
4. Turn the "adjust" potentiometer until the display shows the proper vacuum. Due to the inherent delay of the heat transfer inside of the tube, the controller will be slow to respond to the potentiometer adjustment. The potentiometer are accessed through the back panel near the TC connectors.

IONIZATION GAUGE

Operating Principles

All ionization gauges operate on the basis of ionizing a fraction of the gas molecules present in the gauge and the collecting the gas ions. The gas ions are positively charged and cause an electrical current flow to the ion collector circuit. The magnitude of this current indicates the amount of pressure. A higher pressure (density of gas molecules) will cause a larger rate of ionization, resulting in a greater rate of positive ionic charge on the collector. These positive charges form a current in the collector circuit, from which the pressure is calculated.

Simple hot filament ionization gauges are available in several forms; such as the triode geometry or the more popular inverted triode (Bayard-Alpert) geometry.

A schematic view of a Bayard-Alpert gauge is shown in figure 3. These tubes usually have glass enclosures, however they are also available with no enclosure (nude gauge). The nude gauges are inserted directly into the vacuum system. As shown in figure 3 the ion collector is a slender wire down the center of a grid structure. The electron emitting filaments are outside the grid structure. Since the traditional triode gauge arrangement has the electron emitter inside the grid and the ion collector outside the grid, the Bayard-Alpert gauge is often referred to as an inverted triode gauge.

Figure 3 shows two electron emitting filaments; however only one filament is used during the operation of the gauge. The second one is available for use when the first one burns out. The filaments are usually made of tungsten but thoriated iridium filaments are offered as an option. The thoria coated iridium filaments have a longer life because they can withstand operation in higher partial pressures of oxygen and water vapor.

In the normal operation of the gauge, power is applied to the filament. The filament heats and electrons are emitted. The emission current is usually a few milliamperes when the gauge is operated in the high vacuum pressure range. The emitted electrons are accelerated toward the positively biased grid. Usually this accelerating potential difference is 150 volts. The grid is a relatively open structure therefore, most of the electrons pass through the grid, slow down, turn around and are accelerated back toward the grid again. The electrons pass through the grid and may oscillate back and forth through the grid structure many times before they hit the grid. This long mean free path for the electrons improves the probability that they will hit a gas molecule and ionize it even though the pressure may be in the ultra-high vacuum range. When such an ionizing collision takes place the positively charged gas ion is attracted to the most negative element in the gauge tube, the ion wire. Usually the ion collector wire is held at ground potential or zero volts. The ionized gas molecules are attracted to the ion collector and create a current in the collector circuit, which provides the pressure indication.

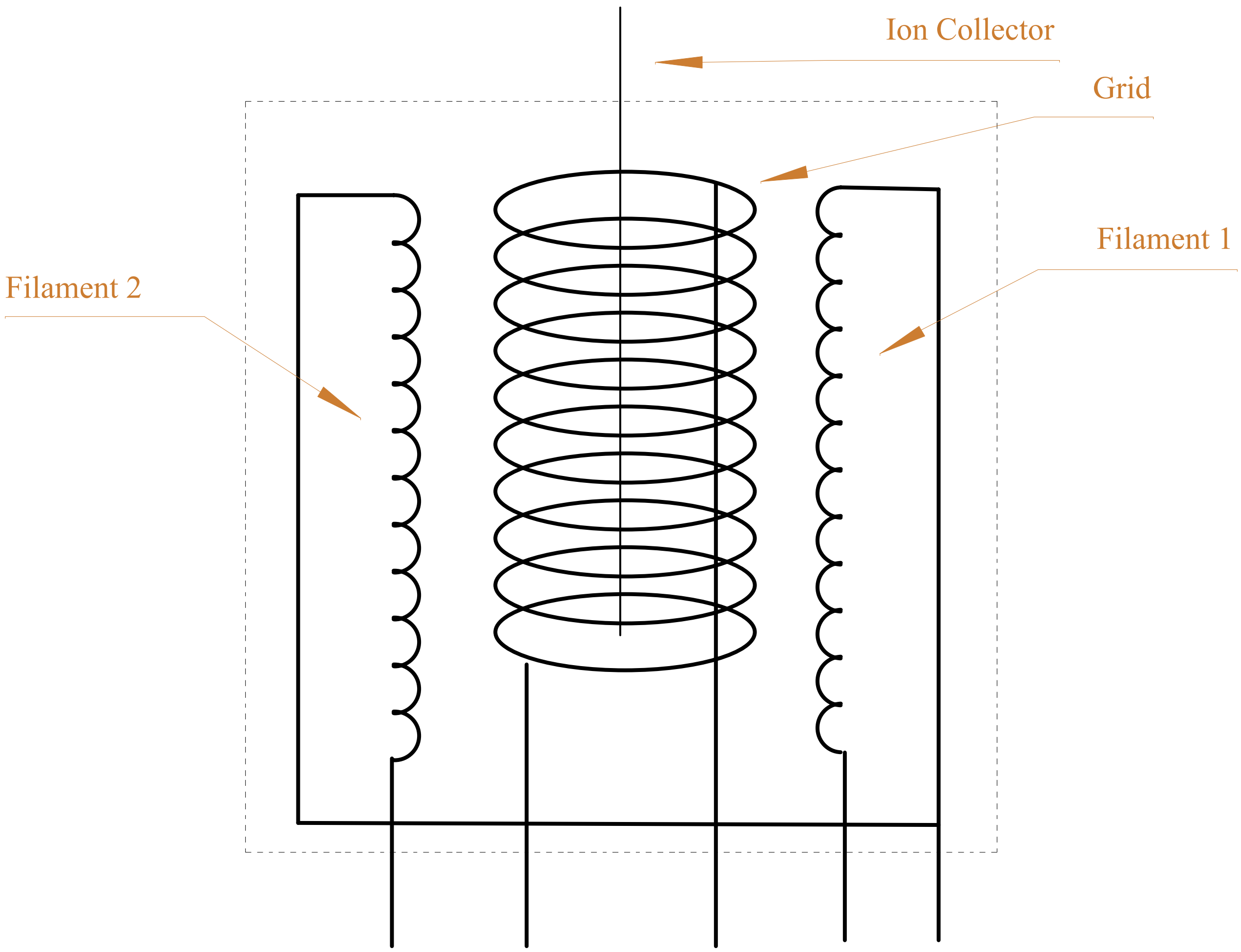


Figure 3

Schematic view of a Bayard-Alpert Ion Gauge Tube

Note: Do not use as reference for connecting KJL4500 cable to tube

Pressure Calculation

In hot filament ion gauges, the ionizing electrons are emitted from the hot filament. The rate at which electrons are emitted is measured by the emission current (Ie) of the filament. The gas ions produced in the gauge are attracted to the ion collector and produce an ion current (Ic) in the ion collector circuit. In order to determine the pressure (P) measured by the ion collector current we need to know what relationship exists among the variables; P, Ie and Ic.

There is a direct relationship between the ion current and the emission current. If the user increases the emission current more electrons are emitted from the filament. Therefore more gas molecules will be contacted and ionized and the ion current will be increased. The ion current is a direct function of the density of the gas molecules present. As the pressure increases, the density of gas molecules increases. Hence there will be more gas molecules hit by the emitting electrons, resulting in an increase of ion current. The ion current is also a function of the geometry of the elements in the tube and to some degree the electrical potentials of the various elements. If the emitted electrons have a very long mean free path from emitter to collector there is an increased probability of hitting a gas molecule, ionizing it and producing an increased ion current. We must remember that the probability of ionization is also a function of the gas species present in the gauge tube. The effect of geometry, electrical potentials and gas species are combined to form the gauge sensitivity (s).

The equation that relates all these quantities is:

$$P = \frac{Ic}{Ie * S}$$

S = Tube Sensitivity x Gas Sensitivity

Effects of Various Gases
(Relative Sensitivity)

Various gases in the gauge tube will different effects have on the indicated pressure. We have to make the distinction between the true pressure in the gauge tube and the pressure that is indicated by the controller. Almost all manufacturers calibrate their gauges so that the indicated pressure is nearly identical with the true pressure when the gas is a normal air mixture.

In any gauge tube that has a fixed volume and operates at a constant temperature, the true pressure is determined solely by the number of gas molecules present. However the indicated pressure in an ionization gauge is determined by the rate at which gas ions are collected. Typically this rate of collection is determined by the rate gas molecules are ionized. This ionization rate varies with gases, other than normal air or nitrogen, causing a discrepancy between the indicated pressure and the true pressure (when nitrogen or normal air is not being used). The relative sensitivity of a gas is the relationship between the ionization rate of the gas and nitrogen. When not using nitrogen, the indicated pressure of the ion gauge controller must be divided by the relative sensitivity number for that gas.

Gas Type	Relative Gas Sensitivity S/SN	KJL4500 Adjustment
Helium	0.178	02
Neon	0.316	03
Oxygen	0.780	08
Water Vapor	0.90	09
Nitrogen	1.00	10
Carbon Monoxide	1.01	10
Carbon Dioxide	1.39	14
Argon	1.42	14
Krypton	1.94	19
Xenon	2.75	28

Degas

There is a possibility at some time during ion gauge operation that the pressure in the gauge tube will be higher than the pressure in the vacuum system because of gases and vapors desorbing from the surfaces of the gauge tube. Degassing is the process by which we attempt to speed up desorbtion or outgassing of the surfaces inside the gauge tube. Once these surfaces are outgassed or degassed, the pressure in the gauge tube is more likely to be equal to the pressure in the vacuum system.

Degassing is accomplished by heating some of the elements in the tube. Heated surfaces outgas more rapidly than cool surfaces. Heat flow, by radiation and conductance, causes all the gauge surfaces to heat, and thus to outgas.

The KJL4500 performs degas by using resistive heating (I^2R). An electrical current is passed through the grid structure. This causes these wires and all the gauge elements to get hot. In order to thoroughly outgas a hot filament gauge tube allow 15 to 45 minutes of operation in the degas mode. It may take a longer period of degas time or repeated degas cycles if the gauge is extremely contaminated.

X-ray Limit

The x-ray limit is one of the fundamental factors, which limit the minimum pressure that is measurable by the hot filament ionization gauge. In any gauge there is a hot, electron emitting filament. In addition to the filament there is a positively biased electron collecting grid, and a negatively biased ion collector surface. Electrons emitted from the filament are accelerated to the grid. At lower pressures some of the electrons hit and ionize gas molecules and some electrons miss the gas molecules and hit the grid

When the emitted electrons hit the grid they impact with enough energy that soft (low energy) x-rays are generated. These x- rays are emitted from the grid structure in all directions, so that many of the x-rays hit the ion collector surface. When a x-ray hits the ion collector it simulates the emission of a negative electron from the ion collector. A negatively charged electron leaving the ion collector is electrically equivalent to a positively charged ion arriving at the collector. The electronics in the ion collector circuit cannot distinguish the difference. Therefore as long as the arriving ion current is much greater than the x-ray stimulated (leaving electron) current, the gauge can accurately indicate the pressure. But, if the pressure is so low that the ion current becomes comparable to or less than the x-ray stimulated electron current, the gauge electronics will only indicate a lowering pressure down to that "stimulated pressure," analogous to the value of the x-ray stimulated electron current. At this point the gauge is said to be at its x-ray limit.

Electrometer

The electrometer collects and monitors the current in the collector circuit and thus indicates the vacuum level by the amount of current. The electrometer is a high precision integration amplifier that converts the current to a pulse width. The microprocessor computes the vacuum by timing the width of the pulse. The electrometer must be able to monitor a large current flow in the 10^{-4} torr range and a very minute current flow in the 10^{-9} torr range.

Troubleshooting

Ion Gauge Shut Down Codes

When the KJL4500 turns off the ion gauge tube, the controller will display a CODE# on the main display. This will stay on the display for about 2 seconds. Here is the list of the code numbers and what they mean:

CODE 1

The Ion Gauge shuts off because it can not get or hold the Emission Current.

Possible Problems: Vacuum is to low
Ion Gauge Cable is disconnected
Filament Fuse is blown

CODE 2

The Ion Gauge shuts off because it can not establish Collector Current.

Possible Problems: Vacuum is too high
Ion Collector BNC is disconnected

CODE 3

The Ion Gauge shuts off because the vacuum lower than $9.9x10^{-4}$. This is the normal shut down mode when bringing the pressure up in the vacuum system.

CODE6

There is a problem with the RS-232 receiver routine.

Possible Problems: RS-232 Cable is loose or broken
Baud Rate or Communication Setting is wrong

Troubleshooting Guide

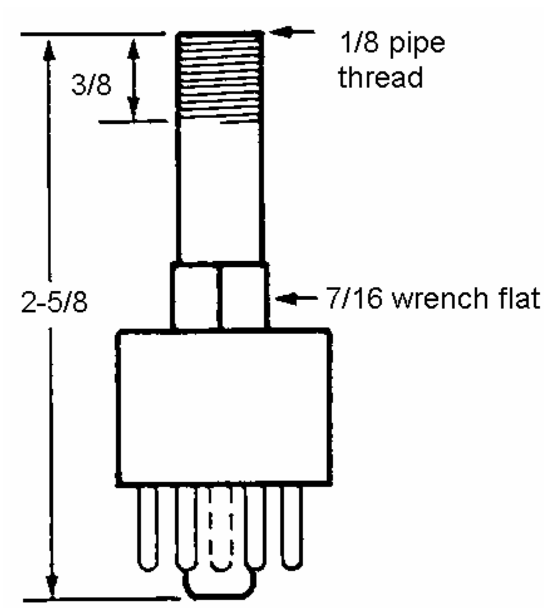
Symptom	Possible Cause
Unit won't power up, no response to power switch.	No power to unit Power cord not inserted tightly Power fuse is blown
3A Power fuse blows repeatedly.	Wrong line voltage Wrong power fuse rating Defective power supply
6A fuse blows repeatedly.	Ion gauge tube filament is shorted Ion gauge cable is shorted
Tube and ION LED won't turn on	Controller is not in vacuum mode
Auto Start Ion won't work	Auto Start Ion set to "Off" TC1 is calibrated wrong
Ion Gauge tube won't come on, controller displays **CodE1**. (The filament does **NOT** light up at all)	Unplugged ion gauge cable Burned out filament Blown 6A fuse Broken ion gauge cable Defective power supply
Ion Gauge tube comes on briefly then shuts off with **CodE1** displayed. (The filament lights up briefly)	System pressure is too high Badly contaminated ion gauge tube Defective ion gauge cable Defective ion gauge tube
Ion Gauge tube won't come on, or comes on briefly then shuts off with **CodE2** displayed.	System pressure is too low Ion collector BNC is unplugged Ion collector wire is off of the tube Defective ion gauge cable
Ion Gauge tube won't come on, or comes on briefly then shuts off with **CodE3** displayed.	System pressure is too high
Degas won't come on	Ion Gauge is not turned on Controller not in vacuum mode
Thermocouple reading stays at 1000 microns	Blown thermocouple tube Bad cable or connection
Thermocouple reading is low or	TC tube out of calibration

never reaches 1.0 x 10^{-3} Torr	
CodE6 is being displayed on the controller.	RS-232 cable is loose or broken Wrong communication settings

Tube Drawings

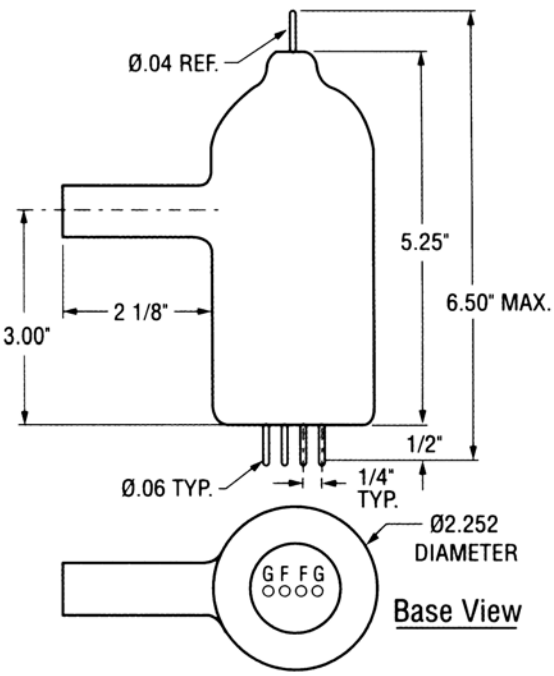
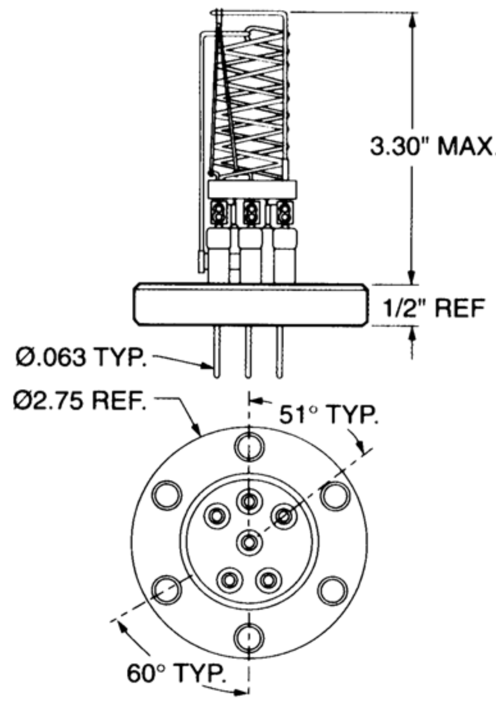
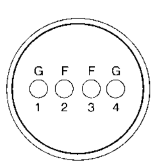
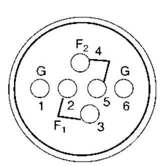
KJL-6000 Thermocouple Gauge Tube

Outline Dimensions, full scale
All measurements in inches.



Operation Specifications	
Measurement range	1 to 1000 microns
Heater current	21 mA
Thermocouple output	10 mv at 1 micron
Thermocouple load	55 Ohms
Connection	1/8" IPS threaded port
Basing	JEDEC 8 FR

IGT Ionization Gauge Tube

BA Glass Ion Gauge Tube	BA Nude Ion Gauge Tube
	
The KJL4500 can be used with any type of Bayard-Alpert glass ion gauge tube.	The KJL4500 can be used with some nude ion gauge tubes. The tube must have resistive degas. Do not use the controller with nude UHV tubes that use **E-beam degas**. Connecting to this type of gauge will **void the warranty**.
The standard ion gauge cable will connect with the pinouts below.	The nude ion gauge cable will connect with this type of tube.
 Single Iridium  Collector connects Dual Tungsten filament type