C-A OPERATIONS PROCEDURES MANUAL

15.5.10 Use of High Vacuum Gauge

(Vacuum Group Procedure VA-008.18.1.10)

Note: This document was formerly a C-A Group Procedure. The content of the group procedure was reviewed by the Technical Supervisor. All approvals and/or issue dates of the original group procedure are maintained for present use.

Hand Processed Changes

HPC No.	Date	Page Nos.	Initials

Approved: _______***Signature on File***_______________ ______
Collider-Accelerator Department Chairman Date

S. Gill

Vacuum Group Procedure VA-008.18.1.10
Original Issue Date: 01/01/00
Revision 01

*****IMPORTANT*****

PRIOR TO THE PERFORMANCE OF ANY WORK WITHIN THE SCOPE OF THIS PROCEDURE, IT IS THE RESPONSIBILITY OF THE SUPERVISOR TO ENSURE THAT ***WORK PLANNING*** HAS BEEN REVIEWED FOR THE PROTECTION OF WORKERS, EQUIPMENT, AND THE ENVIRONMENT.

1.0 PURPOSE:

1.1 TO PROVIDE AN EFFECTIVE PROCEDURE FOR AGS VACUUM TECHNICIANS TO SUCCESSFULLY REBUILD A COLD CATHODE GAUGE.

2.0 RESPONSIBILITIES:

2.1 THE AGS VACUUM SUPERVISOR SHALL BE RESPONSIBLE FOR THE IMPLEMENTATION OF THIS PROCEDURE.

Page Intentionally Left Blank

BALZERS

OPERATING INSTRUCTIONS

8,18,1,10
¢
8,18,1,12

Cold cathode gauge head — IKR 020

1. APPLICATION

The IKR 020 gauge head is used together with BALZERS vacuum gauge control units to measure total pressure in the 5×10^{-3} to approx 10^{-10} mbar range. The lower limit of the range is determined both by the sealing material (for gauge head and vacuum connection) and control unit used.

Systems and instruments designed for the IKR 010 gauge heads can be operated without difficulty with the IKR 020. However, the improved features of the IKR 020 such as the extended measuring range cannot be taken advantage of in such cases.

2. ASSEMBLY AND CONNECTION OF THE IKR 020

The IKR 020 can be installed in any desired position when care is taken that no condensates or contamination can collect in the measurement chamber.

The gauge head is connected to the vacuum system by a standard KF or CF flange connection. Before making the connection be sure that the sealing surfaces are smooth and clean, that there are no scratches across the seal, and that the sealing ring itself is clean and not damaged. We recommend using alcohol for cleaning the sealing surfaces and seals. Do not use grease!

For making flange connections refer to operating instructions BA 800 001 BE.

2.1 IKR 020 with DN 40 KF connection

For pressures under 10^{-6} mbar Viton O-ring seals should be used instead of neoprene because of their low outgassing rate.

Metal seals,for example Al or indium,can also be used with KF flange connections (for details refer to "Component Catalog".)

Using reducing centering rings,DN 32 flanges can be connected to DN 40 flanges.

2.2 IKR 020 with DN 35 CF connection

The sealing principle is that two flanges with a copper ring between them are pressed together with such force that the hard knife edges of the flanges cut into the ring from both sides.

The gauge heads can also be mounted using Viton O-rings. This connection may be baked at 120 °C, or briefly at 150 °C.

For installation, the hood containing the magnets is removed:

Turn the cover 90° and pull off.

See Section 8.2.7 for reassembly

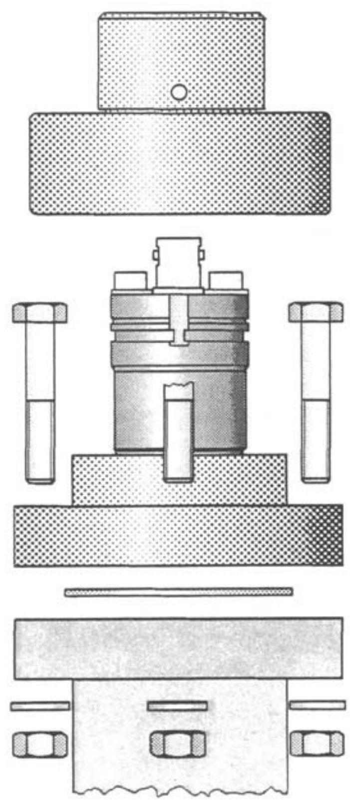


Fig. 1

2.3 Electrical connection

The electrical connection is made using a high voltage coaxial cable which is attached to a current supply and display instrument such as the IKG 010, the IKG 011, the PKG 020, the PKG 100, etc.

Refer to Section 7.3 for cable lengths.

3.2 Ignition delay

If the measurement is begun at pressures $< 10^{-8}$ mbar then an ignition delay must be expected. The ignition delay increases with the dropping pressure and can, for example, be 2 – 4 minutes at 5×10^{-10} mbar.

3. MEASURING

Start up and measurement operations are to be undertaken according to the operating instructions of the control unit used.

When measuring very low pressures ($p < 10^{-8}$ mbar) the following must also be taken into consideration:

3.1 Error of measurement

If there is a portion of non-operate current due, for example, to insufficient insulation, the pressure value displayed will be too high.

Check (while instrument is in operation):

- Remove hood with magnets

  If the pressure display does not return to zero, there is an insulation malfunction:

Further procedures to find the insulation malfunction:

- Remove cable from the IKR

  Display returns to zero – insufficient insulation in the IKR (clean according to Section 8.1.)

  Display does not return to zero – malfunction is in the cable (check) or in the supply unit (refer to separate instructions).

4. ACCURACY OF THE PRESSURE DISPLAY

For a single gauge head, the accuracy or reproducibility of the measured value during a short period is approx. ± 5%.

The following factors have a great influence on the measurement accuracy:

- Geometry of the electrodes
- Contamination of the electrode surfaces

While the mechanical quality can be accurately checked, deposits of foreign films during the operation cannot be so easily measured. At a constant pressure and increasing contamination, the discharge current diminishes and finally becomes unstable ("jumps" in the pressure display).

The pressure display on the control instrument is based on an average calibration curve between the curve of a brand new gauge head and that of a gauge head with contamination that is just barely still tolerable. Thus the pressure shown by new gauge heads is a little bit too high and that from contaminated gauge heads too low. The possible changes are shown in Fig. 2. (Comparison instrument: Hot cathode ionization gauge).

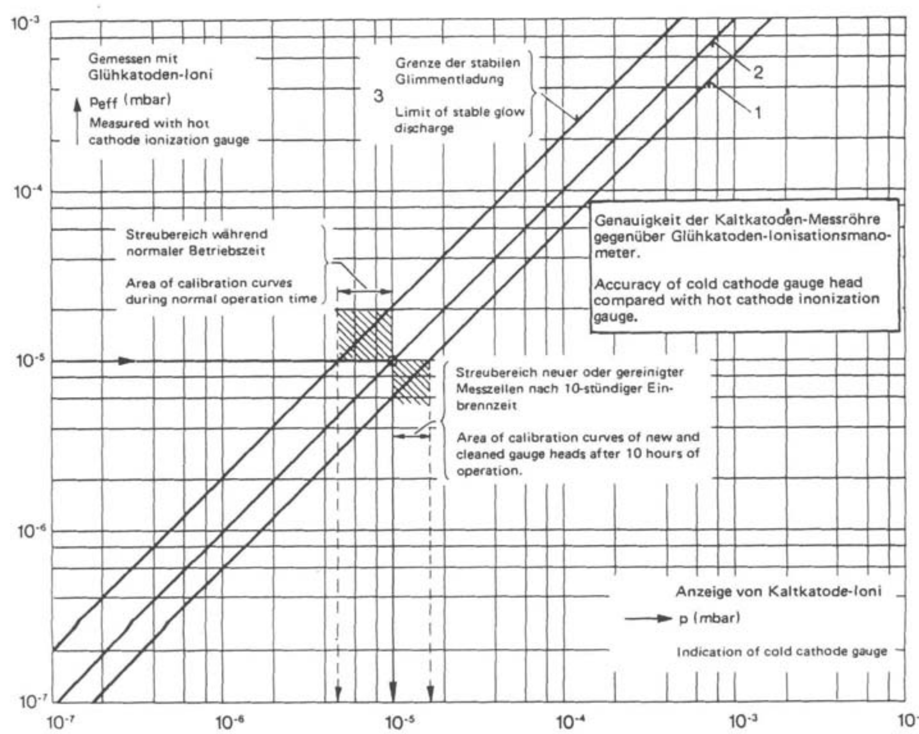


Fig. 2

The values for new or cleaned gauge heads after approx. 10 hours of operation lie within the field between Curves 1 and 2. Experience has shown that gauge heads change the most during this so-called "burn-in" time and then reach a much more stable condition.

During longer operation and increasing contamination the display shifts in the direction of Curve 3. If this boundry is crossed, the discharge becomes unstable. The gauge head must be cleaned.

Note that the curve of the actual measured values need neither run parallel to the boundries drawn or shift parallel to it. The bordered areas contain the distribution of the values from a large number of gauge heads together, as well as the possible production tolerances and changes in the electronic part.

As shown in the graph, in a bad case the devitation can, for example, be a factor 3 between a new gauge head and a very contaminated one. Normally, especially when the gauge head is not operated to its extremes, the display lies somewhere between +60% and −50% of an absolute average value.

5. MEASURING GASES AND VAPORS

Pressures measured with the cold cathode gauge head are dependent on the type of gas. Usually the control instruments are calibrated for air (N_2).

Finding out the actual pressure:

5.1 Display range 10^{-3} to 10^{-5} mbar

The actual values P_{eff} can be determined using the curves in Fig. 3.

Example: Gas = Helium (He)
Display = 1×10^{-5} mbar
actual value P_{eff} = 6×10^{-5} mbar

5.2 Display range under 10^{-5} mbar

The display is linear. For other gases such as air, the pressures can be determined by simple calculation:

$$P_{eff} = K \times \text{displayed pressure}$$

Example: Gas = hydrogen (H_2)
Display = 3×10^{-7} mbar
actual pressure P_{eff} = $2.4 \times 3 \times 10^{-7}$ mbar
= 7.2×10^{-7} mbar

Type of gas	K
air	1.0
Xe	0.4
Kr	0.5
Ar	0.8
H_2	2.4
Ne	4.1
He	5.9

Note:

One often has to deal with mixtures of gases and vapors. In such cases the composition can only be determined with a partial pressure measuring instrument.

The calculation factors given are average values. Please note Section 4 "Accuracy of the pressure display".

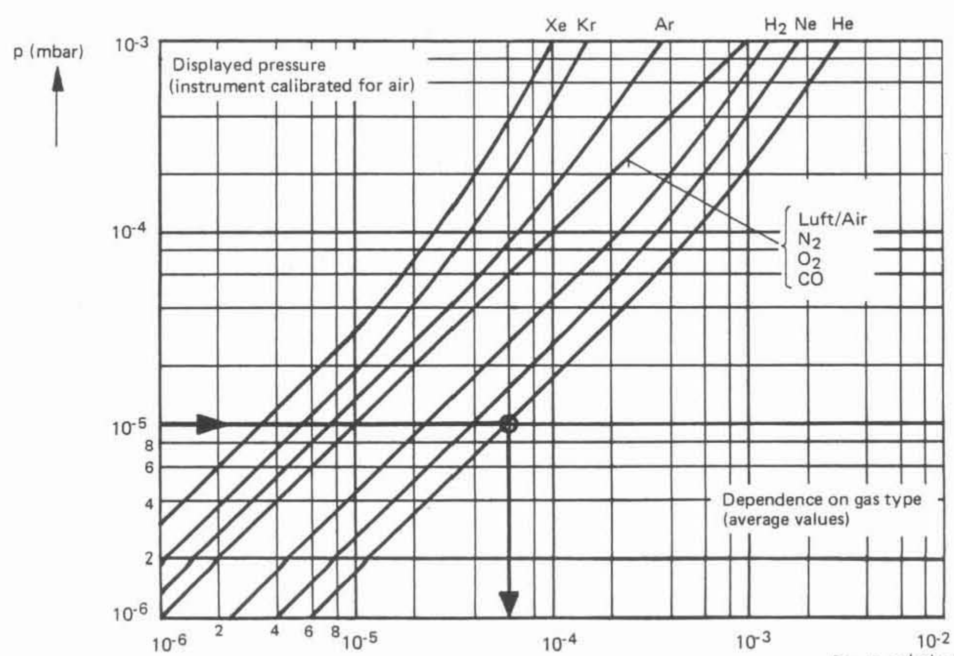


Fig. 3

6. TECHNICAL DATA

Order Nr.	Connection DN	Measuring range from 10^{-3} mbar to	Temperature resistance to °C	Radiation resistance rad	Anode insert seal
BG G12 510	40 KF	10^{-8}	150	10^4	Viton
BG G12 515	40 KF	10^{-10} 1)	250		Copper 2)
BG G12 511	35 CF				
BG G12 516	40 KF			10^9	
BG G12 513	35 CF				

Operating voltage:	3.3 kV
Max. glow discharge current	0.7 mA
Weight, without cable	0.5 kg

1) Lower limits determined by the control unit used

2) Copper seal (Helicoflex/made by Cefilac) can withstand a minimum of 10 bakeout cycles from 25 to 250 °C at a temperature rise of max. 5 °C/min.

Materials coming into contact with the substrate in the vacuum system:

Housing: 1.4016 / 1.4034 / 1.4104 / 1.4301

HV feedthrough: Ceramic (Al_2O_3)

Seal: Viton or copper

Anode: Molybdenum / Chopper

Flange 40 KF: } 1.4036
35 CF: }

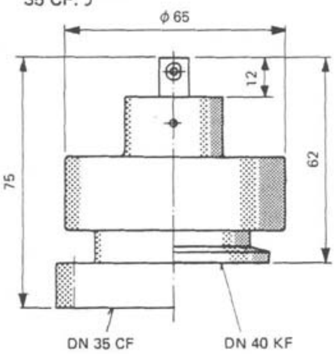


Fig. 4 Scale drawing

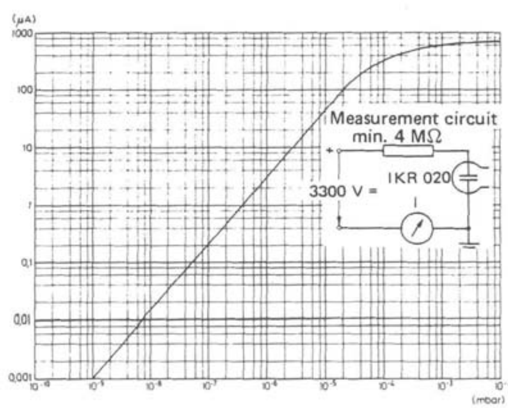


Fig. 5 IKR 020 characteristic curve

7. PRINCIPLE OF OPERATION

7.1 Method of measurement (gas ionization with cold cathode)

The current flowing in an autonomous gas discharge in the high vacuum range depends on the applied voltage, on the gas composition and on the pressure. A magnetic field pentrating the discharge space causes the electrons to move from the cathode to the anode on a spiral trajectory. Thus, even at very low gas density, a sufficient number of ionizing impacts occur. The discharge current is a measure of the pressure for a certain gas composition if the anode voltage and the magnetic field remain constant.

7.2 Description

The reliable IKR 020 gauge head is made chiefly of metal, the measurement chamber as well as the connection flange of stainless steel. The magnetic field is produced outside the measurement chamber by a permanent magnet.

It is supplied with a stabilized direct voltage of 3.3 kV. The current is limited by the measurement circuitry to approx. 700 μA according to Fig. 5. The special design avoids glow discharge breakdown throughout the whole measuring range. The measurement current is stable, virtually inertia free and reproducible within narrow limits. Short operating times at high pressures or inrushes of air do not affect the function of the IKR 020. The gauge head can be disassembled for cleaning purposes. Calibration is restored after short operation.

Depending on the intended bakeout temperature, the ceramic anode voltage feedthrough is either Viton or metal sealed.

Older versions of this gauge head use gold seals. If gold seals are not desired, it is possible to convert this version of the gauge head using a special conversion kit. Refer to Section 10. "Accessories".

7.3 Measurement cable

A coaxial cable is used for connection to the control instrument. It is equipped with bayonet joints at both ends. Standard cable lengths are 2, 3 and 6 meters. Longer cables are available on request. Refer to Section 9 for inidvidual parts or assembly instructions for making measurement cables.

Normally the length of the cable does not influence the measurement.

Note:

If, however, pressure measurements in the range < 10^{-8} mbar are planned with cables > 25 m, we recommend using a triaxial measurement cable. With it measurement errors due to cable insulation leak currents are eliminated.

Cable lengths up to 500 m are possible with an appropriate adjustment of the control instrument.

8. MAINTENANCE

Contamination of the gauge head, and thus the accuracy of measurement, is greatly dependent on:

- contaminants in the environment such as dust, oil vapors, etc.
- working pressure
- length of operation

Thus the time period until a cleaning becomes necessary can be a matter of days or a matter of months. Instability of the discharge current becomes noticeable through "jumps" in the pressure display. A more experienced eye can also judge the degree of contamination in the measurement chamber.

8.1 Disassembly and cleaning of the gauge head (Fig. 6)

8.1.1. Disconnect cable to gauge head and remove the gauge head from the vacuum system.

2. Remove the cover together with the magnets (3) by turning 90° until the fixation knob rises slightly.
3. Remove the tension ring (7) and the pole insert (6)
4. Remove the four screws (11) using the SW3 hex socket head wrench.
5. Remove the pressure piece (5), the entire anode (2), the spacing and support rings (9, 16, 10) and seal (13).
6. Cleaning: Polish the inside of the measurement chamber (1), the sealing surfaces of the measurement chamber, and the surfaces of the pole insert (6) turned towards the measurement chamber, with a fine emery cloth (grain size 400) or a household cleaning agent (take powdered cleaning agent and make into a paste using hot water, apply with a brush or cloth and rub the parts until they are clean).

   The sealing surfaces may only be rubbed concentrically!
7. The anode pin is to be cleaned in the same way using a paste made from a household cleaning agent, or a fine emery cloth.

   Don't bend the anode, don't treat the ceramic part!

   If deposits cannot be removed, the complete anode is to be replaced.
8. Replacement of the ignition aid (8) after each cleaning is advantageous.
9. Rinse all parts that have been cleaned in alcohol and rub dry with a clean cloth or dry using hot air (hot air blower or oven at 40 °C).

8.2 Reassembly (Fig. 6)

8.2.1. Place the pole insert (6) with tension ring (7) into the measurement chamber and cover with plastic cover (18) to protect sealing surfaces.

2. Place seal (10) with supporting ring (13) in the measurement chamber
3. Push ignition aid (8) onto the anode. There should be 1 – 1.5 mm between the ceramic part and the ignition aid. (also refer to Fig. 7)

8.2.4. Place the complete anode in the measurement chamber. Lay disk (16) on the ceramic part, and the spacing ring (9) in the measurement chamber.

5. Place the pressure piece (5) with recepticle (14) screwed on perpendicularly on the anode.
6. To prevent leaks, the following work must be carried out with particular care:

   Lubricate the four screws (11) with temperature resistant thread lubricant (450 g tube, Order Nr. B 0480 126). Put disks (12) in place and screw in screws by hand. Then tighten the screws evenly on the diagonal in 0.5 Nm (5 cmkg) stages to 3 Nm (30 cmkg) using the hexagonal socket head wrench.
7. Mounting the cover (3, 4): Align the fixation knob on the cover with the grooves in the measurement chamber ber (see Fig. 1) and place the cover on the measurement chamber. Push the fixation knob (4) down and turn by 90°.

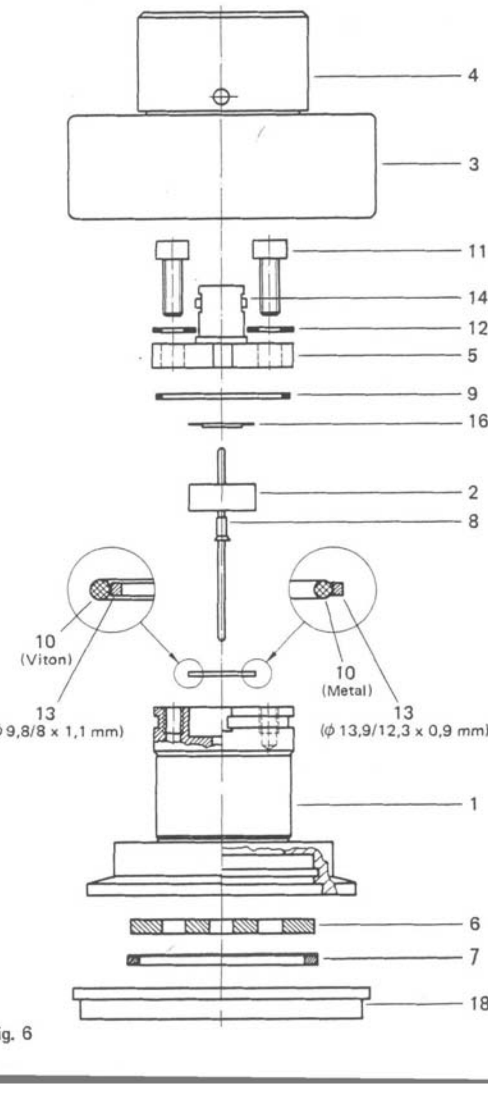


Fig. 6

8.3 Testing the gauge head after cleaning

8.3.1 Make a visual check that the anode pin is lying centrally to the pole insert.If this is not the case (anode pin bent) the anode must be replaced.

2 If arcs occur inside the gauge head between the measurement chamber and the ignition aid (3300 V), the ring gap must be enlarged somewhat with a pair of tweezers (remove cable).

3 Leak test: Permissible leak rate is $\leqslant 10^{-9}$ mbar l/s, with Viton O-ring $< 10^{-8}$ mbar l/s

4. Compare with ionization gauge head as per curve sheet Fig. 5.

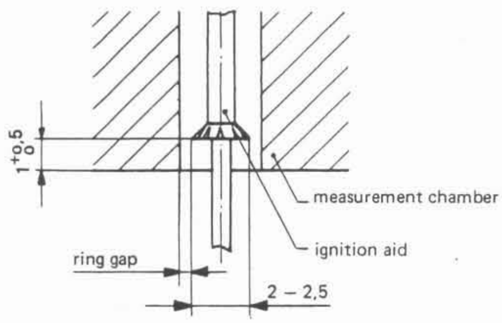


Fig. 7

9. MAKING A GAUGE HEAD CABLE

When making a cable of special length or for repair, proceed as follows:

9.1. Cut off cable sleeve and cable insulation to the dimensions given in Fig. 8.

The conductors must not be damaged. Undo the plaited screening and bend it towards the inner conductor.

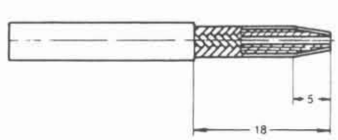


Fig. 8

9.2 Push nipple (31), washer (32), seal (33) and fixing bushing (34) on onto the cable as per Fig. 9. The inner rim of bushing (34) should lie against the cut end of the cable sleeve.

3 Bend the screening outwards and around the fixing bushing (34). Cut it off neatly as shown in Fig. 9.

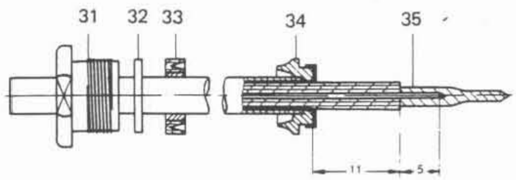


Fig. 9

9.4 Check the protruding length of the dielectric. Apply tin lightly to the inner conductor. Cooling the dielectric with a suitable metal template prevents deformation of the material.

9.5 Carefully solder the inner conductor contact (35) to the cable inner conductor. The space between conductor and contact must be entirely filled with tin. Furthermore, the contact must rest flush against the front face of the dielectric.

Carefully remove excess quantities of tin from the inner conductor contact.

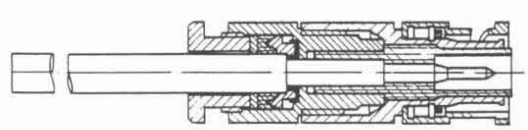


Fig. 10

9.6 Introduce the cable end into the plug body while turning it slightly in both directions. The tip of the inner conductor contact must be brought in the position relative to the plug front as shown in Fig. 10. Push the seal and the washer into the plug and screw the nipple to the housing.

10. ACCESSORIES

Coaxial cable, complete with plug connector, as the connection between the gauge head and the control unit:

2 m long, order nr.	BG 520 401 -T
3 m long, order nr.	BG 520 247 -T
6 m long, order nr.	BG 520 601 -T

IKR 020's with the order numbers BG G12 500 to BG G12 507 are models in which the anode has a gold seal. The following conversion kits allow these anode to be converted to the use of a Viton or copper/Helicoflex (spring supported copper seal) seal.

Conversion:

from gold to Viton 1)	BN 845 500 -T
from gold to copper/Helicoflex 2)	BN 845 504 -T

1) Conversion instructions BG 800 156 BN

2) Conversion instructions BG 800 159 BN

Refer to Balzers "Component Catalog" for control units, assembly and sealing materials.

The various sealing possibilities as well as the sealing materials can be also taken from the operating instructions on the production of flange connections BA 800 001 BE.

11. SPARE PARTS

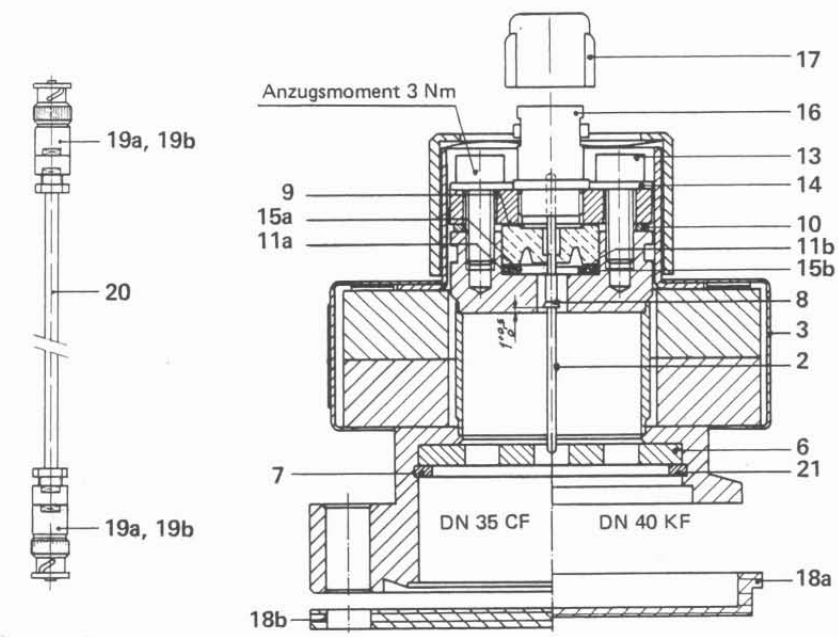
Order spare parts according to the enclosed spare parts list.

When ordering please state type and serial number of the instrument as shown on the nameplate.

Ordering example:

1 anode comp., order nr. BG 510 959 -X, according to spare parts list BG 800 105 E, Item 2.

	Description / Teil	Item / Pos.	Order No. / Bestell-Nr.	S	Reference / Bemerkungen
		1			
1	Anode compl. / Anode kpl.	2	BG 510 959 -X		
1	Cover with permanent magnet / Haube mit Magnet	3	BG 510 997 -X		
		4			
		5			
1	Pole insert / Poleinsatz	6	BG 510 964		
1	Save guard / Sprengring	7	BG 510 965		
1	Igniter / Zündhilfe	8	BG 510 968		
1	Disc / Scheibe	9	BG 510 988		
1	Ring, ϕ 28/25 x 1,05 mm	10a	BG 510 992		Metall
1	Ring, ϕ 28/25 x 1,3 mm	10b	BG 510 989		Viton
1	Centerring ring / Zentrierring, ϕ 13,9/12,3 x 0,9 mm	11a	BG 510 993		Metall
1	Supportring / Stützring, ϕ 9,8/8 x 1,1 mm	11b	BG 510 991		Viton
		12			
4	Screw / Schraube, M4 x 12 mm,	13	N 3059 255 X		
4	Spring disc / Spannscheibe, ϕ 4,3 / 9 x 1,1 mm	14	N 3543 146 Y		
1	Seal / Dichtung HN 100, ϕ 9 / 12,2 x 1,6 mm	15a	B 0140 233		Metall
1	O-Ring, Viton, ϕ 10,82 x 1,78 mm	15b	B 4070 164 PV		Viton
1	Socket / Chassisbuchse	16a	B 4728 459 B9		
1	Socket, rays resistant / Chassisbuchse, strahlungsbeständig	16b	B 4728 458 B9		
1	Cover / Deckel	17	B 4728 907 BA		
	Cover / Schutzdeckel	18a	B 8080 258		DN 40 KF
	Protectiv flange / Transportflansch	18b	BP 414 266		DN 35 CF
2	Plug / Kabelstecker 11 H4 – 50 – 3 – 1	19a	B 4728 401 B9		standard
	Plug, rays resistant / Kabelstecker, strahlungsbe., 10^9 rad	19b	B 4728 408 B9		
	Coaxial cable reys resistant, 10^8 rad / Koax-Kabel, strahlungsbeständig, 10^8 rad	20	B 4582 232 SE		Lenght as required / Länge nach Bedarf
1	Guard ring / Sicherungsring, J37 x 1,5 mm	21	N 3828 624 SV		



Spare Parts for / Ersatzteile zu

IKR 020 — BG G12 510 / BG G12 511 — ab Fabr. Nr.: / from Serial No.: / à partir du no. de fabr.: 4500

BALZERS

BG 800 105 E/2

1.84

Instruction Manual
No. 9-50, Rev. 1

INSTRUCTION MANUAL

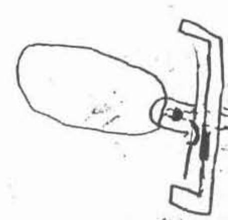
FOR

PENTHERVAC GAUGE

TYPE GPT-450

Products, Inc.

CVC PRODUCTS, INC.
Rochester, N. Y. 14603



1.2 Description of Gauge

The GPT-450 Penthervac is a combination Penning-Thermistor vacuum gauge providing continuous pressure coverage from atmospheric pressure to 2×10^{-8} torr on six overlapping scales. Range changing is fully automatic. When the Thermistor gauge indicates a satisfactorily low pressure (typically 5 millitorr) it will automatically switch the Penning gauge on.

A second Thermistor gauge station and a pressure responsive relay control accessory are available.

Gauge tubes are not damaged by exposure to atmospheric pressure, and the Penning power supply will operate continuously under short circuit conditions without harm.

1.3 Specifications

Pressure Ranges:

Thermistor Section	Range 1 -- 0 to 100 millitorr Range 2 -- 0.1 torr to atmosphere
Penning Section	Range 1 -- 2×10^{-8} to 10×10^{-7} torr Range 2 -- 1×10^{-6} to 10×10^{-6} torr Range 3 -- 1×10^{-5} to 10×10^{-5} torr Range 4 -- 1×10^{-4} to 10×10^{-3} torr

Pressure Sensing Tubes

Thermistor Section	Type GT-034
Penning Section	Type GPH-001 A

Number of Sensing Stations

Thermistor Section	One station standard, second station optional
Penning Section	One station

Tube Cable Lengths	10 feet standard. Longer lengths to 200 feet available
Pressure Responsive Output Signals (for Recorder use)	
Thermistor Section	0 to 2.5 Volts DC
Penning Section	0 to 3 Volts DC
Relay Control Accessory	
Number of control relays	Two (one for each gauge section)
Pressure control range:	
Thermistor Section	0 to 100 torr
Penning Section	approx. 5×10^{-6} to 10×10^{-3} torr
Contact arrangement and rating	S.P.D.T., 2 amps 115 Volts AC or 28 Volts DC non-inductive.
AC Power Input	115 Volts, 60Hz., 18 Watts (230 Volts, 50Hz. available)
Cabinet	Bench or rack mounting; 19" wide x 3-1/2" high x 8" deep
Weight	13 pounds

1.4 Operating Principles

The thermistor section operates as a thermal conductivity type vacuum gauge. Pressure is measured as a function of the heat loss from the sensing element to the gauge tube walls. The sensing element is a tiny thermistor bead which is connected as one arm of a Wheatstone bridge circuit. Bridge current heats the thermistor while the gas within the gauge tube tends to cool it. The resultant changes in thermistor temperature (and resistance) cause varying degrees of unbalance in the bridge circuit. The unbalance current is amplified and read out on the meter which is calibrated in terms of pressure.

2. INSTALLATION

2.1 Installing The Sensing Tubes

Cleanliness is important in vacuum work. Do not remove the protective plastic caps from the gauge tubulations until just before installation into the vacuum system.

Sensing tubes are installed in the system where the pressure is to be measured. Avoid locations where heavy backstreaming of pump fluid vapor or process contaminants will enter the tubes and thus necessitate frequent cleaning.

Vacuum-tight connections can be made using the AC type vacuum connectors listed in Section 6 and shown in Figure 8. If the threaded joint on the tubulation of the thermistor tube is used, threads must be sealed with a low vapor pressure material such as Teflon tape.

2.2 Electrical Connections

Be sure the gauge voltage and frequency, as shown on the name plate, match the power line. Power and sensing tube electrical connections are made by plug-in cables.

NOTE: Do not plug the sensing tube cable for Thermistor station 2 into its socket at the back of the gauge cabinet unless a sensing tube is plugged into this cable. If you plug in the cable only, it will disturb the gauge zero setting.

A coaxial cable is provided with BNC type connectors on both ends. One end plugs into the Penning tube, and the other end plugs into the rear of the gauge.

Because the GPH-001A sensing tube operates at high voltage and may not be in good electrical contact with a grounded vacuum system, install a separate grounding wire to the sensing tube as a safety backup.

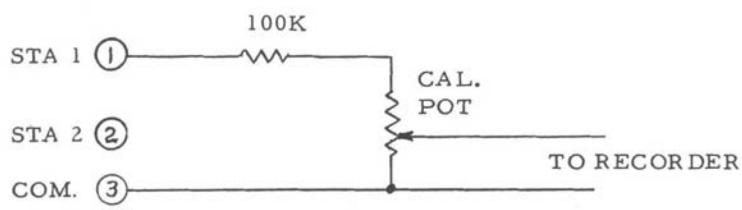
2.3 Recorder Connections

Pressure responsive signal voltages for recorder use are available at the terminal strip for Thermistor gauge stations 1 and 2, and for the Penning gauge. These voltages are not affected by the station selector or range switches. Curves giving the relationship between recorder signal voltages and pressure are shown in Figs. 3 and 4.

Potentiometer R3 provides internal calibration of the Penning gauge recorder signal.

No provision has been made for calibrating or attenuating the Thermistor gauge recorder signals. The wiring diagram and table below provide the necessary information for this purpose when a 10-millivolt, high-impedance recorder is used.

If desired, both station 1 and station 2 can be recorded simultaneously.



	Recording Low Pressure Range	Recording High Pressure Range
Calibrating Potentiometer	3 kilohms	500 ohms

3. OPERATION

After the sensing tubes have been installed and electrical connections made, the gauge is ready for operation.

3.1 Basic Procedure

3.1.1 Press in MAIN POWER and STA. ONE buttons. The .1-750 TORR range light will come on and the Thermistor meter pointer will swing fully to the right. After approximately 20 seconds the meter pointer should swing back on scale and indicate the pressure in the station 1 sensing tube.

3.1.2 As the system pressure decreases, the meter will continue to indicate the pressure on the upper scale. At approximately 0.1 torr, the range will switch to the 1-100 mTORR range.

3.1.3 When the pressure has fallen to approximately 5 millitorr, the Penning gauge may be turned on by pressing in PENN. PWR. button. For automatic turn-on of the Penning gauge, this button can be left in the on (button in) position. The Penning gauge will then automatically be switched on when the pressure at the station 1 Thermistor sensing tube reaches approximately 5 millitorr and be switched off at approximately 10 millitorr.

NOTE: When the Penning gauge is first turned on with the sensing tube at very low pressure (10^{-6} torr or lower), it may take from a few seconds to a few minutes for the tube discharge to ignite. Ignition is usually immediate if the pressure is above 5×10^{-6} torr.

3.1.4 There may be occassions when you will want to turn on the Penning gauge even though the station 1 Thermistor sensing tube is not under vacuum. To accomplish this, unplug the station 1 Thermistor sensing tube and connect a dummy load of approximately 117 ohms across socket pins 1 and 3 of the sensor cord . A suitable plug with resistor is included with the gauge for this purpose.

3.1.5 The Penning gauge meter will indicate the pressure in the GPH-001 sensing tube. Range changing takes place automatically. The pressure range is indicated by the range lights.

3.2 Leak Detect Feature

The sensitivity of the Thermistor gauge circuit is increased greatly when the LEAK DET. button is depressed. At the same time, a zero suppression L. D. ADJ. potentiometer is connected into the bridge circuit to permit bringing the meter on scale when the pressure is between 10 and 500 millitorr. For leak hunting when the pressure is outside these limits, operate the GPT-450 in its normal pressure mode.

To locate a leak, allow the system pressure to stabilize. Then probe the suspected area with a suitable gas and watch the meter for fluctuations. Any gas having a thermal conductivity substantially different from that of air is suitable for probing. Hydrogen or hydrogen-rich gases such as propane, acetylene, and natural gas, will cause up-scale meter deflections.

Acetone, squirted from a fine tipped squirt bottle, can also be used to probe for leaks. However, small leaks may be temporarily plugged by solids carried in with the liquid. Furthermore acetone will attack the plastic meter cover as well as many types of paint and some gasket materials.

> NOTE
>
> ALL OF THE ABOVE MATERIALS ARE INFLAMMABLE.
>
> USE CAUTION.

Argon is also a fairly good probe gas and can be used with complete safety. It causes a down-scale meter deflection.

4. MAINTENANCE

4.1 Cleaning the Sensing Tubes

Inaccurate pressure measurements or zero drift conditions are often caused by pump fluid vapor or other contaminants coating the sensing elements.

4.1.1 Thermistor Tube

Clean the type GT-034 Thermistor sensing tube by rinsing with a strong detergent solution in hot water followed by thorough rinsing with clear hot water and a final rinse with acetone or isopropyl alcohol. Then dry the tube under mild (50° - 75°C) heat.

If cleaning does not restore correct gauge reading, replace the sensing tube with a new one, or readjust the zero per 4.2.1, para. C.

4.1.2 Penning Tube

The type GPH-001A Penning gauge tube will in time become contaminated with residue from the vacuum system. It may be cleaned as follows:

A. Unplug the control circuit power cord and disconnect the tube cord from the tube.

B. Remove the tube from the vacuum system. Although the tube magnet is protected by a blue plastic coating, you should take ordinary precautions to avoid the possibility of demagnetizing.

C. Unscrew the knurled cap-nut and withdraw the anode assembly from the tube casing. Remove or protect the gasket. Protect the gasket sealing surfaces.

D. Remove all carbon and residue from inside the tube casing. If suitable equipment is available, vapor blast (liquid honing) is an excellent method. Otherwise, remove deposits using a wire brush, scraper, or fine abrasive cloth. A special brush (Part No. 60151) is available for this purpose. See Section 6.

Soaking for 5 minutes in a strong sodium hydroxide solution will help to soften tenacious deposits.

CAUTION: Sodium hydroxide will burn skin, eyes and clothing. This solution will also damage the magnet coating. Confine the solution to the inside of the tube casing. If necessary, the magnet may be removed by pressing off with an arbor press. Use non-magnetic tools to avoid altering magnet strength.

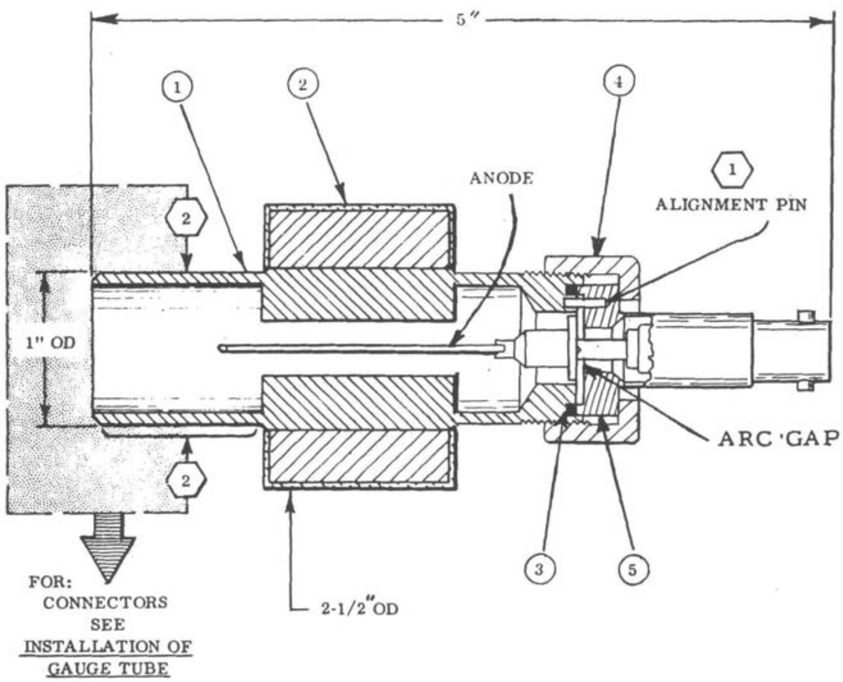
E. Loosen the set screw and remove the anode loop from the rod extending from the center of the high-voltage insulator. Examine the interior of the insulator. If it's dirty, clean it with the vapor blast method or a chemical cleaning solution. Also clean deposits from the anode loop assembly.

F. Wash the parts in clean water and isopropyl alcohol, and dry them under mild heat. Be sure to flush any particulate matter from inside the anode insulator and dry thoroughly.

G. Reassemble the anode loop assembly to the center rod. Note that the loop must be perpendicular to the magnetic field. Maintain an arc gap of 0.010-0.015 inches between the projection of the anode support bushing and the grounded mounting ring. (See Figure 5).

H. Clean the vacuum sealing surfaces and lightly coat the O-ring gasket with high quality vacuum grease.

I. Reassemble the anode assembly to the casing.



CAUTION :
1 ENGAGE ALIGNMENT PIN BEFORE TIGHTENING CAP NUT ITEM NO. 4

2 PROTECT SEAL SURFACE

ITEM NO.	IDENTIFICATION	PART NO.
1	CASING ASSEMBLY	61351
2	MAGNET	66267
3	GASKET	264091-5
4	CAP NUT	60053
5	ANODE ASSEMBLY	282395

FIG. 2 DISCHARGE GAUGE TUBE TYPE GPH-001A

4.2 Calibration

(Refer to Schematic Figure 7, Board Assembly Figure 6, and label on inside of top cover of the gauge.)

In normal use the GPT-450 should not require recalibration. Errors in pressure indication, caused by dirty sensing tubes, should be corrected by cleaning as described in Section 4.1. After long use, or if circuit components have been changed, it may be desirable to recalibrate. Recalibration requires reference gauges of known accuracy and a clean vacuum system with provisions for connecting the reference gauge tube and the tube under calibration. A throttling type high-vacuum valve and a precision metering air inlet valve are needed to control the pressure. The system is normally operated in a near static condition; i.e. with the high-vacuum valve nearly closed and a small flow through the air inlet valve. Gas flow should be well diffused throughout the test chamber by suitable baffling.

4.2.1 Calibration of The Thermistor Gauge

> **CAUTION**
>
> HIGH VOLTAGE IS PRESENT INSIDE THE GAUGE CABINET. WHILE THE THERMISTOR GAUGE OPERATES AT LOW VOLTAGE, LINE VOLTAGE AND PENNING GAUGE VOLTAGES EXIST ON MANY COMPONENTS.

A. Reduce the system pressure to 10^{-4} torr or lower. Turn on the gauge and allow the circuit to stabilize (with cover in place) for approximately 1/2 hour.

B. Remove the chassis cover and check the 10-volt regulated supply, TP 10 (+) to terminal E22 (-), with an accurate DC voltmeter. It should be 10.00 $\pm$ .02 volts. Correct the voltage if necessary by adjusting R33.

C. With a millivoltmeter, measure the voltage across terminal board terminals 1 & 3 (station 1) or 2 & 3 (station 2). This should be 0.00 volts at zero pressure. If this voltage is not zero, remove the cover from the socket which plugs into the Thermistor sensing tube, insert a small screw driver through the center of the socket and down into the key post, and adjust the small potentiometer inside the key post for a millivolt reading as close to zero as possible.

D. The Thermistor gauge meter should now read zero. If it doesn't,adjust R20 for zero meter reading.

E. Raise the pressure in the vacuum system to 100 millitorr. Adjust R43 (station 1) or R41 (station 2) for a meter reading of 100 millitorr. NOTE: The range relay must remain in the 100 millitorr range for this adjustment. If the relay switches before reaching 100 millitorr, turn the range potentiometer R52 clockwise to bring the range relay back to the 100 millitorr range.

F. Increase the pressure to 106 millitorr. Adjust R52 counter-clockwise until the range relay switches to .1-750 TORR range.

G. Increase the pressure to 10 torr. Adjust R44 (station 1) or R42 (station 2) for a gauge reading of 10 torr. NOTE: If preferred, this range can be calibrated at atmospheric pressure (750 torr near sea level)

4.2.2 Calibration of the Penning Gauge

CAUTION:

HIGH VOLTAGES ARE PRESENT IN

THE PENNING GAUGE CIRCUIT.

SERVICING SHOULD BE DONE BY QUALIFIED

PERSONNEL ONLY.

The easiest way to calibrate the Penning gauge circuit is to adjust the calibration potentiometer for each pressure range (R5, R8, R9, R10) to bring the meter into agreement with the Pressure versus tube Current curve, Figure 4. The current can be measured as a function of the voltage appearing at Recorder terminals 8 and 9 on the terminal strip. With the gauge turned off, the resistance across terminals 8 and 9 can be adjusted with R3 to some known value, eg. 1000 ohms. For this resistance value, one volt across 8 and 9 equals 1 milliamp of tube current.

If an adjustable voltage DC power supply is available, the above calibration procedure can be performed without a vacuum system or use of the high voltage circuitry. To do this, turn the power off and disconnect the T1 primary leads at taper pin terminals E3 and E4. Then connect the adjustable 0-20V power supply to Terminal Strip 8 (+) and E22 (-).

Turn on the gauge power and then energize the 0-20V Supply. If Thermistor station 1 is not under vacuum, it will be necessary to plug in the Dummy Load (Section 1. 1, item 7 and Section 3. 1. 4) in order to energize the Penning Circuit.

After gauge power is on, turn on the 0-20V power supply. Adjust for desired full scale current on each pressure range as determined from Figure 7 and calibrate the Penning gauge meter by adjusting the appropriate calibration pot.

Turn off the 0-20V power supply before turning off gauge power. NOTE: Gauge power must be on before signal voltage is applied to the amplifier input terminals to avoid reverse biasing of the input diodes.

Reconnect T1 primary leads.

The above calibration procedure will correct any normal circuit mis-adjustments. It does not cover variations in the high voltage power supply or the sensing tube. When a suitable vacuum system and reference gauge are available, actual pressure calibrations can be carried out as follows:

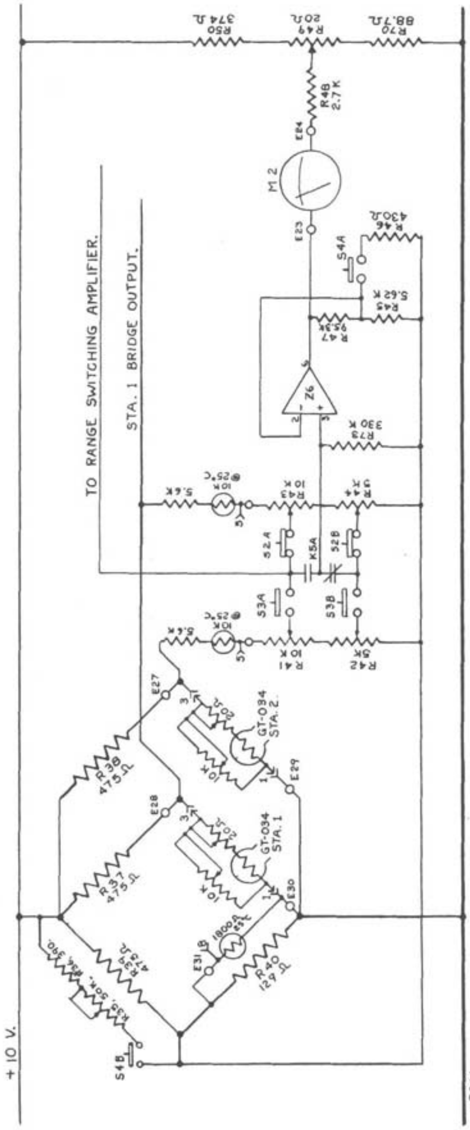


FIGURE 7

A. Install the GPH-001A Penning sensing tube in the vacuum system and reduce the pressure as low as possible.

B. Turn on the Penning gauge and allow it to operate for 1/2 hour or more. The base pressure of the vacuum system should be approximately one decade lower than the lowest pressure at which you will be calibrating the gauge. For example, if the 10^{-7} range is to be calibrated, the base pressure should be low in the 10^{-7} torr range.

C. Raise the pressure to 10×10^{-7} Torr. Be sure the range switch holds the gauge in the 10^{-7} range. (If necessary adjust range pot R17). Adjust R5 for a meter reading of 10×10^{-7} torr.

D. Repeat the procedure for 10^{-6} and 10^{-5} ranges. The 10^{-4} range should be calibrated at 1×10^{-3} torr rather than at full scale.

E. Adjust the range switching relay pots R17, R21, R22 as needed to obtain range switching at the proper point on each range.

4.3 Circuit Description

4.3.1 Thermistor Gauge Section

AC power is brought to the circuit through step-down transformer T2, full wave rectified by CR15, and regulated by 12-volt regulator VR2. Diodes CR16 and CR17 raise the regulated voltage to approximately 13.2 volts. This voltage is used to power all amplifiers and relays.

The 13.2 volts is further regulated and reduced to 10.00 volts by Q5 series pass transistor working in conjunction with VR1, Q6, and voltage adjustment network R32, R33, R34.

The 10.00 volt output is applied to station 1 bridge network R39, R40, station 1 Sensing tube, and R37. The 1800 ohm thermistor (located in the tube cable socket cap) compensates for effects of ambient temperature on the sensor at zero pressure. The shunt and series resistors in the sensor arm are for pre-calibrating each GT-034 sensing tube so the tubes can be interchanged in the field without the need for further adjustment of the gauge. These resistors are located inside the base of the GT-034 sensing tube.

Station 2 bridge consists of R39, R40, Station 2 Sensor and R38. Both bridges are continuously energized regardless of the position of the station selector switches. Bridge outputs are connected across calibration networks R43, R44, and R41, R42. The 5.6K and 10K resistors (located in the tube cable socket cap) are for temperature compensation at atmospheric pressure.

Station selector switches S2 and S3 are mechanically interlocked and serve to direct the selected bridge output to voltage follower amplifier Z6 which drives the Thermistor gauge meter. This amplifier has a voltage gain of approximately 20. Network R50, R49, R70 provides a nulling voltage for setting the meter to zero, at zero pressure.

Station 1 bridge output is also used as the signal voltage for Penning power control relay system Z8, K6 and, when used, the Pressure Responsive Relay Control Accessory system Z9, K7. The signal voltage for the Thermistor range switching system Z7, K5, is selected from the station being read out on the meter. Reference voltage inputs for all of the relay systems are obtained from resistor networks connected across the 10.00 volt supply.

The Leak Detect function is activated by closing push-button switch S4. Contacts S4A change the feedback ratio on Z6 increasing its gain to approximately 360. Contacts S4B connect the L. D. Adjust potentiometer into the bridge circuit allowing the bridge to be balanced (on-scale meter reading) even at relatively high pressures. Contacts S4C raise the reference voltage on Z7 range change amplifier, thereby holding the range relay in the sensitive low pressure range.

Amplifiers Z7, Z8, Z9 are provided with negative feedback capacitors to reduce response to transient "spikes" and noise signals. Positive feedback resistors R54, R59, R64, provide a degree of hysteresis, or differential between relay pull-in and drop-out. All relays are shunted by diodes to absorb the inductive "kick" when de-energized.

Signal polarity on the relay amplifiers is such that the relays pull-in on decreasing pressure.

4. 3. 2 Penning Gauge Section

AC power is brought to the self-regulating high voltage transformer T1 via Main Power switch S1, Penning Power switch S5, and Penning Power Control relay contacts K6B. T1 secondary delivers approximately 1320 volts RMS to the voltage doubler rectifier circuit CR1, CR2, C1, C2, resulting in an open circuit DC output of approximately 3000 volts. Resistors R1 and R71 are current limiting resistors and R2 serves to bleed the charge off capacitors C1 and C2 when the gauge is turned off.

Positive (+) high voltage is applied to the anode of the GPH-001 Penning sensing tube. The cathode returns to DC negative via the recorder potentiometer R3 and the string of calibrating resistors. Diode strings CR3 thru CR7 and CR8 thru CR10 shunt portions of the calibration network. Their function is to limit the voltage drop across the 10^{-7} and 10^{-6} calibrating resistors when the tube current is high, and allow these resistors to operate substantially unshunted when the tube current is low. Without this protection, excessive voltage would be applied to the input of the amplifiers Z2 and Z3 at high pressure.

The Penning pressure meter is connected to the appropriate calibration potentiometer via the network of range changing relay contacts K1, K2 and K3 and voltage follower amplifier Z1. This amplifier has a voltage gain of approximately 3.

The Range Changing and Process Control relay circuits operate in a manner similar to that described for the Thermistor gauge section.

4.4 Trouble Shooting Chart

SYMPTOM	POSSIBLE CAUSE	REMEDY
1. Thermistor meter remains at full up-scale regardless of pressure	1. Sensing tube defective (open circuit)	1. Replace with new GT-034 tube
	2. Tube cable open	2. Check cable wires and socket contacts for continuity
	3. Bridge voltage incorrect	3. Check and readjust per sect. 4.2.
2. Thermistor meter remains at full down-scale position regardless of pressure	1. Amplifier Z6 defective	1. Replace Z6
	2. Sensing tube or cable shorted.	2. Check for short circuits across the red (pin 1) and white (pin 3) wires
	3. Leak Detect button is depressed	3. Release L.D. button. See operating instructions.
3. Thermistor meter shows no response	1. Meter defective	1. Replace meter
	2. Neither STA.ONE or STA. TWO button is depressed	2. Press button to select desired station
	3. Open drcuit in K5A relay contacts or S2 or S3 switch contacts	3. Check relay and switch contacts for continuity. Clean contacts if necessary.
4. Thermistor Automatic range switch does not function	1. Defective amplifier Z7, or relay driver transistor Q7.	1. Replace as required
	2. Open relay coil	2. Replace K5
	3. Dirty relay contacts	3. Clean contacts with alcohol. Polish surfaces with lint-free paper.

SYMPTOM	POSSIBLE CAUSE	REMEDY
5. Thermistor process control relay does operate	1. Accessory card not seated properly in edge connector	1. Position card properly
	2. Defective amplifier Z9 or transistor Q9	2. Replace as required
	3. Open relay coil or dirty relay contacts	3. Replace relay K7 or clean contacts.
6. Penning gauge power will not come on when PENN. PWR. button is pressed.	1. Thermistor gauge indicates pressure is too high for Penning gauge	1. Pump system to lower pressure
	2. Trip level of Penning control relay improperly set.	2. Adjust R57.
	3. Thermistor station 1 sensing tube not under vacuum.	3. Use dummy sensor load resistor. See Sect. 3.1.4
7. Little or no pressure reading on Penning meter	1. No high voltage present at Penning sensing tube	1. Open winding in transformer T1. Shorted rectifier CR1 or CR2, or capacitor C1 or C2. Replace defective component.
	2. Broken conductor in tube cable.	2. Repair as necessary
	3. Defective amplifier Z1	3. Replace Z1
	4. Sensing tube has not ignited (may occur if tube remains de-energized at very low pressure for an extended time).	4. Allow power to remain on for a few minutes. See sect. 3.1.3.

5. REPLACEMENT PARTS LIST

MINIMUM ORDER BILLING OF $30.00 PER ORDER. PLEASE INCLUDE PART NUMBER AND DESCRIPTION OF EACH PART ORDERED.

5.1 Printed Circuit Board Components - See P.C.B. Ass'y Dwg. 279962, Sh. 2

		Part Number
5.2	Main Chassis Components	
	Meter -Penning (M1)	279964
	Meter-Thermistor (M2)	279965
	Light-Pilot Neon(DS1-DS6)	279697-2
	Transformer (w/capacitor C21)	280039-60

5.3 Miscellaneous Parts

Thermistor Sensing Tube, Type GT-034		277289
Thermistor Tube Cable	Station 1	Station 2
10 ft. length (Standard)	280072-1	280073-1
15 ft. length	280072-2	280073-2
25 ft. length	280072-3	280073-3
50 ft. length	280072-4	280073-4
100 ft. length	280072-5	280073-5
Penning Sensing Tube, Type GPH-001A		282396
Penning Tube Parts		
Anode Assembly		282395
Gasket, O-Ring (Viton)		264091-5
Magnet		66267
Penning Tube Cable		
10 ft. length (Standard)		282394-1
15 ft. length		282394-2
25 ft. length		282394-3
50 ft. length		282394-4
100 ft. length		282394-5
200 ft. length		282394-6
Line Cord - 3 Wire grounding		5506953

6. ACCESSORIES

MINIMUM ORDER BILLING OF $40.00 PER ORDER. PLEASE INCLUDE PART NUMBER AND DESCRIPTION OF EACH PART ORDERED.

	Description		Part Number
6.1	Vacuum Fittings (See Fig. 8)		
	CGB Type Vacuum Connector, less bushing		61083
	Bushing for CGB Connector, 3/8" I. D.		61081-2
	AC Type Vacuum Connector with 3/8" O-Ring		
	for Thermistor Tube	Stn. Steel	268891-5
		Brass	268891-1
	AC Type Vacuum Connector with 1" O-Ring		
	for Penning Tube	Stn. Steel	268891-8
		Brass	268891-4
6.2	Miscellaneous		
	Wire Brush for cleaning Penning Tube		60151
	Penning Sensing Tube with 1" dia Pyrex Glass Tubulation, Type GPH-005		272093
	Relay Control Accessory Kit		280046
	Vacuum Grease, Celvacene Medium, 4 oz.		269352-11
	Leak Sealant-Celvaseal Silicone, Brush Bottle		271375
	Leak Sealant-Celvaseal Silicone, Spray Can		271373
	Silicone Rubber Sealant, 3 oz. Tube		0412-1129