QUANTAR TECHNOLOGY

3300 SERIES
OPEN-FACE MCP/RAE SENSORS

INSTALLATION AND MAINTENANCE MANUAL

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LIMITED WARRANTY

Quantar Technology products are warranted against defects in material and workmanship for a period of one year from the date of shipment. During the warranty period, Quantar Technology will, at our option, repair, replace or refund the purchase price of products which prove to be defective. For warranty service or repair, this product must be returned to Quantar Technology.

For products returned to Quantar Technology for warranty service, Buyer shall prepay shipping charges to Quantar Technology and Quantar Technology shall pay shipping charge to return the product to Buyer. However, Buyer shall pay all shipping charges, duties, customs clearance charges and taxes for products returned to Quantar Technology from another country.

LIMITATION OF WARRANTY

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by Buyer, Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

Special Notes regarding MCP's and products containing MCP's (microchannel-plate electron multipliers): Warranty does not cover damage to MCP's caused by warpage or cracking due to improper storage, shock, vibration, contamination or improper handling. Users are cautioned that MCP's are sensitive to water vapor absorption and may warp and crack if stored outside of clean vacuum systems for extended periods.

For sealed-tube detectors, warranty does not cover damage resulting from exposure to excessive input radiation levels, thermal shock, exposure to temperatures below 35° C or above 45° C operating or non-operating, excessively rapid rates of change of temperature, mechanical shock or excessive high voltage applied to tube.

NO OTHER WARRANTY IS EXPRESSED OR IMPLIED. WE SPECIFICALLY DISCLAIM IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

EXCLUSIVE REMEDIES

THE REMEDIES PROVIDED HEREIN ARE BUYER'S SOLE AND EXCLUSIVE REMEDIES. NEITHER QUANTAR TECHNOLOGY NOR ANY OF ITS EMPLOYEES SHALL BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES ARISING OUT OF USE OF ITS PRODUCTS, WHETHER BASED ON CONTRACT, TORT OR ANY OTHER LEGAL THEORY, EVEN IF QUANTAR TECHNOLOGY HAS BEEN ADVISED IN ADVANCE OF THE POSSIBILITY OF SUCH DAMAGES.

SUCH EXCLUDED LOSSES SHALL INCLUDE, BUT ARE NOT LIMITED TO: COSTS OF REMOVAL AND INSTALLATION, LOSSES SUSTAINED AS THE RESULT OF INJURY TO ANY PERSON, OR DAMAGE TO PROPERTY.

Figure 1.0: Model 3390A 25 mm Open-Face MCP/RAE Sensor, Photo

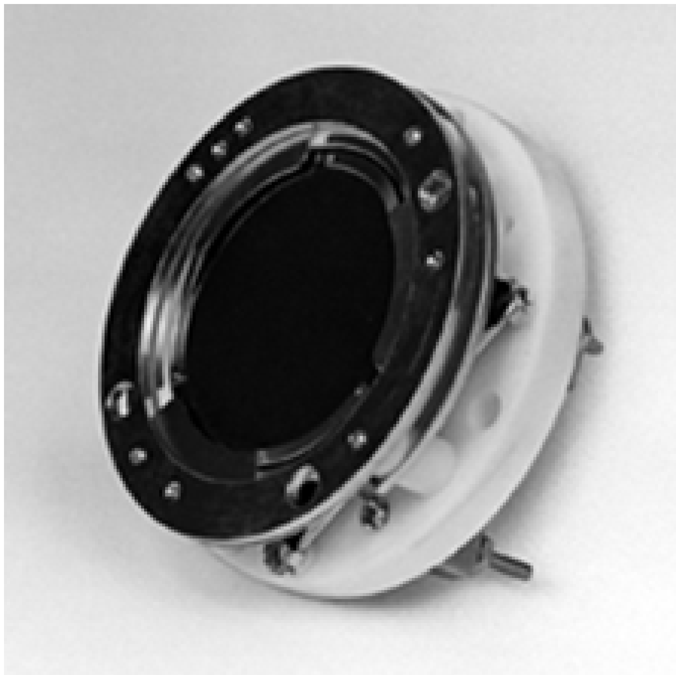
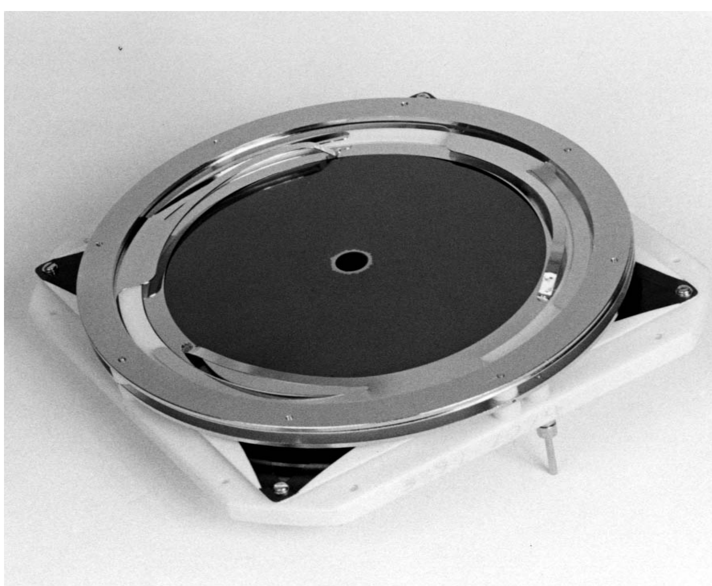


Figure 1.0A: Model 3392A 75 mm Open-Face Sensor Head w/option SK, 6mm center hole, Photo



SECTION 1. GENERAL DESCRIPTION

1.0 SCOPE OF THIS MANUAL

This Installation and Maintenance Manual provides information regarding the installation and limited maintenance of Series 3300 Open-Face MCP/RAE Sensors. For information regarding electrical installation, HV biasing, turn-on, operation and diagnostics, consult the Series 3300/2400 System Installation and Operation Manual and the Model 2401A/B or Model 2502A Position Analyzer Installation and Maintenance Manual, which provide detailed information pertinent to MCP/RAE position-sensitive detector system set-up, configuration, operation, electronic adjustments and electronics corrective maintenance. Options are discussed in this Manual.

Manual Update Inserts may be provided that update specific information contained in this manual regarding manual errors and design changes.

1.1 GENERAL DESCRIPTION

The Series 3300 MCP/RAE Sensors are electron-optical devices which convert an incoming charged particle, neutral particle or energetic photon to four charge signals proportional to the spatial position of incidence.

These devices consist of a resistive anode (charge-division) position encoder (RAE), 2 or more wafer-type, microchannel-plate electron multipliers (MCPs), and integral anode bias and signal decoupling circuits. These components are mounted in a bakeable, UHV-compatible, alumina-ceramic and gold-plated stainless-steel holder assembly. These devices must be operated in clean vacuum environments with pressures lower than 10^{-6} torr.

Signal processing and spatial position decoding of the four low-level output signals from these sensors is provided by the Quantar Technology 2300 (e.g. 2391), 2400 (e.g. 2401) and 2500 Series (e.g. Model 2502A) Position Analyzers (Computers) and data collection and display systems.

The sensor is designed for detection of charged and neutral atomic and molecular particles (electrons, positive particles and positive and negative ions) and energetic photons (X-rays, extreme UV and vacuum UV). Detection efficiency depends primarily on the conversion efficiency of the first MCP surface for the particle type, angle of incidence and incident energy involved in the specific application, and can range from less than 1 percent to more than 80% depending on these variables. The user is referred to the many references available in the scientific literature which discuss this topic in detail.

The microchannel plates are supported above the resistive anode encoder (RAE) by gold-plated stainless steel rings, and held in place by spring-loaded 3-point contacts. All bias and signal connections are made to pins on the underside of the ceramic baseplate. Signal leads are capacitively de-coupled, so the detector can be biased with respect to ground. A typical model is shown in Figure 1.0 &1.0a. The mechanical configuration is illustrated in Figures 1.1 and 1.2, Dimensioned Mechanical View, showing mechanical dimensions and identifying major components.

1.2 THEORY OF OPERATION

In operation, incident particles and energetic photons strike the front surface of the first MCP, resulting in secondary electron production from the wall of one or more microchannels. Under the influence of the applied electric field, electron avalanche occurs. The resulting charge cloud emanating from the last MCP travels in a uniform electric field and is deposited on the resistive anode encoder (RAE). This charge packet then diffuses in the uniform resistive sheet surface of the RAE toward collection electrodes located on the periphery of the RAE and the charge is conducted to four metallic contacts located at the four corners of the anode. The relative charge reaching each of the four corner contacts is a linear function of the position along the X and Y orthogonal axis of the RAE, and thus the position can be decoded by arithmetic processing.

The size of the charge packet deposited on the RAE in response to a single incoming event depends on the gain of the multi-MCP stack preceding the RAE. The typical electron gain of a 2 MCP stack is 5×10^{6}, and the gain of a 5 MCP stack is 5×10^{7}. Given that the resistive noise (Johnson noise) produced by the resistive nature of the RAE is fixed and the preamplifier noise is fixed for a given design, the gain determines the S/N ratio and thus the spatial resolution "blur" (event-to-event variation in calculated spatial position). In other words, each time a position calculation is performed, a finite amount of random-amplitude noise is superimposed on each variable term. The percentage this noise represents of the total value of the term, and thus the "jitter" in the successively calculated spatial positions, is determined by the magnitude of the variables themselves, the magnitude of the noise and additional accuracy factors.

Consult the 3300/2400 System Installation and Operation Manual and the Installation and Operation Manual for the Series 2400 Position Analyzers for additional information concerning the principles of operation and complete detector system operation and maintenance.

1.3 SPECIFICATIONS

MODELS AND SPECIFICATIONS

Model Number	Active Diameter	Number of MCP's	Fractional Spatial Resolution*	Microns, Spatial Resolution
3390A	25 mm	2	1/100	250
3391A/010	25 mm	3	1/400	62.5
3391A	25 mm	5	1/400	62.5
3392A	75 mm	2	1/100	750
3394A	40 mm	2	1/100	400
3395A/010	40 mm	3	1/400	100
3395A	40 mm	5	1/400	100

*Spatial Resolution is specified in terms of fractional part of active area diameter and is FWHM of point-spread "blur" function formed by histogrammed distribution of electronically-reported spatial positions of large number of individual events (integrated for a sufficient period of time) imaged at same physical position (theoretically infinitely narrow) on detector.

Typical Background Count Rate: at 10^{-6} torr pressure (sea level):	5-10 counts per sec (25mm and 40mm) 100-125 counts per sec (75 mm) (background counts at higher altitudes may be slightly higher due to higher rate of cosmic rays)
Maximum Bakeout Temperature:	200 degrees C without Teflon lead set 150 degrees C with Teflon lead set
Decoupling capacitor voltage rating:	5000 V DC maximum.
Net Weight:	Models 3390A, 3391A (25 mm): 3.5 oz (100 grams) Models 3394A, 3395A (40 mm): 6.2 oz (180 grams)
Shipping Weight:	Approximately 5 lbs (2.27 kg)
Mechanical Dimensions:	25 mm: see drawing in this Manual 40 mm: see drawing in this Manual

Figure 1.1: Dimensioned Mechanical View, 25 mm Sensor

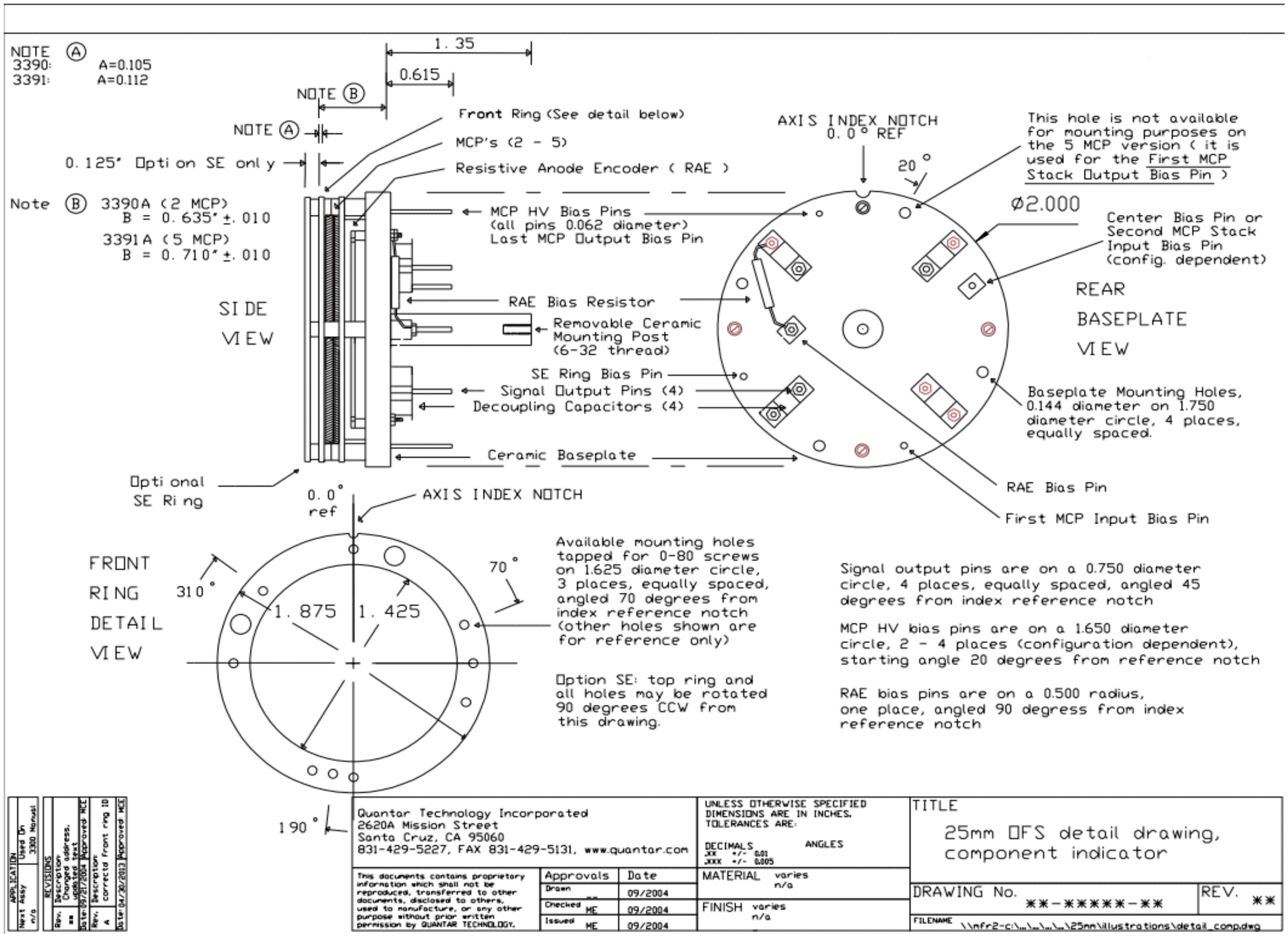
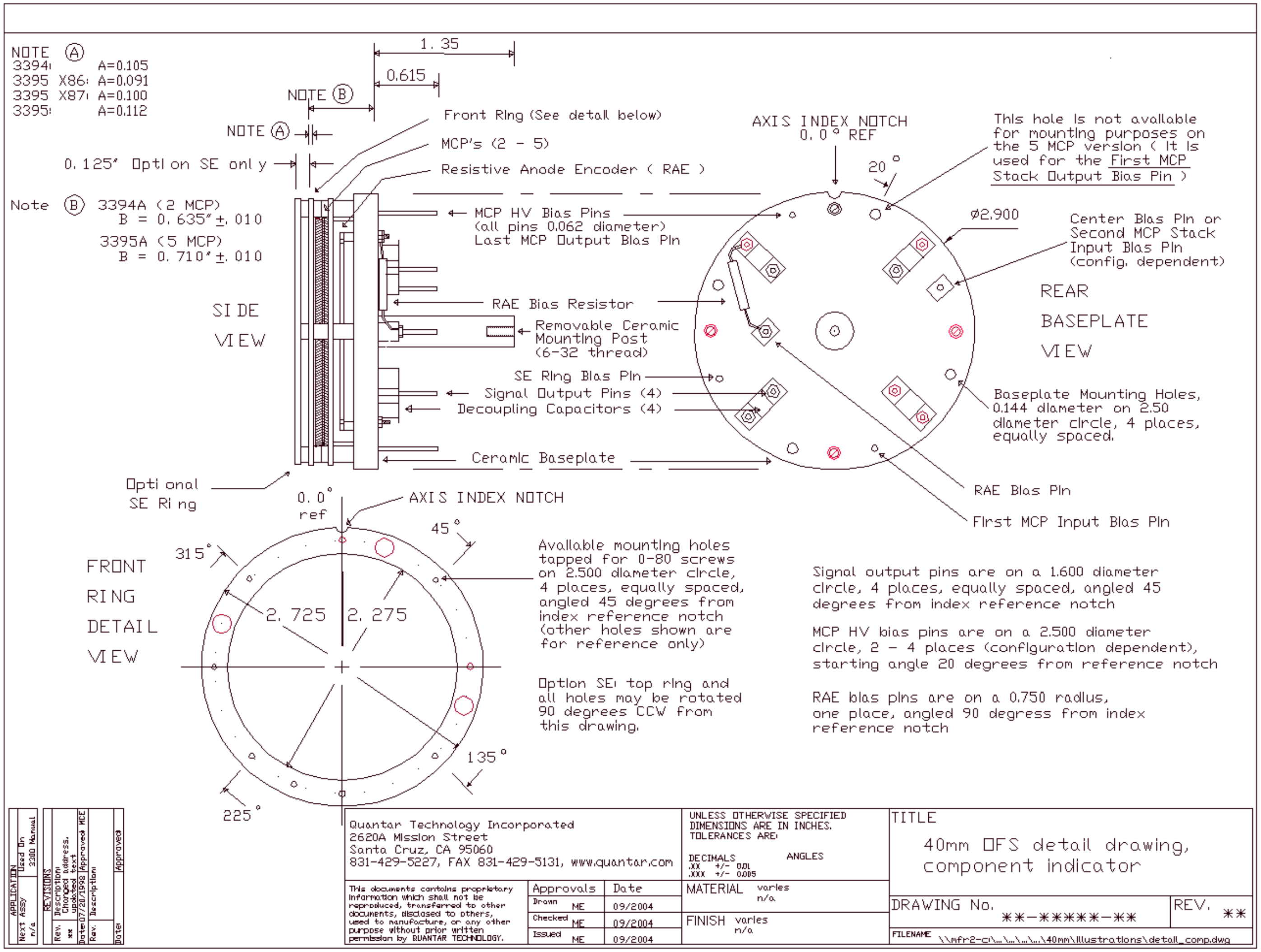


Figure 1.2: Dimensioned Mechanical View, 40 mm Sensor



1.4 OPTIONS AVAILABLE

OPTION SE: ADD ELECTRICALLY-ISOLATED FRONT MOUNTING RING

This option adds an additional, electrically-isolated metal ring in front of the first MCP of the standard models. This added ring can be electrically biased independently of the other sections of the sensor and is typically used to mount and bias an electron-optical lens, a transmission grid for repelling or accelerating charged particles to be imaged or to mount the sensor to a surface which is at an electrically different potential than the front section of the sensor (the front surface of the sensor is normally at the potential of the first MCP). (See Biasing section).

In mounting a lens or grid on this ring, it is preferable to use screws (0-80) or use an additional hold-down ring to clamp the grid in place. Complete removal of this optional ring for mounting of grids using spot-welding techniques requires some disassembly of the sensor since the optional SE ring is held in place by the same screws that hold the entire detector assembly together. In removing this ring, therefore, use extreme care to avoid allowing the remaining sensor assembly to come completely apart. See Section 2.1.1 for more information on grid installation.

The optional ring can be electrically biased by connection from the contact pin on the rear of the ceramic baseplate.

OPTION SK: ADD 6 MM DIAMETER HOLE IN CENTER OF SENSOR

This option provides a 6 mm circular hole directly through the center of the sensor, including the ceramic baseplate, RAE and MCP's. The typical purpose of this option is to enable an incident beam to travel through the sensor, on axis, in applications such as LEED (low-energy electron diffraction) and related techniques.

Although techniques are utilized to minimize image distortion caused by the presence of the center hole, some residual distortion in the immediate vicinity of the center hole (extending to about 4 mm from the edge of the hole) should be expected. Higher background count rates than with standard MCP's should also be expected, particularly around the center hole but also around the MCP edges due to the fact that MCP's with center holes typically do not have solid outer rims, leading to higher background count rates.

Care must be exercised with this option to avoid allowing any device inserted into this hole (e.g. electron gun) from physically contacting the MCP's or RAE. Guard rings on a gun assembly may be beneficial in the region between MCP's and the RAE to minimize field distortion.

OPTION SH: RAE COMPATIBLE WITH 2500 SERIES POSITION ANALYZERS (n/a as of 12/2009).

This option provides for a shorter-time constant, lower-resistance RAE in place of the standard RAE. All other aspects of the MCP/RAE sensor are standard. This option is offered in a 2 MCP configuration.

The shorter-time constant (10x) RAE is necessary to be compatible with the shaping time of the preamplifiers in the Quantar Technology 2500 Series Position Analyzers, which exhibit an electronic counting dead-time of 400 ns, 10x shorter than the 2400 Series Position Analyzers and exhibit a maximum practical counting rate of approximately 1 MHz.

OPTION SM: HOT TYPE MCP's IN PLACE OF STANDARD (generally not applicable as of 2010; MCPs now standardly used in all detectors have a higher bias-current).

In some cases, special high bias-current MCP's are used to support the higher counting rates encountered in applications with Option SH.

SECTION 2. MECHANICAL INSTALLATION

2.0 UNPACKING SENSOR

CAUTION

MCP's are highly hygroscopic and can warp, crack and thereby be permanently damaged by exposure to atmospheric humidity and water vapor. It is essential that MCP's be exposed to such conditions for an absolute minimum of time. While it is not possible to give exact safe time durations due to variations in conditions, exposure over periods of several hours in most conditions should be acceptable. Exposures exceeding a single day pose substantial risk. If exposure is expected to exceed one day, the sensor should be stored under clean vacuum. **STORE MCP DETECTORS UNDER DRY, UHV VACUUM CONDITIONS ONLY.**

FAILURE CAUSED BY WARPAGE, CRACKING OR CONTAMINATION IS NOT COVERED BY THE TERMS OF THE PRODUCT WARRANTY.

This type of sensor is extremely fragile and can be easily damaged by mechanical shock or by contamination by particulate matter (dust) or other contaminants incompatible with vacuum operation at high voltage (e.g. finger oils, pump oils, etc).

The sensor is shipped in a special vacuum evacuated, sealed container to protect the sensor from particulate contamination and especially to provide a vacuum environment with very low water vapor content. It is important to open this shipping container as soon as possible upon receipt in a dust-free cleanroom or Class 100 laminar-flow clean-bench environment and inspect the sensor for any shipping damage. Wear clean-room type gloves in handling the sensor. Open the valve on the shipping container slowly to avoid shock to delicate components.

After inspection, the sensor should immediately be installed into a dry, clean, oil-free UHV vacuum chamber operating at vacuum pressures better than 10^{-6} torr. The sensor must NOT be left for periods exceeding several hours (maximum) in a non-vacuum environment where water vapor may be present. If this caution is not observed, adsorption of water vapor may result in MCP warpage and eventual cracking, which permanently damages the MCP.

Do not allow any object to contact the active surface of the MCP. If any dust or other particles collect on the surface, carefully blow them off using a filtered nitrogen flow or ionized air gun operated at very low pressure, or remove them using a charged hair. Particulate contamination (dust) can cause emission points (hot spots) on the operating MCP.

NOTE
After installation, please return the special reusable shipping container to:

Quantar Technology Inc.
2620A Mission Street
Santa Cruz, CA 95060

2.1 SENSOR ASSEMBLY MOUNTING

The detector assembly can be mounted from either the rear ceramic baseplate or from the front mounting ring.

To mount from the rear baseplate, use the clearance holes (0.140 inch, 3.6 mm diameter) provided in the baseplate for mounting the sensor on machined support posts or tabs from the rear (e.g. from a vacuum flange). See Figures 2.1, 2.2 (25mm) and 2.3 (40mm). Since the ceramic baseplate is electrically isolated from all electrodes, supporting hardware can be maintained at another potential with respect to the detector.

To mount from the front surface, 0-80 size screws can be used to mount to the front ring which has several 0-80 threaded holes. Be certain that the screws are not excessively long, such that they could electrically short the front and rear rings, resulting in arcing and improper operation.

If mounted from the front ring, be certain the surface to which the sensor is to be mounted will be at the same electrical potential as the front ring, which is at the potential of the front MCP. Whether the front surface of the sensor is operated at ground potential or a high negative potential depends on the biasing arrangement chosen by the user based on the application details.

If the sensor is equipped with option SE, Electrically-Isolated Front Ring, the sensor can be supported from this additional ring in the manner described above, and the ring can be maintained at any desired potential within 2 KV of the input electrode voltage.

The sensor can be mounted on a standard Conflat-type, copper or O-ring gasket, rotatable-type vacuum flange (rotatable types are usually, but not always, preferred to enable alignment of the detector coordinate axes with other apparatus). A 4-1/2 inch size Conflat-type (CFF) flange is generally the smallest size flange that can be used for mounting the 25 mm size sensors and the 4-5/8 inch size Conflat-type the smallest for the 40 mm size sensors. An 8-inch diameter Conflat-type flange is required for the Model 3392A 75 mm MCP/RAE Sensor.

Figure 2.1: Suggested Sensor Mounting Methods

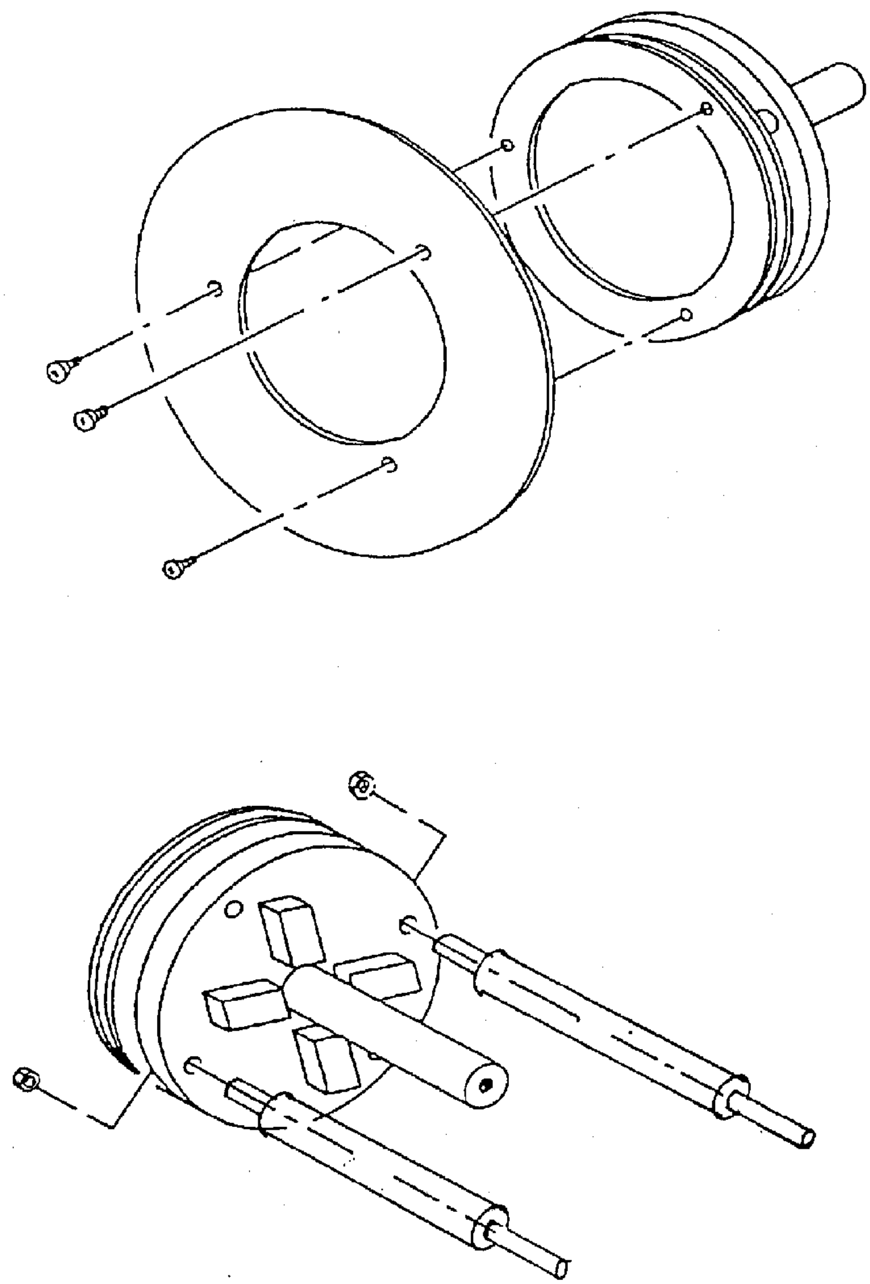


Figure 2.2: Mounting Hole Locations, 25 mm, Models 3390, 3391

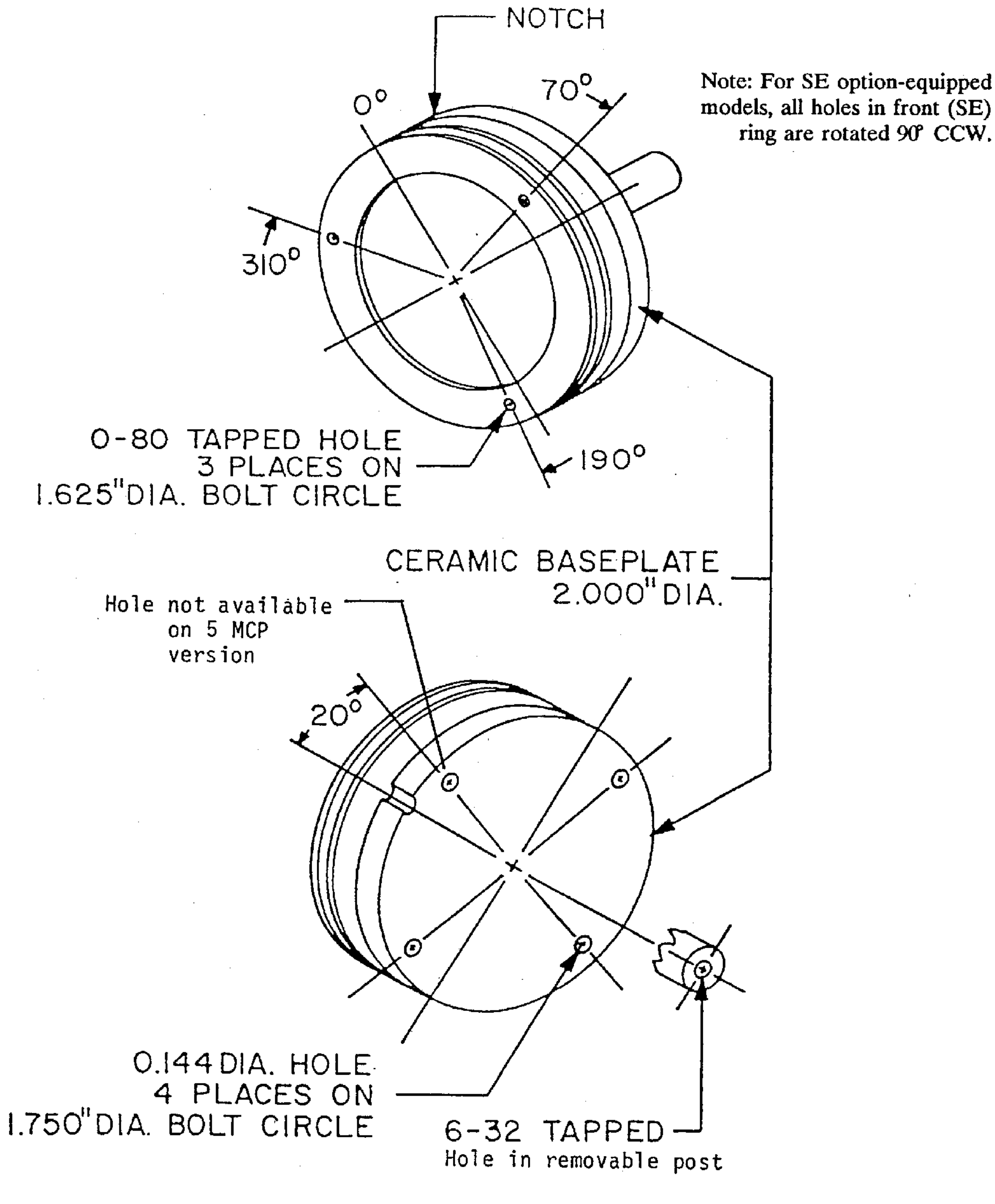
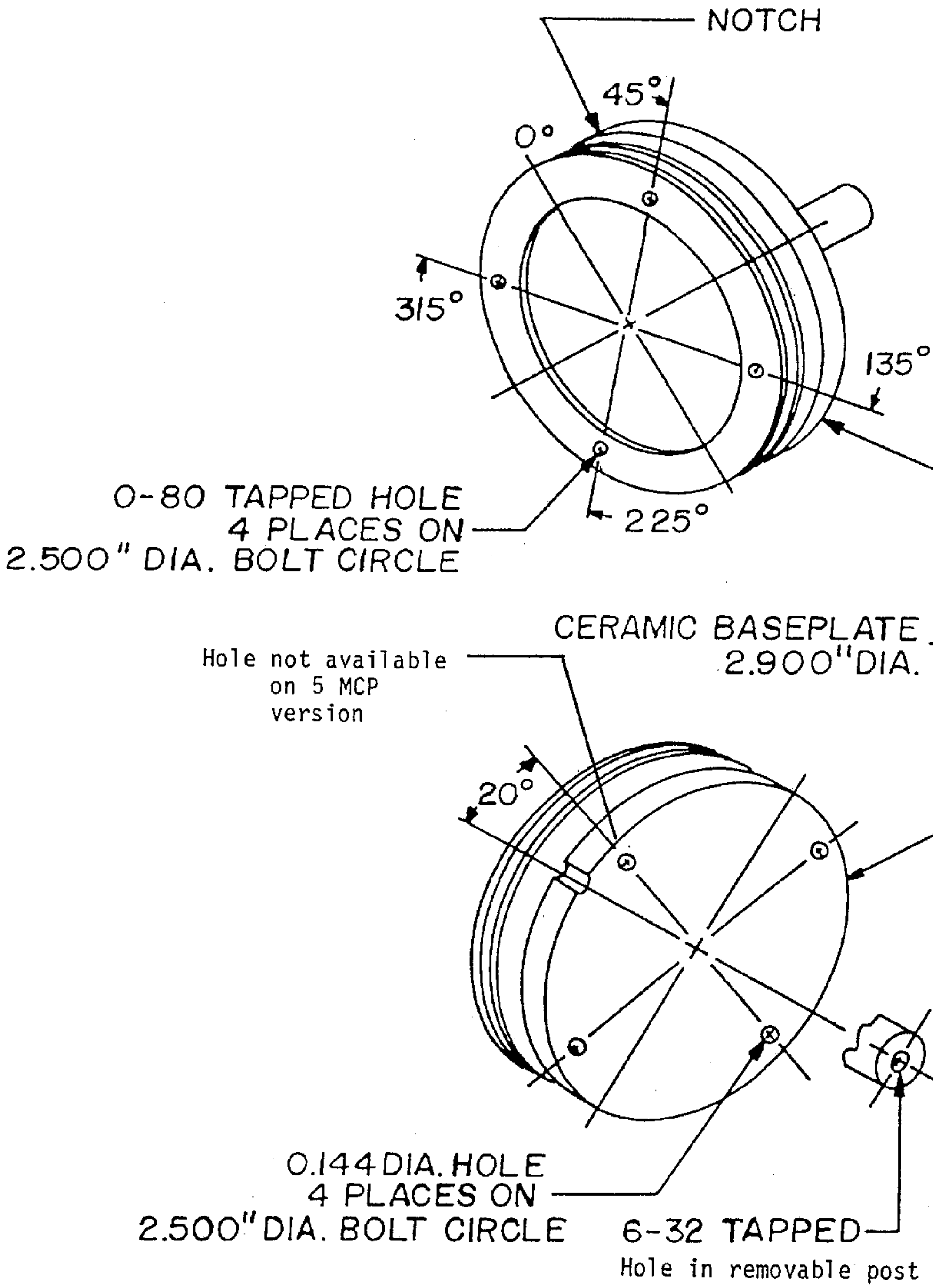


Figure 2.3: Mounting Hole Locations, 40 mm, Models 3394, 3395



2.1.1 INSTALLATION OF METAL GRIDS ON SENSORS

In some applications, it is desirable to use an electrically-biased, conductive, high-transmission grid in front of the MCP sensor to either accelerate charged particles arriving at the sensor surface or attract reflected charged particles from the MCP surface.

A source of etched grid material is Buckbee-Mears Company which offers a wide variety of mesh types in terms of materials, mesh densities, open area ratios, etc. They normally have minimum order quantities.

Buckbee-Mears Micro Products Division
245 E. 6th Street
St. Paul, MN 55101
612-228-6400

A source of woven-type mesh grid is Howard Wire Cloth. Woven mesh is not as flat as etched mesh but is less expensive.

Howard Wire Cloth
28976 Hopkins
Hayward, CA 94545
650-887-8787

The above sources are indicated only as possible sources and are not necessarily recommended by Quantar Technology.

MOUNTING OF GRIDS

The grid can be stretched flat and then spot-welded to the top surface of the Option SE ring which can then be separately biased using the Option SE contact pin on the rear baseplate. This method, however, requires partial disassembly of the 25 mm and 40 mm size sensors since the sensor assembly itself is held together by the same screws that secure the Option SE ring in place. This method will place the grid approximately 0.125" from the normal front hold-down ring of the sensor and, therefore, about 0.185" ± 0.030" from the MCP surface.

As an alternative, an additional ring, identical to the option SE Front Ring can be obtained, and a grid can be mounted (stretched and then spot-welded) onto this ring. This ring-grid assembly can then be screwed onto an existing, installed Option SE ring using short 0-80 size screws. (The grid could also be clamped between the two rings without spot welding). Both of these methods have the advantage that the MCP sensor does not have to be disassembled to remove the ring to attach the grid, and later, the grid (on the third ring) can be more easily taken on and off if necessary. A possible disadvantage is the height of the sensor assembly will be increased by an additional 0.050"+ (0.050" ring thickness plus the thickness of the grid material) beyond the normal Option SE height.

In addition, Quantar Technology now offers chem-etched, molybdenum grids with a solid outer area, matching the front ring pattern. The grids can easily be installed and removed using short 0-80 size screws, requiring no additional ring. Contact Quantar Technology for price and availability information for these components.

2.2 BIASING AND ELECTRICAL CONNECTIONS

SAFETY WARNING

> The electrical potentials applied to this MCP sensor for proper operation are potentially harmful. Personnel should use extreme care in handling HV leads, making connections and performing tests.

The electrical connection points for the 2 MCP versions (Models 3390 and 3394) and 3 MCP Option 010 versions (Model 3391-010 and 3395-010) are shown in Figure 2.4 and for the 5 MCP versions (Models 3391 and 3395) in Figure 2.5.

Figures 2.6a, 2.6b and 2.7 show System Interconnection and Biasing for the 2 MCP, 3 MCP and 5 MCP versions.

Each MCP requires approximately 700-1000 VDC. The exact voltage to produce the desired level of electron gain (and, therefore, spatial resolution) without introducing excessive background varies from unit to unit. The MCP voltage used in production tests will be indicated on the test data supplied with each sensor. Some experimentation with this voltage by the user can often result in an optimum voltage for a specific application environment. In no case should the bias voltage need to exceed 1000 VDC per MCP. The voltage bias between the output of the last MCP and the RAE is not critical in most environments (providing there are no strong transverse magnetic fields) but should be at least 200 volts and no more than 500 volts.

The RAE is normally biased through the 1 megohm s (vacuum-compatible) resistor supplied with the sensor and mounted on the rear surface of the ceramic baseplate. This resistor presents a much higher impedance than the approximately 50 ohm input impedance of the preamplifiers and thus results in essentially no signal loss, yet provides a fixed bias path to the RAE to maintain a uniform electric field between the last MCP surface and the RAE which is necessary for proper spatial imaging.

Each of the four RAE signal outputs is capacitively decoupled by 1000 pF ceramic block capacitors mounted on the rear of the ceramic baseplate. These capacitors are rated at a maximum of 5000 VDC. The purpose of these capacitors is to enable biasing of the anode at a high DC potential relative to ground and yet to avoid applying this high voltage to the preamplifier signal inputs.

Consult the 3300/2400 Series System Installation and Operation Manual for additional information regarding electrical connections, HV biasing, turn-on, operation and diagnostic procedures for operation of a complete detector system including position electronics.

Figure 2.4: Electrical Connections for 2 MCP versions, Models 3390 and 3394, and for 3 MCP Option 010 versions, Model 3391-010 and 3395-010

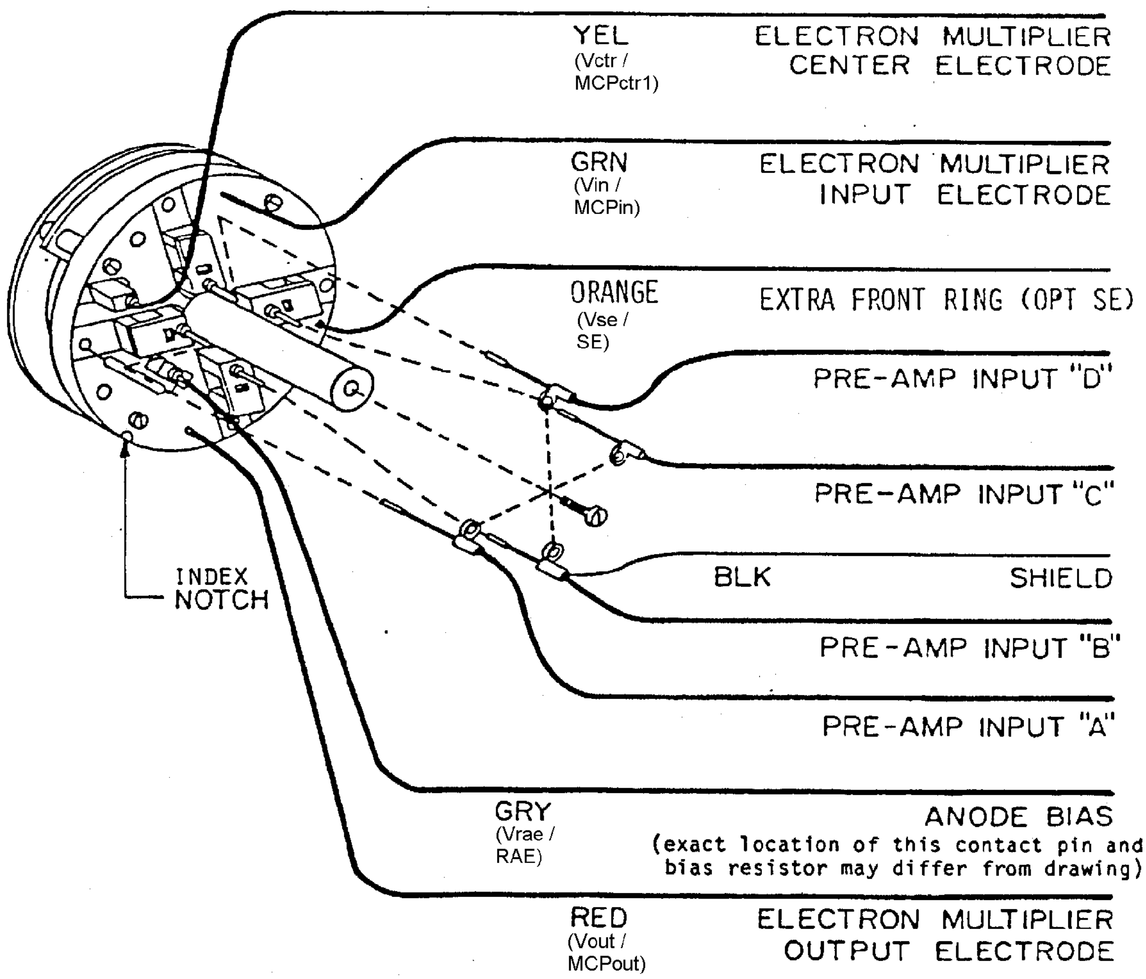


Figure 2.5: Electrical Connections, 5 MCP versions, Models 3391 and 3395

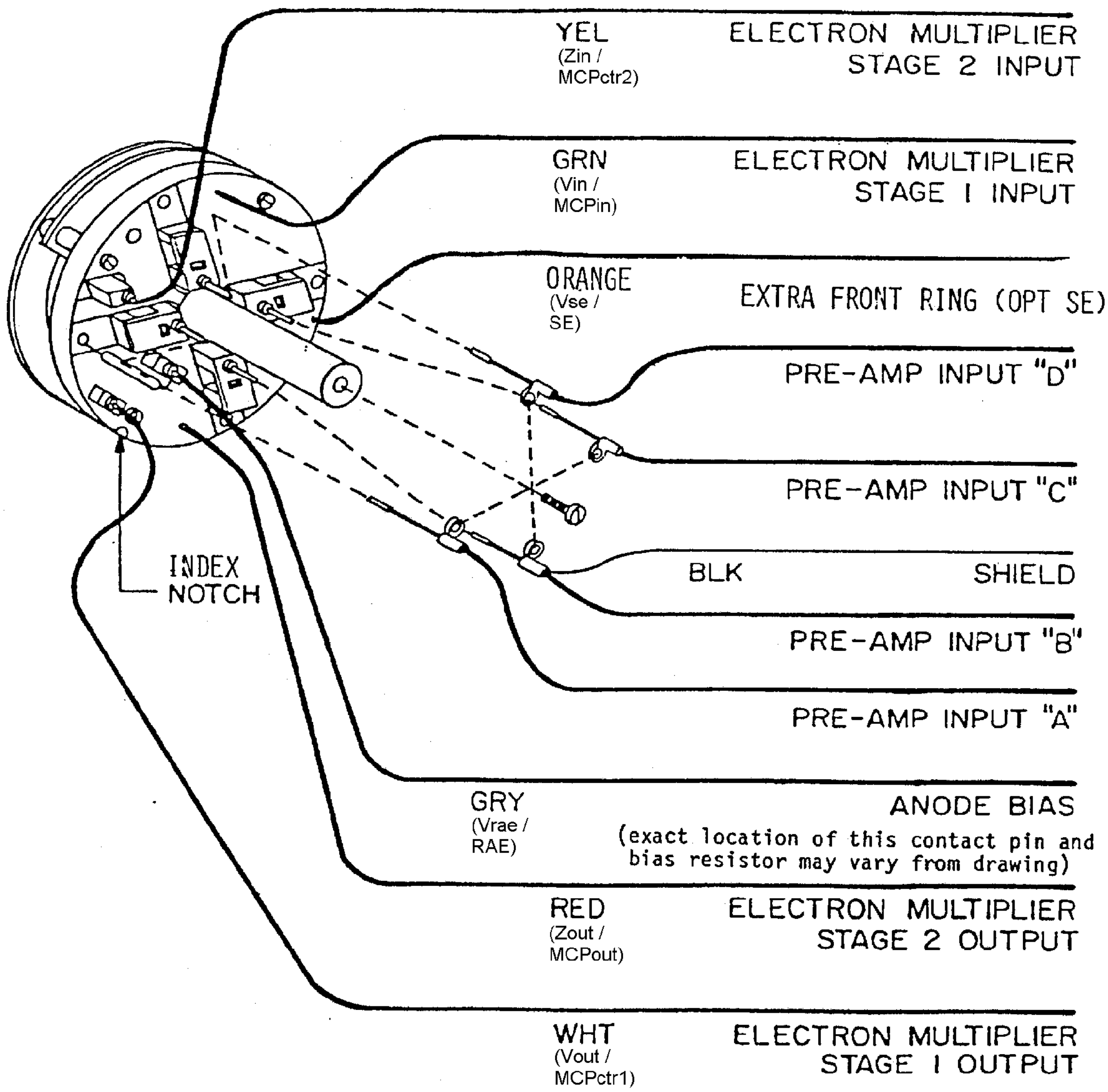


Figure 2.6a: System Interconnection and Biasing, 2 MCP Sensors, Models 3390, 3392 and 3394

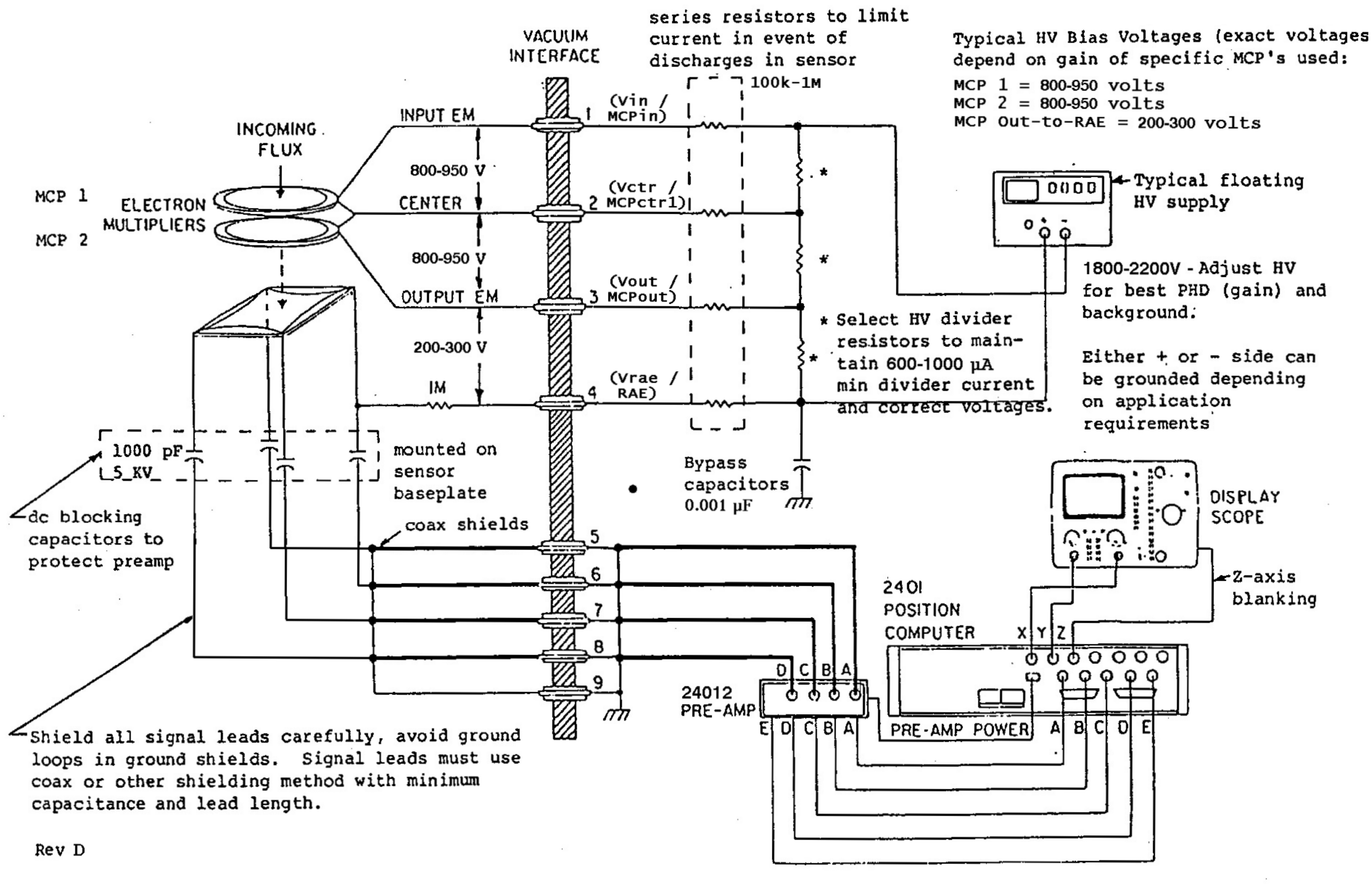


Figure 2.6b: System Interconnection and Biasing, 3 MCP Option 010 Sensors, Models 3391-010 and 3395-010

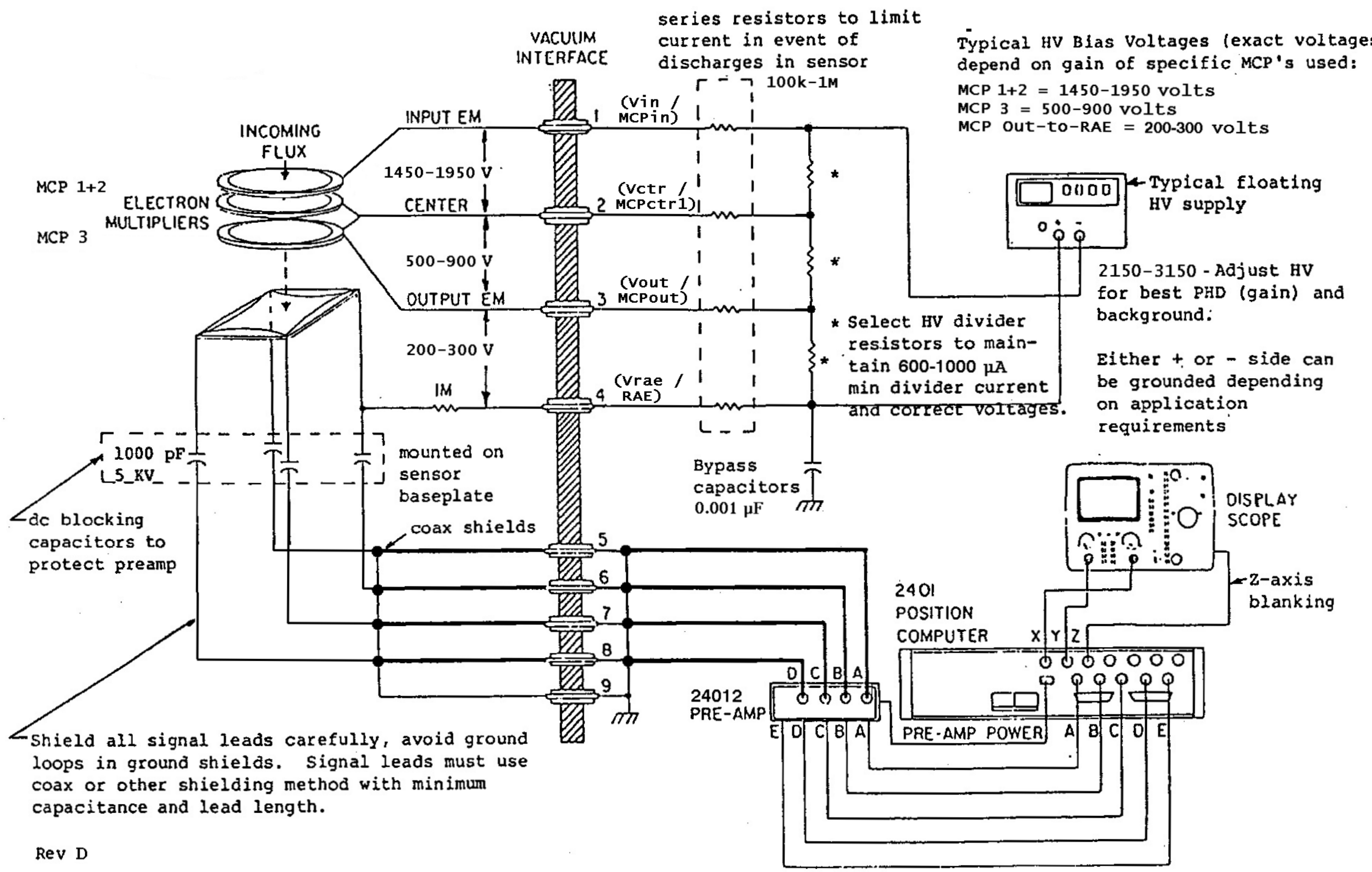
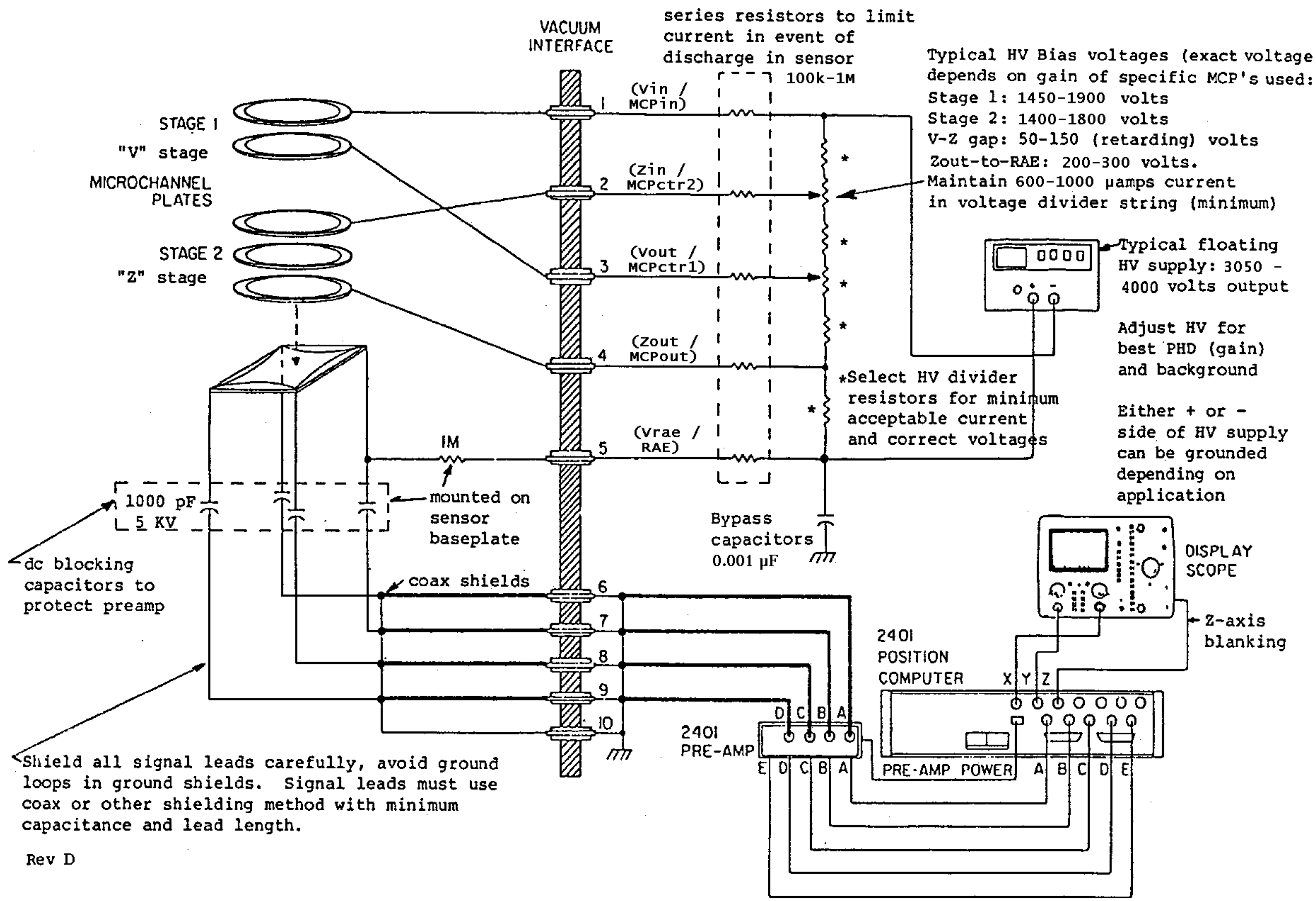


Figure 2.7: System Interconnection and Biasing, 5 MCP Sensors, Models 3391 and 3395



SECTION 3. MAINTENANCE

3.0 EXPLODED ASSEMBLY VIEWS

Figures 3.0 and 3.1 show exploded views of the entire MCP/RAE detector assembly for the 2 MCP version. The 3 MCP, Option 010 version, uses the same assembly as the 2 MCP version with the first and second MCPs making a V-stack, followed by the center contact and third MCP. The 5 MCP version is similar in construction but with the addition of the second stage, consisting of 3 MCP's (Z-stack) and a second center contact, separated from the first stage by a thin non-conductive spacer.

3.1 MAINTENANCE PROCEDURES

In general, little user-supplied maintenance is normally necessary providing the MCP/RAE sensor is not subjected to contamination, excessive voltage, excessive input flux level or exposed to excessive atmospheric water vapor.

Gradually, MCP gain will decrease, depending on accumulated counts and quality of operating vacuum. The MCP's effective multiplication lifetime is primarily determined by the total charge (counts x gain) depleted from the MCP. Changes in gain can be monitored by making Pulse Height Distribution measurements (see 3300/2400 System Manual). Often, decreases in gain can be compensated for by increased bias voltage. Ultimately, however, MCP's can reach a condition where they must be replaced. While it is possible for the user to replace the MCP's, Quantar recommends returning the unit to the factory for this procedure.

To remove particles of dust or other particulates from an MCP surface, use a gentle flow of filtered air or nitrogen (preferably ionized air). An electrostatically-charged hair or other soft object may also be used. If disassembly of the MCP/RAE Sensor is attempted, it should be done under a laminar-flow unit to prevent dust accumulation and with clean gloves and tools to avoid contamination.

To disassemble the detector, remove all leads and hold the detector in a gloved hand. Grasp the detector around its baseplate with the input MCP facing downward into the palm and taking care not to touch the MCP surface. Remove the ceramic center mounting post, if applicable, to allow the detector to rest in a stable position when placed on a clean bench table surface.

Ensure the baseplate along with the rings are being held together by the holding hand/fingers to prevent the detector from separating prematurely when the screws are released. Release and remove the four long 0-80 screws that hold the assembly together. Turn the detector upright and place on the clean bench table surface before release it from grip.

Lift off each part sequentially. Be certain to note the proper orientation of each part before it is removed.

The MCP's have an index mark which is on the top surface of the MCP and indicates the direction of the slightly sloping microchannels from top to bottom (microchannels slope away from the arrow from top to bottom). Alternate MCP's should be rotationally aligned such that each index mark is rotated 180° from the index mark of the adjacent MCP (chevron pattern).

Re-assembly is the reverse process of disassembly. Make sure MCP rotational orientation is correct and that the rotational orientation of the top spring contact is such that the point of finger contact to the MCP is directly above the MCP support feet on the bottom ring.

In general, it is recommended that repairs to the sensor be done at the factory. The instruction above are supplied only for use in situations where factory repair is not feasible and it should be understood by the user that handling of such components, particularly by inexperienced personnel, can lead to permanent damage to MCP's, etc.

Figure 3.0: Exploded View, 2 MCP Sensor, Baseplate Section

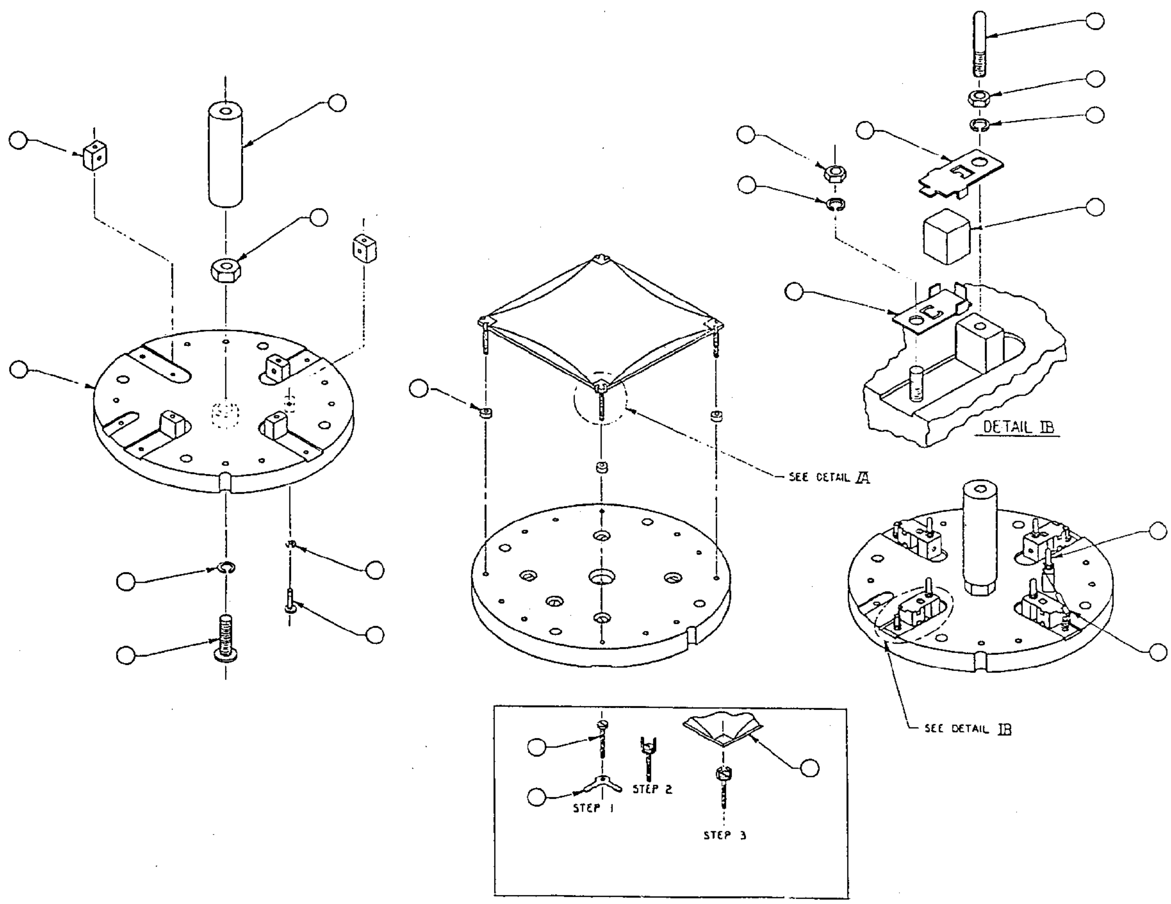
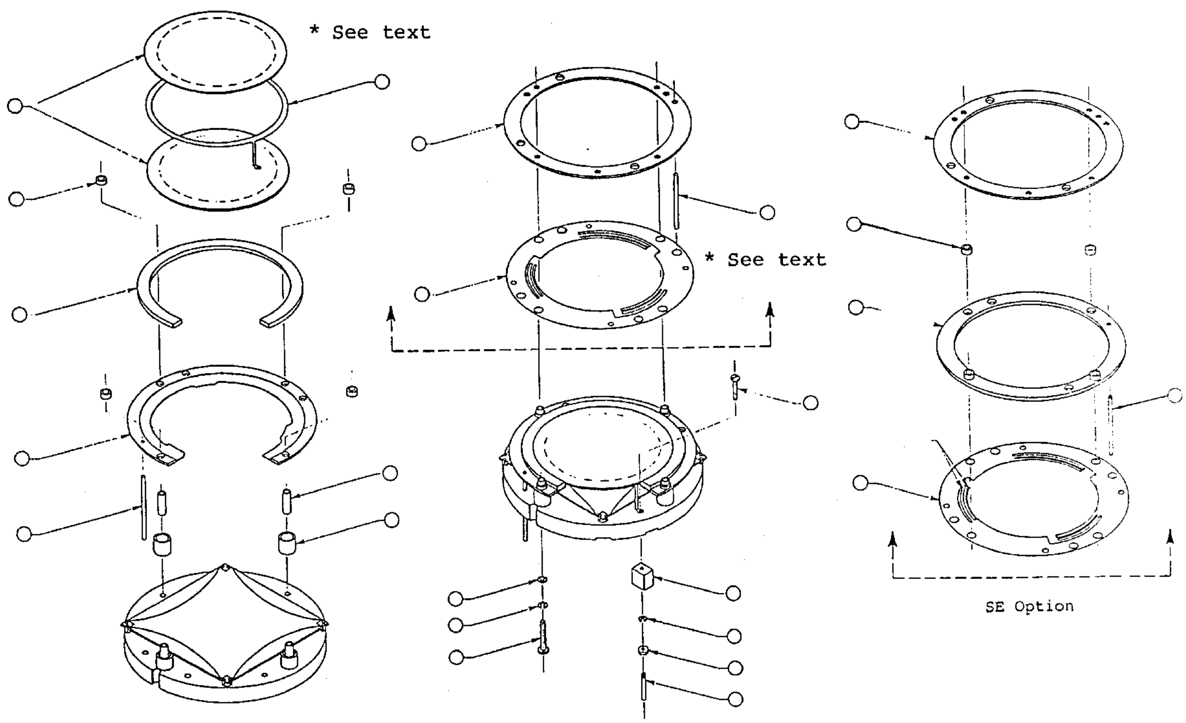


Figure 3.1: Exploded View, 2 MCP Sensor, Top Section



The following procedure can be used to attempt to clean MCP's that have been more contaminated. Always use extreme care in handling chemicals and take suitable precautions for personnel, including proper ventilation.

MCP Cleaning

1. Fill two (2) beakers with isopropyl alcohol (electronic grade or better) and place on hot plates (with magnetic stir bars).

2. Place MCP's into first beaker of stirring isopropyl and bring to a boil. Allow to boil for 5 minutes.

3. Remove boiling isopropyl alcohol beaker from hot plate and put into ultrasonic cleaner for one minute.

4. Place MCP's into second stirring isopropyl alcohol and bring to a boil. Allow to boil for 5 minutes.

5. Repeat Step 3.

6. Using same beaker of boiling isopropyl alcohol, let stir and boil for 5 minutes.

7. Vacuum desiccate and dry plates for 1/2 hour at 100 degrees C.

8. Protect MCP's from particulate contamination and atmospheric water vapor.

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MATERIAL SAFETY DATA SHEET
Date Prepared: September 20, 1995

I. General Information

Manufacturer:	Galileo Electro-Optics Corporation Galileo Park, P.O. Box 550 Sturbridge, MA 01566
Manufacturer Phone:	(508) 347-9191
Emergency Phone Number:	(508) 347-9191
Chemical Name & Synonyms:	Microchannel Plates and Single Channel Detectors
Chemical Family:	Inorganic Glass
DOT Hazard Classification:	None
Proper DOT Shipping Name:	None

II. INGREDIENTS

Principle Hazardous Components	CAS (number)	Percent (by weight)	Exposure Standards: OSHA PEL 8-hour TWA (Mg/M3)	Exposure Standards: ACGIH TLV 8-hour TWA (Mg/M3)
Lead Oxide	1317-36-8	40-65	0.050 (1)	0.050 (2)
Silica (quartz)	14808-60-7	35-50	10.000 (*)	0.100 (3)
Barium Oxide	1304-28-5	1-10	0.500 (*)	0.500
Rubidium Oxide	18088-11-4	1-10	N/A	N/A
Cesium Oxide	20281-00-9	<1	N/A	N/A
Arsenic Oxide	1327-53-3	<1	0.010 (4)	0.010 (5)
Nickel Oxide	1440-02-0	<1	1.000 (*)	1.000 (6)
Chromium Oxide	7440-47-3	<1	0.500 (*)	0.500

(*) OSHA "Z" table standard. These are not currently enforceable due to court action; however, OSHA standards are enforceable.
(1) OSHA action level is 0.030 Mg/M3.
(2) Suspected animal carcinogen, unconfirmed human carcinogen.
(3) Refers to respirable fraction. ACGIH is proposing to designate quartz as an "A2" (suspected) human carcinogen.
(4) OSHA action level is 0.005 Mg/M3.
(5) Confirmed human carcinogen.
(6) ACGIH proposes to change TLV to 0.050 Mg/M3 due to classification as confirmed human carcinogen.

III. PHYSICAL DATA

Boiling Point	N/A
Vapor Pressure (mm Hg)	N/A at Room Temperature
Vapor Density (Air = 1)	N/A
Solubility in Water	Limited
Appearance & Odor	Metallized black glass, odorless
Specific Gravity (Water = 1)	>1
Percent Volatile by Volume (%)	N/A
Evaporation Rate	N/A
pH	N/A

IV. FIRE & EXPLOSION HAZARD DATA

Flash Point:	NA
Flammable Limits:	LEL: N/A UEL: N/A Range: None
Extinguishing Media:	Use appropriate media for material that is burning, glass is non-flammable, but may give off fumes at high temperature (>1000°F).
Special Fire Fighting Procedures:	Use protective clothing as specified by NFPA and self contained breathing apparatus.

V. HEALTH HAZARD DATA

EXPOSURE STANDARDS:
No exposure standard for the finished, inorganic glass has been determined. The exposure standards cited in section II were developed to protect workers exposed to significant quantities of raw materials in manufacturing and other industrial operations. No significant exposure to any hazardous components are expected to end-users of the finished product when utilizing the components in the manner intended. However, exposure to hazardous components may occur if product is misused, heated, abraded, broken, ground, treated with chemicals or otherwise altered.

CARCINOGENIC COMPONENTS:

Lead Oxide	Suspected animal carcinogen, unconfirmed human carcinogenic.
Silica (quartz)	ACGIH is proposing to designate quartz as a suspected human carcinogen.
Barium Oxide	Not currently considered a carcinogen.
Rubidium Oxide	Not currently considered a carcinogen.
Cesium Oxide	Not currently considered a carcinogen.
Arsenic Oxide	Coafirmed human carcinogen.
Nickel Oxide	ACGIH proposes to lower TLV due to confirmed carcinogencity of some forms of nickel.
Chromium Oxide	Certain oxidation states considered carcinogenic (e.g., chromium VI).

Not significant exposure to any carcinogenic components of the finished glass are expected to end-users of the finished product when utilizing the components in the manner intended. However; exposure to carcinogenic components may occur if product is misused, heated, abraded, broken, ground, treated with chemicals or otherwise altered.

VI. REACTIVITY DATA

Stability:	Stable
Incompatibility:	None, Hazardous polymerization will not occur.
Materials to Avoid:	Glass may be damaged if exposed to water, strong acids and alkalis.
Conditions to Avoid:	Do not expose this product to high heat (>1000°F).
Hazardous Decomposition Products:	Exposure to strong acids or alkali solutions and/or elevated temperatures may cause this glass to dissolve and/or produce solutions or fumes containing lead.

VII. ENVIRONMENTAL PROTECTION PROCEDURES

Spill Response:	Contain spill. Clean up and transfer material into DOT approved waste container.
Waste Disposal Method:	This glass is considered a hazardous waste

by EPA. Lead is leachable using the TCLP test procedure defined in 40 CFR. Disposal protocols must follow all federal, state and local hazardous waste regulations.

VIII. SPECIAL PROTECTION INFORMATION

Eye Protection:	Safety glasses, goggles or face shields are recommended when handling glass.
Respiratory Protection:	Not required under normal use. If exposure to dust or fumes are suspected, consult an industrial hygienist for recommendations.
Skin Protection:	Latex gloves and aprons are recommended when handling glass to protect glass from skin oils and protect skin from cuts.
Ventilation:	Sufficient ventilation should be provided to keep exposure to any fumes or dust emitted by the glass to levels below that recommended by OSHA.
Other Protection:	None

IX. SPECIAL PRECAUTIONS

Minimize handling of glass as much as possible to protect both the employee as well as the glass. Wash thoroughly after handling the glass.

Prepared by

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Reviewed and Approved by