

3 cm

RF ION SOURCE

MANUAL

When contacting Ion Tech, Inc. concerning parts or service for this equipment, please provide the following information:

MODEL NUMBER:

SOURCE SERIAL NUMBER: _____

GRID SERIAL NUMBER: _____

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ION TECH, INC.

2330 E. Prospect, Fort Collins, Colorado 80525
(303) 221-1807 • FAX (303) 493-1439

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CUSTOMER SERVICE INFORMATION

For customer service, contact:

Ion Tech, Inc.
2330 East Prospect
Fort Collins, CO 80525
(303) 221-1807
FAX (303) 493-1439

When contacting Ion Tech, Inc. for parts or service for your ion source, please provide the source model number, the source serial number, and grid serial number. The source model and serial number are engraved on the downstream surface of the grid mount plate. The grid serial number is engraved on the upstream surface of each of the grids. As a handy reference, these numbers are also recorded on the front sheet of this manual (for the equipment with which this manual was originally shipped).

To aid us in troubleshooting an operation problem with your ion source, it is also helpful to have at hand the model and serial number of your ion source power supply, and a list of all the operating parameters and/or error messages displayed by the power supply at your particular operating condition, the gas flow rate, and the vacuum chamber pressure.

EXPLANATION OF COMMENTS

WARNING

WARNINGS ARE USED WHENEVER CONDITIONS OR PROCEDURES COULD RESULT IN INJURY TO PERSONNEL. WARNINGS MUST BE OBSERVED.

CAUTION

Cautions are used whenever conditions or procedures could result in damage to equipment. Cautions Should Be Observed.

NOTES: Notes supply additional information that may be useful in installing or operating the equipment.

Section 1

SAFETY REQUIREMENTS

The equipment described herein utilizes high voltage at an amperage sufficient to be dangerous. Because of this potential hazard, the maintenance and troubleshooting procedures in this manual are intended for qualified personnel using established safety procedures.

Complete Ion Beam Systems provided by Ion Tech are equipped with electrical interlocks which prevent operation of the electrical system with the ion source electrical connections exposed, with the vacuum system at atmosphere, or with the rear door on the electronics cabinet open. The first two interlocks prevent the operation of the electronics while the source or its electrical connections can be touched; another interlock prevents operation while the power supplies can be touched.

Customers purchasing less than complete systems for retrofit into existing pumping stations are urged to incorporate this interlocking strategy for the safety of their personnel.

Section 2

DESCRIPTION

A cross-section of the Model 3RF-1200-100 RF Ion Beam Source is shown in Figure 1. The gas to be ionized is introduced into the upstream end of the quartz discharge chamber through a specially designed gas isolator assembly. Radio frequency power at 13.56 MHz is inductively coupled into the ion source discharge chamber to ionize the gas. Some of the ions that are produced in the RF discharge reach the two grids of the accelerator system and are focused by the positive screen grid and accelerated through the apertures in the negative accelerator grid. The accelerated ions form the directed beam of mono-energetic ions. The Plasma Bridge Neutralizer (PBN) then provides electrons to the positive ion beam. The neutralizing electrons are readily distributed within the conducting plasma of the beam to give a near uniform potential for most operating conditions. In addition to neutralizing the ion beam, the PBN is used as an electron source to ensure reliable, low pressure ignition of the ion source discharge.

The various currents and voltages required for operation of the ion source are supplied by the power supply system. The Ion Tech RFB-1200 microprocessor controlled power supply includes all ion source beam, accelerator and neutralizer power supplies in a single, compact, rack mountable unit. In addition, an RF power source is required for operation. This is provided by the RF

power supply system which includes the RF5S RF generator, the AM-5 automatic matching network, and the AMPS-2A controller. The RF5S generator and AMPS-2A matching network controller are rack mountable. The AM-5 matching network must be mounted on the vacuum chamber within 18" of the RF vacuum feedthroughs. Block diagrams for the power supply systems are shown in Figure 2.

Further detailed descriptions of the ion source components and operation are given in the remainder of this section. Depending on interests and needs, the reader may wish to either read these further descriptions or to go directly to the OPERATION section.

DISCHARGE CHAMBER

In normal operation the discharge chamber is filled with a conducting plasma, which is composed of nearly equal numbers of electrons and ions, in a background of neutral atoms. Because of their small mass and high velocity, the electrons preferentially escape to any discharge chamber surface that is not negative relative to the plasma. As a result of this preferential escape mechanism, the discharge chamber plasma is self-biased positive by about 25 volts of the most positive discharge chamber surface, which is the screen grid.

The ion beam current is nearly proportional to the plasma density in the discharge chamber. Because the plasma density is propor-

tional to the RF input power, the ion beam current can be adjusted independently of ion energy or accelerating voltage within the extraction capability of the grids.

Because the RF discharge is filamentless, the ion source discharge can operate for long periods (several hundred hours) without discharge chamber maintenance on a variety of gases, including pure oxygen.

ACCELERATOR SYSTEM

The positive ions produced in the RF discharge suffer one of two fates. Ions which collide with any solid surface pick up an electron at the surface and rebound as a charge neutral particle to be re-ionized or to eventually be pumped out of the system. Positive ions which approach the accelerator system eventually reach a point where they can "see", or are attracted to, the negative accelerator grid. As those ions pick up velocity in the acceleration process, they are collimated, or focused, into individual beamlets by the apertures in the screen grid. The accelerated ions in the individual beamlets form the broad directed beam of energetic ions as they pass through the accelera-

tor system. The final directed energy of the beam ions is equal to the potential difference between the discharge chamber ions and facility ground. This potential is the BEAM VOLTAGE (V_{beam}) displayed by the RFB-1200 power supply. It is equal to the positive voltage applied to the screen grid by the BEAM power supply, as shown in Figure 2, plus the discharge chamber plasma potential.

NOTE: Ions in the discharge chamber have a self-bias (or plasma) potential about 25 volts positive of the screen grid during normal operation. Therefore, the ion beam energy is equal to the applied beam voltage plus 25 volts. The RFB-1200 power supply compensates for this 25 volt self-bias, so that the displayed BEAM VOLTAGE is equal to the actual ION BEAM ENERGY.

Although their final energy is V_{beam} , the ions as they approach the accelerator grid are accelerated by a total potential difference equal to the applied positive beam voltage plus the applied negative accelerator voltage, that is ($V_{\text{total}} = |V_{\text{beam}}| + |V_{\text{accel}}|$). As the ions pass the plane of the accelerator grid, they have a negative potential (V_{accel}) relative to ground. In the region just downstream of the accel grid plane they go through a deceleration process in which they give up an energy equal to V_{accel} . This leaves them with a net energy equal to V_{beam} . This acceleration-deceleration process serves two purposes. One is that without the negative potential barrier pro-

vided by the applied accelerator voltage (V_{accel} is negative relative to facility ground), the neutralizer electrons would backstream through the accelerator system and give a false indication of ion current. The other purpose of the applied accelerator voltage is to increase the beam current. The ion current through the accelerator system varies as $(V_{\text{total}})^{3/2}$, so that use of a large accelerator current will substantially increase the ion beam current over what it would be for a total applied voltage of only V_{beam} (i.e. with $V_{\text{accel}} = 0$, $V_{\text{total}} = V_{\text{beam}}$ and the beam current will be reduced). This effect is particularly significant at low beam energies. For low beam energies extraction of large beam currents require use of relatively large negative accelerator voltages.

It should be noted that the accelerator voltage affects the divergence of the ion beam. For each combination of beam voltage and beam current, there is an accelerator voltage which gives the minimum beam divergence. This condition of maximum collimation of the individual beamlets corresponds to an observed minimum value of the accelerator drain current. Operation at accelerator voltages greater than that which minimizes accelerator current causes the beam to diverge. Increasing the beam divergence by operating at high accelerator voltages may or may not be desirable depending on the particular application.

A high beam current capacity at moderate accelerator system voltages requires closely spaced screen and accelerator grids

with many small apertures in both. In particular, maintaining small, uniform spacing with accurate alignment of the apertures requires mechanically and thermally stable grids. Ion Tech uses precision machined, dished nickel grids to obtain this stability over a wide range of thermal conditions. Pyrolytic graphite grids are also available as an option. The high performance design of Ion Tech grid systems permit current densities up to 5 mA/cm² at 1000 eV ion energies and up to 0.5 mA/cm² at 50 eV energies.

PLASMA BRIDGE NEUTRALIZER

The Plasma Bridge Neutralizer (PBN) serves two functions. It provides electrons to ensure reliable, low pressure ignition of the ion source RF discharge. It is also used to neutralize the directed ion beam. As a neutralizer it provides electrons to space charge neutralize the directed ion beam, and it prevents the build up of damaging surface potentials on targets and substrates. Because of the low electrical potential and very high mobility of the neutralizer electrons exact neutralization of the ion beam is not necessary. Instead, a rough equality in the emission of PBN electrons and beam ions is sufficient to ensure that sputter targets and substrates are within a few volts of facility ground potential, even if they are insulators. It is generally better to have an excess of neutralizer electrons rather than too few. We, therefore, recommend operating the PBN emission current at 125 to 200% of the beam current.

It should be pointed out that in the neutralization process described here the neutralizer electrons do not recombine with the beam ions to form charge neutral particles. Such recombination is not necessary. Instead, the electrons are simply emitted as a cloud of free electrons to minimize space charge divergence of the ion beam and prevent damaging positive charge build up on surfaces within the process chamber.

As shown in Figure 1, the PBN is located outside the periphery of the ion beam, thereby eliminating neutralizer ion impingement damage and forward sputtered contamination problems. The electrons are obtained by passing a flow of argon through a small chamber containing a biased filament emitter. (Refer to Figures 2 and 5.) A discharge is produced between the emitter and walls, forming a plasma. The plasma is then extracted through a small orifice at the end of the chamber and electrically couples to the ion beam. This coupling, or bridging, is aided by biasing the PBN negative with respect to the beam. Typically, coupling voltages on the order of 20 volts allow adequate electron emission currents to be obtained.

The PBN is designed for operation only on argon or other inert gases. However, it can be operated in process chambers containing large backgrounds of reactive gases such as oxygen. For argon gas and a tungsten filament that is 0.25 mm (.010 inch) in diameter, the PBN filament life should be 15 to 50 hours depending on PBN emission current and reactive gas background level.

Section 3

INSTALLATION

GENERAL REQUIREMENTS

1. Pumping system. The vacuum pumping system should be able to maintain a process chamber pressure of 5×10^{-4} Torr or less with a gas load of 6 to 10 SCCM of argon per ion source. Ion Beam Sources operating in vacuum systems unable to maintain this pressure MAY experience electrical breakdown between the high voltage leads or in the area between the RF coil and the source shroud. Also, operation of the ion source at pressures above 5×10^{-4} Torr will result in increased erosion of the accelerator (downstream) grid due to sputtering from charge-exchange ions. As the pressure is increased above 5×10^{-4} Torr, the charge-exchange ion density and, thus, the sputtering due to these ions, increases rapidly. If possible operation at pressures below 2×10^{-4} Torr is desirable to minimize the effects discussed above.

NOTE: The accelerator system acts as a gas flow restriction so that for moderate flow rates the ion source internal pressure is high enough to sustain a stable plasma discharge. Because of this design feature, the ion source is relatively insensitive to the background pressure into which it operates.

In fact, as long as the gas flows through the source and PBN are sufficient (3 to 6 SCCM for the source and 3 to 4 SCCM for PBN), the ion source will operate at as low a background pressure as the pumping station can maintain or that the process will tolerate. This is in contrast to some other sputter deposition and etching processes which are sensitive to process chamber pressure and require a relatively high process chamber pressure (10^{-3} Torr) to sustain a discharge.

2. Gas supply and control. The ion source was designed for operation with argon but will also operate on the other inert gases as well as on oxygen, and nitrogen. Process grade gas is recommended. The gas flow rate through the source is an independent control parameter and should be controlled through a micrometer valve or an electronic gas flow controller both available through Ion Tech as part of the ion source interface package. The gas line in this ion source contains a unique high voltage gas isolator assembly to separate the high potential of the source from the grounded gas flow system. This allows all exposed gas lines to operate at facility ground potential.

The PBN is designed for operation only on argon or other inert gases. However, it can be operated in

process chambers containing large backgrounds of reactive gases such as oxygen. The PBN requires a separate micrometer valve or electronic flow controller in its gas supply line.

3. Cooling. The ion source is cooled by conduction through the mechanical mounting and by radiation to its surroundings. The only special requirement for cooling is that the source shroud and RF power cables (vacuum side) should be installed such that they can radiate to cool surfaces (50° C or less) during operation. It is important that they are shielded during operation from direct exposure to other sources of thermal radiation such as quartz lamps and electron beam or thermal evaporators.

4. Electrical. The various currents and voltages required for operation of the ion source are provided by the power supply system. The Ion Tech RFB-1200 requires 200-220 VAC line voltage, 50/60 Hz, 20 amperes, single phase. The RF5S RF generator requires 198-250 VAC, 50/60 Hz, single phase, 6 amperes (100-125 VAC, 11 amps optional) line power. The AM-5 automatic matching network with AMPS-2A controller requires 115 VAC, 50/60 Hz, 1.5 amperes line power. Detailed instructions for installing and connecting the power supplies and cables are provided in the INSTALLATION section of the various

power supply manuals. A summary of all required electrical connections is provided in the INSTALLATION section of the RFB-1200 manual.

5. Safety interlocks. Complete Ion Beam Systems provided by Ion Tech are equipped with electrical interlocks which prevent operation of the electrical system with the ion source electrical connections exposed, with the vacuum system at atmosphere, or with the rear door on the electronics cabinet open. The first two interlocks prevent the operation of the electronics while the source or its electrical connections can be touched; another interlock prevents operation while the power supplies can be touched.

WARNING

ALL ION SOURCE ELECTRICAL LEADS OPERATE AT HIGH VOLTAGES - VOLTAGES WHICH CAN BE LETHAL.

Customers purchasing less than complete systems for retrofit into existing pumping stations are urged to incorporate this interlocking strategy for the safety of their personnel. Ion Tech power supplies include an interlock port and connecting cable for this purpose. Refer to the installation section of Ion Tech RFB-1200 power supply manual for interlock connection instructions.

6. Electrical shielding. During operation the ion source will produce a low density conductive plasma which fills the process chamber. This results from the interaction (charge exchange) between some of the directed beam ions and the background gas present within the process chamber. This low density plasma provides a conductive path which can lead to an electrical discharge breakdown to facility ground of any exposed high voltage surface or electrical lead. All electrical connections within the process chamber that will operate at high voltage (>100 volts) while an ion beam is being extracted must, therefore, be shielded either by an insulating surface or a ground shield. This includes the electrical connections for devices such as quartz lamps, heaters, and electron beam guns as well as the leads for the ion source itself. Insulating shields can be fabricated from vacuum compatible insulators such as mullite, alumina, quartz, and mica. Ground shields can be fabricated from aluminum or stainless steel shim stock, fine mesh screen, or perforated metal. Shields should be vented to facilitate pumping of the enclosed areas. Venting holes should be a maximum of 0.060 inches (1.5 mm) diameter to provide adequate electrostatic shielding from the low density background plasma. Aluminum foil is useful for fabricating temporary shielding. If grocery store variety

aluminum foil is used, it should be cleaned with acetone and/or alcohol to remove the vegetable oil residue left during manufacturing.

NOTE: The probability of electrical discharge breakdowns at high voltage connections increases with increasing process chamber pressure. This is one of the reasons why operation at a low background pressure is desirable.

ION SOURCE INSTALLATION (Refer to Figure 3.)

1. Securely mount the ion source inside the process chamber using the 10-32 tapped holes provided in the back plate or the source mount bracket with 1/2 inch diameter shaft clamp.

CAUTION

All unused mount holes must be blocked with 10-32 screws to prevent the charge exchange plasma from causing an electrical breakdown around the RF coil.

2. Install the gas/electrical feedthrough/s at a convenient location in the process chamber.
3. Connect an 1/8 inch diameter stainless steel gas line between the ion source and the gas feedthrough, using the 1/8 inch union provided. Connect the gas supply to the gas feedthrough. Repeat the above procedure for the PBN gas line.

4. Connect the shielded electrical leads from the source and PBN to their matching pins on the electrical feedthrough/s, that is connect D to D, E to E, 1 to 1 and 2 to 2. The letter and number designations for the source electrical connections are shown in View A-A of Figure 1 and those for the PBN are shown in Figure 5.

- NOTE:
- a) The RF power leads between the feedthrough and source should be routed parallel to each other and strapped tightly together. If possible they should be routed at least 2 inches away from any other electrical leads and from conductive surfaces or components in the vacuum system. These procedures will help minimize RF tuning problems and noise generation.
 - b) Each feedthrough includes a vented metal shield or ground screen. After connecting the source electrical leads to the feedthrough, slide the ground screen in place over the connections. Screw or clamp in place, as required. To minimize RF tuning problems, it is important the ground screen for the RF power leads provides a good electrical connection between the braided shield and the vacuum chamber at the feedthrough end.

5. Install the RFB-1200 ion beam power supply, the RF5S RF generator, and the AM-5 matching network and controller. A summary of the installation and electrical connection instructions for these units is provided in the INSTALLATION section of the RFB-1200 manual. The electrical block diagram in Figure 2 at the end of this manual also shows the required electrical connections.
6. Evacuate the process chamber.
7. The Ion Beam Source is now ready for operation. Refer to the OPERATION section for detailed operating instructions.

Section 4

OPERATION

The operational procedures described in this section are intended to be general in nature and are directed towards the user that is new to the equipment. After gaining operating experience many users will find that minor variations such as different gas flow rates or different initial power settings are more efficient for their particular application or process.

PREPARATION

1. Evacuate the facility to 1×10^{-4} Torr or lower.
2. Check the installation for proper gas and electrical connections. (See INSTALLATION Section 3.) Refer to the RFB-1200 power supply operating manual for the power supply cable connections.

WARNING

ALL ION SOURCE ELECTRICAL LEADS OPERATE AT HIGH VOLTAGES - VOLTAGES WHICH CAN BE LETHAL. PRECAUTIONS MUST BE TAKEN TO INSURE THE SAFETY OF PERSONNEL.

3. Carefully purge the gas supply lines prior to initial start-up or after they have been disconnected. This can be done by fully opening the gas control valves and evacuating the supply lines back to the high purity gas

supply. Leak check the lines while they are evacuated, then back fill the lines by simultaneously closing the gas control valve and opening the gas supply valve.

4. Adjust the ion source argon flow rate to 4-6 SCCM (oxygen requires 6-10 SCCM) and the PBN flow rate to 2-4 SCCM. The vacuum chamber pressure should be 5×10^{-4} Torr or less at these gas flow rates.

OPERATION WITH RFB-1200 POWER SUPPLY

Your RFB-1200 power supply was used for the preshipment check out of your ion source. At that time, typical operating conditions were programmed into its memory registers. These operating parameters are indicated on the checkout data sheet shipped with the source. After installation in your vacuum system, you may want to use these preprogrammed conditions to verify proper operation of your ion source. To use these preprogrammed operating conditions for your source check out, complete the PREPARATION Steps 1 through 4 above then follow the procedures given below.

1. Turn on the front panel power switches on the RFB-1200 ion beam power supply, the RF5S RF generator and the AMPS-2A matching network controller.
2. After the RFB-1200 power supply has completed its self-test, use the MEMORY switch to select either memory 1 or 2, then set the MODE switch to LOCAL.

NOTE: The source check out data sheet will indicate the parameters stored in MEMORY 1 and 2.

3. Set the AMPS-2A controller TUNE and LOAD toggle switches to REMOTE.
4. Press the SOURCE button on the RFB-1200. The word "SOURCE" will illuminate above the SOURCE switch.

When the SOURCE switch is activated, several changes will be observed on the front panel of the RFB-1200 and RF5S:

- (a) The RFB-1200 will turn the RF power "on" and the red RF ON indicator will light on the RF5S generator. This will take about 5 seconds. The RF power level will then ramp to 80 Watts and the automatic matching network will tune the system to a few watts of reflected power. This will also take a few seconds.

NOTE: The AM-5 matching network and AMPS-2A controller were set up at the factory to automatically tune to a reflected power level which provides good discharge stability. The reflected power will range from zero to approximately 15 Watts depending on the

forward power level. Call Ion Tech for assistance if the reflected power does not drop below 15 Watts after tuning.

- (b) The PBN filament current (NEUTRALIZER CURRENT) will increase until the BODY VOLTAGE has dropped to between 20 V and 25 V.

NOTE: The PBN filament current will not increase beyond the NEUTRALIZER LIMIT value. If the PBN BODY VOLTAGE does not drop below 25 V, either the NEUTRALIZER LIMIT value or the gas flow rate probably needs to be increased.

- (c) The NEUTRALIZER EMISSION current will increase to 300 mA and remain there until the RFB-1200 determines that the ion source discharge has been started. Once the source discharge has started, the emission current will ramp to the requested value.

NOTE: If the NEUTRALIZER EMISSION does not rise to 300 mA, increase the PBN gas flow rate. A zero emission current probably indicates a zero target value. Go to MANUAL mode and set a non-zero emission current target value.

(d) When the SOURCE switch is turned on, the above steps sequence automatically and are visible on the RFB-1200 front panel. In addition, the beam voltage is cycled on and off automatically to aid in starting the source discharge. This beam voltage pulsing is not evident from the front panel but is usually visible in the plasma discharge in front of the ion source. This pulsing cycle raises the beam voltage to 1000 V for one second then turns it off for four seconds. This sequence begins after the RF power reaches the target value and will continue until the power supply senses that the discharge has started. Normally the discharge will start on the first voltage pulse. If this does not happen then the source gas flow rate is probably too low and should be increased.

NOTE: In some applications substrates may be damage-sensitive to the small flux of 1000 eV ions generated during the one second beam pulse. If such substrates cannot be protected by use of a shutter during ion source start up, special software with lower beam start up voltages (down to 100 V) can be provided. Operation of sources with this software

will require higher source gas flow rates for starting (up to 6.0 SCCM with argon and up to 10.0 SCCM with oxygen). Please contact Ion Tech, Inc., if your application requires this type of software.

5. Allow a few seconds for the discharge conditions to stabilize, then press the BEAM button.

NOTE: If the BEAM button is pressed before the discharge has started an error message E-72 will be displayed until the discharge starts.

6. When the BEAM button is pressed the BEAM VOLTAGE is applied to the screen grid and an ion beam will be extracted from the source. The RF power will adjust automatically until the extracted BEAM CURRENT is equal to the requested value for the selected memory.

NOTE: An error message E-71 indicates the beam current has dropped to zero, i.e. the discharge has extinguished. If this happens shortly after the BEAM is turned on, the source may need a longer warm up period. Press SOURCE to restart the discharge and allow a few minutes for the source to warm up.

7. To operate at the other preprogrammed conditions, use the MEMORY switch to recall the alternate memory.

Toggling the switch once recalls the memory for preview; toggling it a second time enters the stored conditions as operating parameters.

CAUTION

Do not operate the ion source continuously at RF powers above 225 watts, as this may cause overheating. Note that, for a given beam condition, the RF power level can usually be decreased by increasing the gas flow rate.

8. Instructions for other operating modes and further information on setting parameters, explanation of error messages and troubleshooting procedures will be found in the RFB-1200 and RF5S operating manuals.

NOTE: For starting, an RF power level of 60 to 80 Watts is recommended for all operating modes, including MANUAL mode. The discharge may be difficult to start at either higher or lower powers.

SHUTDOWN

1. After the desired run duration, press the BEAM switch on the RFB-1200 to turn the beam off. At this point the PBN and source discharge will continue to operate and the BEAM can be turned back on by simply repressing the BEAM switch.

2. The ion source can be completely shutdown by pressing the SOURCE switch on the RFB-1200. This will turn off both the RF power and power to the PBN.
3. Turn off the main power switch on each of the power supply front panels (RFB-1200, RF5S, AMPS-2A).
4. Allow the source to cool at least 15 minutes before venting the vacuum system.
5. If shutdown will be for 1 hour or less, it is recommended that the argon flow remains on. If shutdown will be for an extended period of time, shut off the argon flow.

ACCELERATOR CURRENT

The accelerator grid current is indicated by a display on the RFB-1200 front panel. No particular value can be given as a limit for accelerator current. Instead, it is a rapid rise in accelerator current with increasing beam current that should be avoided. There are two contributions to accelerator current. One is the background current due to low-energy charge-exchange ions. This contribution increases with both facility pressure and beam current. The contribution of more concern is the direct impingement of high energy ions on the accelerator grid. As the beam current is increased at approximately constant voltage, the diameters of the beamlets passing through accelerator grid holes are also increased. When these beamlets become large enough to

impinge on the sides of the accelerator grid holes, then any further increase in beam current will result in a rapid increase in measured accelerator current. If this current cannot be decreased by adjusting the accelerator voltage, then the beam current should be reduced. If operation is prolonged at a high impingement condition, the accelerator will wear at an increased rate and there may be contamination due to sputtered accelerator material. This material may forward sputter and contaminate the work surface. The material can also back sputter and coat the inside of the discharge chamber causing a degradation of source performance.

It will not be necessary to make frequent checks on accelerator current. Once a maximum beam current and corresponding accelerator current has been established at a particular beam voltage and a particular accelerator voltage, that limit will be reproducible within fairly close limits. An increase in accelerator current with other parameters fixed is usually an indication of a grid alignment problem, coated insulators, or an increase in system pressure.

It should be noted that the accelerator voltage affects the divergence of the ion beam. For each combination of beam voltage and beam current, there is an accelerator voltage which gives the minimum beam divergence. This condition of maximum collimation of the individual beamlets corresponds to an observed minimum value of the accelerator drain current. Operation at accelerator voltages greater than that which minimizes accelerator current

causes the beam to diverge. Increasing the beam divergence by operating at high accelerator voltages may or may not be desirable depending on the particular application.

Section 5

MAINTENANCE

Maintenance is usually limited to replacement of the PBN filament and removal of loose flakes of sputtered material. The PBN filament lifetime will range from 15 to 50 hours depending on operating conditions and reactive gas background level. The large ion current densities that are possible with the Ion Tech source permit large quantities of material to be sputtered. Deposits of this sputtered material in and around the source may require periodic removal. An occasional short to the accelerator grid may need cleaning. After a long period of operation (several hundred hours, in most cases), the quartz discharge chamber and various insulators may require cleaning or replacement.

PLASMA BRIDGE NEUTRALIZER FILAMENT REPLACEMENT

1. REMOVE ALL POWER TO THE ION SOURCE.

WARNING

ALL ION SOURCE ELECTRICAL LEADS OPERATE AT VOLTAGES -
VOLTAGES WHICH CAN BE LETHAL.

2. Disconnect the two (2) cathode filament leads by removing the 10-32 screws attaching them to the back of the PBN.

3. Remove the four (4) 4-40 nuts holding the back plate to the PBN body; and remove the body lead and the back plate filament assembly from the PBN body. Refer to Figure 5.

WARNING

AFTER OPERATION AT EMISSION TEMPERATURES, THE TUNGSTEN FILAMENT USED IN THIS NEUTRALIZER BECOMES VERY BRITTLE. CARE MUST BE EXERCISED IN HANDLING THESE FILAMENTS AS THEY CAN EASILY PUNCTURE THE SKIN AND BREAK OFF, LEAVING PIECES OF EMBEDDED WIRE.

4. Loosen the two (2) 10-32 nuts securing the old filament and remove the filament.
5. Cut a length of new 0.010 inch (0.25 mm) tungsten filament wire approximately 4 inches (10 cm) long.
6. Using the filament jig supplied in the tool kit, form the wire into a hairpin shape with a loop at the end of each of the legs as shown in Figure 6.
7. Position the filament on the two (2) supports and install and tighten the two (2) 10-32 retaining nuts.
8. Replace the back plate filament assembly and body lead, and secure using the fasteners removed in Step 3.
9. Reconnect the two (2) cathode leads.

REMOVAL OF LOOSE FLAKES

Depending on system geometry, flakes of sputtered material can fall from the ion source onto whatever surface is being sputtered resulting in an uneven material removal (for sputter machining) or undesirable contamination (for sputter deposition). The thick layers of sputtered material that build up over a number of runs, tends to detach after exposure to air. Because little flaking occurs in a vacuum, most flaking problems can be avoided by brushing off the external surfaces of the ion source before the vacuum chamber is closed for evacuation. A stainless steel wire brush may be used on most ion source surfaces but a soft bristle brush should be used on the accelerator system grids.

ACCELERATOR SYSTEM

The only routine maintenance required for the accelerator system is to keep the downstream surface of the accelerator grid free of loose flakes of conducting material. It is particularly important to keep the narrow gap between the accelerator grid and the inside diameter of the grid mount plate free of loose flakes. This should be done by brushing or vacuuming loose material from these surfaces. An attempt to blow these surfaces clean using compressed gas may cause particles to lodge in the gap resulting in an accelerator grid short.

After a long period of operation (several hundred hours, in most cases), the insulators in the accelerator system may become coated with conducting material, resulting in current leakage at

high voltages. When the grid leakage becomes greater than a few milliamperes, then the grids should be disassembled and the insulators cleaned or replaced as detailed in Section 7.

Grid alignment is normally only necessary after reassembly, although it is possible that the grids may shift slightly during operation or when cooling after operating at high power levels. Grid alignment procedures are covered in Section 7.

Diagnosing various accelerator system problems such as shorts, arcing, coated insulators and misalignment is covered in Section 6.

DISCHARGE CHAMBER

After a long period of operation (several hundred hours, in most cases), the quartz discharge chamber may become coated with conducting material. This may affect RF tuning. However, it will probably be first evident when conductive particles begin to flake from the inside surface of the chamber and cause accelerator system shorts. When this occurs the quartz discharge chamber can be easily cleaned or replaced, as detailed in Section 7.

Section 6

TROUBLESHOOTING

The problems described below involve fuses, maintenance, operating conditions, and wiring problems in the vacuum system and cables. The OHMMETER CHECK at the end of this section is helpful for diagnosing many of the ion source problems described below. Problems within the power supply (other than fuses) are also possible, but less likely. The error codes and fuse specifications listed below are for the Ion Tech RFB-1200 power supply. For additional information on power supply error codes refer to the RFB-1200 manual.

WARNING

ALL ION SOURCE ELECTRICAL LEADS OPERATE AT HIGH VOLTAGES - VOLTAGES WHICH CAN BE LETHAL. DISCONNECT THE MAIN POWER TO THE POWER SUPPLY BEFORE REPLACING ANY FUSE OR TROUBLESHOOTING ANY ELECTRICAL CONNECTION.

<u>SYMPTOM</u>	<u>POSSIBLE CAUSE</u>	<u>PROBABLE SOLUTION</u>
Front panel display does not light, fan does not come on.	Power cable disconnected.	Connect power cable.
	Circuit breaker tripped.	Close circuit breaker on rear panel.
	Power plug is wired incorrectly.	Wire plug correctly, check for damage.
<u>"E-20" on RFB-1200 current display.</u>	External interlock open.	Close interlock circuit.
Source discharge won't start.	RF power off or not at starting level.	Set RF power at 80 watts.
	Low source or PBN gas flow.	Increase gas flow.

SYMPTOM

POSSIBLE CAUSE

PROBABLE SOLUTION

"E-72" when BEAM is pressed with SOURCE on.

Source discharge has not started yet.

Wait for discharge to start. "E-72" will clear when discharge starts.

"E-71" and SOURCE and BEAM have turned off.

Beam current has dropped below 3 mA, indicating discharge has gone out due to:

Press SOURCE to restart.

- 1) Gas flow to low.
- 2) Source not warmed up sufficiently.
- 3) Momentary arc between grids.

- 1) Increase gas flow.
- 2) Allow source to warm up for 3 to 5 minutes.
- 3) Often this will also improve with longer warm up. Otherwise see p. 6-11.

RF reflected power greater than 15 watts.

AMPS-2A matching network controller is off or not in REMOTE.

Turn on power to AMPS-2A and set toggle switches to REMOTE.

Poor RF electrical connections.

Check all RF electrical connections for good contact.

Matching network not properly set up.

Check set up. If no obvious solution, contact Ion Tech, Inc.

Above normal beam current with no RF discharge power and little or no beam voltage. (Check in MANUAL mode.)

- 1) Screen grid shorted to facility ground.
- 2) Conducting flake between accelerator system grids.

- 1) Locate and remove short.
- 2) Remove flake. (See p. 6-11 of this manual.)

SYMPTOM

POSSIBLE CAUSE

PROBABLE SOLUTION

(page 6-2 cont'd)

"E-05" on both beam and accelerator current displays; or "E-71" on all displays; or LOCAL mode "E-24" on neutralizer display. (See NOTE 1.)

3) Glow discharge or arc between accelerator grids.

3) These are probably due to high gas flow rate, resulting in a pressure near the Paschen law minimum. Reduce the gas flow rate.

Above normal beam current that disappears when discharge power is stopped or decreases to normal when beam voltage is dropped. Gas discharge glow or sparking may be visible with above normal beam current. May indicate "E-05" on beam current display; or "E-71" on all displays; or in LOCAL mode "E-24" on neutralizer display. (See NOTE 1.)

Glow discharge or arc between ion source high voltage lead (or surface) and ground potential.

May also be due to defective insulation or shielding of leads in the vacuum system. If possible, observe location of glow or arc, or look for visible evidence of these. Repair insulation or add additional shielding.

Above normal accelerator current with little or no accelerator voltage. "E-05" on accelerator current display; or "E-71" on all displays; or in LOCAL mode "E-24" on neutralizer display. (See NOTE 1.)

Accelerator lead shorted.
Conducting flake between accelerator system grids.

Locate and remove short.
Remove flake. (See p. 6-11 of this manual.)

NOTE 1: Usually a beam or accelerator over-current condition (E-05) will cause the source discharge to go out resulting in an E-71 error message. However, in LOCAL mode it may trigger an E-24 (beam current greater than neutralizer emission current).

SYMPTOM

POSSIBLE CAUSE

PROBABLE SOLUTION

(page 6-3 cont'd)

In MANUAL mode with RF power off and beam or accel voltage on (See NOTE 2), the beam and accel displays both indicate low currents (a few mA's) which are approximately equal. Resistance between accel connection (pin E) and screen connection (pin D) measures a few mega ohms or less. See Ohmmeter check p. 6-7.

Alumina grid spacer has an arc track or a conductive coating.

Clean or replace grid spacer. (See p. 6-11 of this manual.)

In MANUAL mode with discharge off and beam (or accel) voltage on (See NOTE 2), the beam (or accel) current is a few mA's. Resistance between the screen connection (pin D) or accel connection (pin E) and ground measures a few mega ohms or less. See Ohmmeter check p. 6-7.

Grid insulator, or electrical lead insulator beads have a conductive coating.

Disassemble source and clean or replace insulators. (See DISASSEMBLY, Section 7.)

Slightly high accelerator currents during operation, and requires higher than normal accel voltage to minimize accel current.

Grids are misaligned.

Remove and align grid assembly. (See Section 7.)

NOTE 2: Run this diagnostic test by turning the RF5S main power off, waiting for E-70 to appear on RFB-1200, then turning SOURCE and BEAM on.

SYMPTOM

POSSIBLE CAUSE

PROBABLE SOLUTION

No accelerator current.

Accelerator lead not connected.

Connect lead.

PROBE

No probe current.

Open probe fuse due to:

- 1) Possible short in probe lead.
- 2) Polarity of probe leads reversed.

Repair short or connect leads with proper polarity. Replace "PROBE" fuse (F10: 1/32 A) on RFB-1200 rear panel.

PLASMA BRIDGE NEUTRALIZER

No PBN filament current. "E-23" on emission current display.

Open PBN filament.

Replace filament. (See MAINTENANCE section, p. 5-1.)

Open filament lead.

Connect filament lead.

Open PBN fuse.

Replace "PBN" fuse (F3:5A) on RFB-1200 power board. If new fuse blows, consult Ion Tech, Inc.

No PBN internal discharge. Usual indication is PBN body voltage >75V.

- 1) Insufficient PBN filament current due to PBN filament current limit set to low.
- 2) Insufficient argon flow.
- 3) Open PBN body lead.
- 4) Open PBN body fuse due to body-to-ground or body-to-filament short.

Reset PBN filament current limit. (6.5A recommended for 0.010" tungsten filament.)

Verify proper gas supply connections. Increase gas flow rate.

Connect PBN body lead.

Repair short and replace fuse (F12:1A Picofuse) on RFB-1200 adaptor board. If new fuse blows, consult Ion Tech, Inc.

SYMPTOM

POSSIBLE CAUSE

PROBABLE SOLUTION

(page 6-5 cont'd)

5) Insulating coating on inside of PBN chamber. Usually caused by exposure to atmosphere while hot.

Clean coating from inside of chamber.

Internal PBN discharge present but PBN body voltage >25V.

Same as 1), 2), 4), and 5) above.
NOTE: It is possible for the internal discharge to start with a blown body fuse F12. However, this requires an abnormally high filament current and/or gas flow rate.

No PBN emission current.

MANUAL mode: No error message present. LOCAL mode: PBN emission at zero during start up.

PBN emission request set at zero.

Enter PBN emission current request.

MANUAL mode: "E-03" on PBN emission current display.

Same as 1), 2), 4), and 5) above.
or

Open PBN emission fuse.

Replace PBN emission fuse (F11:2A Pico-fuse) on RFB-1200 adaptor board. If new fuse blows, contact Ion Tech, Inc.

"E-24" on neutralizer display.

Neutralizer emission-to-beam current ratio is less than one due to:

1) Transition from MANUAL to LOCAL mode with insufficient PBN emission current.

1) Increase PBN emission current target.

2) Short causing a large beam current.

2) See high beam current symptoms (p. 6-2) and DIAGNOSING ACCELERATOR SYSTEM PROBLEMS p. 6-11.

3) Loss of PBN emission current.

3) See PBN symptoms above.

OHMMETER CHECK

The following resistance checks can be helpful in tracing shorts between the various leads and components of the Ion Beam Source. The source and the neutralizer cables must be disconnected for this procedure.

1. Turn all power supplies OFF and disconnect the source and the neutralizer cables from the rear panel of the RFB-1200 power supply cabinet.

WARNING

ALL ION SOURCE ELECTRICAL LEADS OPERATE AT HIGH VOLTAGES - VOLTAGES WHICH CAN BE LETHAL.

2. Verify ground connection. Measure the resistance between the feedthrough cable connector body and both the facility ground and the source gas line. The resistance in both cases should be zero. If the resistance is greater than zero check for a loose or disconnected ground lead and correct the problem.
3. Check for shorts to facility ground. At the vacuum feedthrough connector, measure the resistance between every pin and facility ground. This check should indicate an open circuit except for Pin G which is a ground connection. If any of the pins other than G show a short to ground see Step 6 below.

4. Check for shorts between components. At the vacuum feedthrough/s, measure the resistance of every pin with respect to every other pin. This check should indicate an open circuit between every pair of pins except for the following ones which should show a resistance of less than 0.5 Ohms indicating the presence of a PBN filament. If any pins are shorted, other than the ones indicated below, see Step 6.

COMPONENT / PINS

PBN Filament/A and B

5. Cathode and neutralizer filament check. The PBN filament resistance measured in Step 4 above should be less than 0.5 Ohms. An open circuit indicates a loose connection or a failed filament.
6. Troubleshooting shorts. Possible causes of shorts are:
 - a) Incorrect or faulty lead connections, either between the power supply cable and the feedthrough or the feedthrough and the source.
 - b) Loose flakes of conductive material trapped between adjacent components.
 - c) Coated insulators.
 - d) An internal mechanical problem.

Use the following procedures to help identify and correct the cause of the short.

- A. Disconnect all source leads on the vacuum side of the electrical feedthrough.
- B. Repeat Steps 3 and 4 above. If the short is still present, the problem is in the power supply cable or the cable connections in the feedthrough high voltage cover. Identify the faulty connection and correct it.
 - a) Check that the leads are connected to the correct feedthrough pin as shown in the electrical connection diagram in the RFB-1200 manual.
 - b) Check that none of the lugs or feedthrough electrical connectors are touching an adjacent lug or connector.
- C. If Step B shows no short, then repeat Steps 3 and 4, this time measuring the resistance at the electrical connectors on the feedthrough end of the source and PBN leads, using the source shroud as the ground reference. If this check shows no short, the problem was probably due to a loose flake of conductive material, and the source

should be disassembled and cleaned. If the short is still present during the above check, then:

- a) Use the pin designations in Figure 1 (source) and Figure 5 (PBN) to identify the shorted components.
- b) Follow the SOURCE DISASSEMBLY procedure in Section 7 to gain access to the shorted components.
- c) Inspect for flakes of loose material between surfaces of adjacent components and around insulator assemblies.
- d) Remove any loose flaking material and blow clean with a clean dry gas such as nitrogen.
- e) Measure the resistance between the shorted components. i) If they are still shorted and show a resistance less than approximately 10 Ohms, visually inspect the components for a mechanical problem, such as a damaged part, parts out of position or misassembled. ii) If they are still shorted and the resistance is greater than 10 Ohms the insulators are probably coated with conductive material and should be cleaned or replaced. (See INSULATORS page 7-12.)

- D. Correct any problems identified in Steps B. and C. above.

ACCELERATOR SYSTEM

There are a number of different types of high voltage shorts which can occur in the accelerator system. These are described below with their symptoms and probable cause. These shorts normally require removal and cleaning of the grid assembly. Detailed instructions for this are given in Section 7.

Loose Flakes

A flake of sputtered material can become lodged between the accelerator system grids or between the accelerator grid and the source shroud resulting in a continuous high voltage short. Such a short is indicated if large beam and accelerator currents are present with the BEAM on but the RF power turned off. This can be checked in MANUAL mode as described in the NOTE on page 6-12. If there is a short between the grids, the RFB-1200 power supply will display high currents or an E-05 error message on the current display for both the beam and the accelerator. An E-05 indicates an over-current condition. If the short is between the downstream surface of the accelerator grid and the source shroud, the E-05 will appear only on the accelerator display. An accelerator to shroud short can probably be cleared by brushing or vacuuming off any loose flakes around the accelerator grid. If the flake is between the grids, the grids must be disassembled and cleaned as detailed in Section 7.

Sometimes shorts due to loose flakes are not continuous but are intermittent during operation. In such cases the E-05 error message described above may not occur. Instead, during normal operation the short may cause the source discharge to extinguish resulting in an E-71 error message. In LOCAL mode, an E-24 error message (beam current greater than PBN emission current) may occur.

Coated Insulators

After a long period of operation (several hundred hours, in most cases), the insulators in the accelerator system may become coated with conducting material, resulting in current leakage at high voltages. Such a condition is indicated if turning up the beam and/or the accelerator voltage with the source discharge off results in small to moderate beam and accelerator currents. (See NOTE below.) Such leakage currents are likely to be larger when the source is at operating temperature than when it is cold. When the grid leakage currents become greater than a few milliamperes, then the grids should be disassembled and the insulators cleaned or replaced as detailed in Section 7.

NOTE: Grid shorts and insulator leakage currents can be tested in the following manner. Place the RFB-1200 power supply in MANUAL mode and turn the RF5S main power off. Wait for E-70 to appear on the RFB-1200, then turn on the SOURCE and BEAM. The beam and accelerator volt-

ages will increase to the values shown on the voltage displays. The grid leakage currents can then be read on the beam and accelerator current displays.

Plasma Breakdown or Arcing

The grid problems described above are relatively easy to identify. Much more difficult problems to diagnose are those associated with plasma breakdown or arcs between the grids, because they result in symptoms which are common to a variety of causes. Similar symptoms are common to either a brief arc or a sustained glow discharge around any of the high voltage components in the source. The breakdowns may occur, for example, between the grids, around the RF coil, or around the high voltage electrical connections. In general, such electrical breakdowns are due to a combination of high voltage in a locally high pressure region, high voltage components exposed to a plasma which is near ground potential (e.g. the charge exchange plasma), or a high voltage plasma (e.g. the source plasma) exposed to ground potential surfaces. The local high pressures can be caused by outgassing or by gas flow rates which are too high. Plasma exposure can be due to poorly shielded high voltage leads or components assembled improperly.

If the discharge breakdown is between the grids, the condition will result in a sudden drop in the beam and accelerator voltage accompanied by a large increase in both the beam and accelerator current. Depending on the duration of the breakdown, there may

or may not be an indication on the RFB-1200 displays. While an E-05 error message is possible with this type of short, it is not very likely. Usually a beam or accelerator over-current condition (E-05) will cause the source discharge to go out resulting in an E-71 error message before the E-05 can be displayed. In LOCAL mode a beam over current condition can trigger an E-24 error message (beam current has exceeded neutralizer emission current). The grid leakage current test described in the NOTE on page 6-12 will be negative (i.e., show zero or very low currents) if the problem is due to a discharge breakdown between the grids. This is because a discharge breakdown between the grids will usually not occur when the RF power is turned off even with the beam and accelerator voltages on.

Often the above symptoms are related to outgassing during initial start up and will decrease as the source is warmed up. If the symptoms persist after a reasonable warm up period (5 to 10 minutes), then it may be necessary to disassemble the source and grids to inspect for evidence of arcs or glow discharge breakdowns. See Section 7 for DISASSEMBLY.

Coated Screen Grid

After a long period of operation (typically hundreds of hours) the metal surfaces exposed to the source discharge (the screen grid and grid mount ring) may coat with an insulating coating. These surfaces provide the DC electrode for beam extraction. If they become coated with an insulated coating, then the source

5. Remove the ion source from its mounting bracket inside the process chamber.
6. Carefully place the ion source on a clean work surface.
7. Disconnect the PBN electrical connections from the PBN.
8. Remove the four (4) 10-32 socket cap screws from the grid mount plate and set the PBN aside.
9. Remove the two (2) 4-40 socket cap screws on each of the split collar lead clamps for the screen and accelerator grid leads.
10. Remove the grid mount plate/discharge chamber assembly by carefully sliding it (axially) away from the shroud, far enough to disengage the gas inlet tube, then disconnect the screen and accelerator grid leads.

NOTE: The screen and accelerator leads must slide through the back plate during the step above.

11. Place the grid mount plate assembly, grid side down, on a clean flat surface, and remove the three (3) 4-40 nuts and retainer ring holding the discharge chamber to the grid mount ring.
12. Remove the discharge chamber and set it aside.

13. Remove the two (2) 4-40 screws holding the grid assembly to the grid plate and carefully place the grid assembly out of the way.
14. Remove the four (4) 10-32 socket cap screws from the shroud back plate and remove the back plate/RF coil assembly from the shroud. Also remove the screen and accelerator grid leads from the back plate; and the leaf spring from the gas inlet tube.
15. Loosen the 4-40 socket set screw on each of the RF power lead connectors and remove the connectors and the first alumina bead from each lead.
16. Temporarily reinstall and tighten the connector on each power lead to hold the alumina beads in place while the outer braided shield is being removed.
17. Loosen the knurled collar for each of the power lead shields at the shroud back plate and slide the shield off the beaded leads.
18. Again remove the power lead connectors and slide the alumina beads off the solid copper conductor.

NOTE: The conductor will probably need to have kinks and bends straightened before the alumina beads can be removed.

19. Loosen the 4-40 socket set screw on the collar for each of the RF power leads and remove the collars.

NOTE: Set screw access is through the vent hole in the shield housing.

20. Remove the RF coil assembly, the four (4) #10 male insulators and two (2) #10 cups from the shroud back plate.
21. Remove the retainer ring from the gas isolator assembly and remove the isolator assembly from the shroud back plate.
22. This completes disassembly of the ion source. Servicing procedures for various components and sub-assemblies are described below in the sections following SOURCE REASSEMBLY.

SOURCE REASSEMBLY

1. Reassemble the ion source by reversing Steps 1 through 22 of the SOURCE DISASSEMBLY procedure with the following additional guidelines.
2. When reassembling the alumina beads and braided shields to the RF power leads, be sure to leave the last bead off each lead for installation after the braided shields are in place.

NOTE: As during disassembly, it is recommended that the lead connectors be attached and tightened in place when the braided shield

is being slipped over the beads. This prevents the beads from sliding off the end of the conductor.

3. During operation the RF coil material is annealed and becomes relatively soft. After reinstalling the coil, check that the individual turns are approximately equally spaced and have a minimum of .060" (1.5 mm) gap. Adjust as necessary.
4. When reassembling the grid assembly to the grid mount plate, make sure that the index marks on the grid mount ring and the grid mount plate are aligned.
5. When reassembling the grid mount plate/discharge chamber assembly to the shroud, make sure that the index marks on the grid mount plate and shroud are aligned and take care to gently engage the gas inlet tube into the hole in the upstream end of the quartz discharge chamber.

NOTE: There should be plenty of clearance on all components of the RF coil, gas isolator and discharge chamber assemblies to allow the discharge chamber to slip easily into the RF coil and engage the gas inlet tube. DO NOT FORCE IT. If the assembly does not slip

together easily, check that the RF coil is centered around the gas isolator, and adjust as necessary.

6. When reassembling the beam and accelerator leads to the shroud back plate, make sure that the lead labels marked on the last bead on the feedthrough end of the lead correspond to the designations (D and E) engraved on the back plate.

NOTE: The screen grid lead (D) ends in a #40 ring lug. The accelerator grid lead (E) ends in a connector with set screws.

7. After reassembling the ion source and reinstalling it in the vacuum system, perform the OHMMETER CHECK outlined on page 6-7.

GRID ALIGNMENT CHECK, INSPECTION, AND CLEANING

CAUTION

To prevent contamination, wear clean gloves or finger cots whenever handling grid components.

1. Remove the grid assembly by following Steps 1 through 13 in the SOURCE DISASSEMBLY section.

2. Unthread the accelerator post bushing from the 0-80 screw on the upstream side of the grid assembly (Figure 4); then place the assembly upstream side down on a clean work surface.
3. Grid alignment can now be checked by carefully inserting a #46 (0.081 inch; 2.06 mm) grid alignment pin (supplied) into each of the three (3) grid alignment holes (see Figure 4). If the grids are properly aligned, the pins should pass easily through the alignment holes in both grids without binding. DO NOT FORCE, use a gentle rotating motion.
4. If only grid alignment is required, loosen the three (3) 4-40 screws shown in Figure 4 and go to Step 8 on page 7-11 of the GRID ASSEMBLY AND ALIGNMENT section.
5. To completely disassemble the grids, remove the three (3) 4-40 screws holding the grid stack together, then remove the 0-80 nut and lock washer from the accelerator post screw.
6. Inspect the grids for pits or deposits caused by arcing and deposits due to sputtered material from the workpiece.

NOTE: Arcing is usually indicated by a projection of melted metal or deposited graphite (depending on grid material option) on the

downstream side of the screen grid and a corresponding pit on the adjacent surface of the accelerator grid. Arcing may be the result of contamination such as finger oils, salts, or moisture. This is usually indicated by a matching irregular pattern, on adjacent surfaces of both grids, which appears darker than the surrounding surface.

7. Remove any projection due to arcing and any loose sputtered material. If the material can be easily picked loose with a sharp knife or wiped off by a light pass of 600 grit silicon carbide paper, this should be done. Deep sanding should not be used. Sanding should be stopped as soon as the normal gray color of the pyrolytic graphite (silver for metal grids) is visible. Deposits on the downstream side of the accelerator grid are generally not of concern unless they are so loose that they might fall on the workpiece. If the sputtered material strongly adheres to the grid, it is recommended that it be left on the grid.
8. Lightly blow off any dust or loose particles from the grid using a clean dry gas such as nitrogen.
9. If the grids are contaminated with fingerprints or other oily residues they should be cleaned in a hot water and detergent solution. (We have found that

"Ivory[®]" brand liquid detergent works well and leaves little residue.) If possible, a 15 minute ultrasonic cleaning is recommended. After cleaning, rinse thoroughly in very hot water. Blow off water using a clean dry gas such as nitrogen, then dry using a heat lamp or in an oven for at least 60 minutes at 300° C. Remember to wear gloves or finger cots while cleaning and handling components.

NOTE: The 300° C bakeout is probably not necessary for metal grids.

10. Inspect the grid spacer and grid insulator for arc tracks around their edges and for conductive coatings which might bridge the grid sputter-break grooves shown in Detail A of Figure 4. Some coating is normal around the edge of the insulators but it should not extend over the flat faces to a point where it will contact the adjacent grid surface. If the insulators are coated to the extent that they provide a conductive path between the grids or from the accelerator grid to the shroud, then they must be cleaned or replaced. Cleaning can be done by bead blasting, followed by the cleaning procedure outlined in Step 4 on Page 7-13.

GRID ASSEMBLY AND ALIGNMENT

If the grids are already assembled and only need alignment, go to Step 8 below.

NOTE: For ease of assembly, the accelerator grid, the screen grid, the alumina grid insulator, the grid mount ring, and the grid mount plate are each marked on their upstream surface with an index mark filed approximately 0.015 inch deep near the outside edge. The accelerator grid is the grid with a 0.010 inch deep annular groove on both sides.

1. Hold the accelerator grid with the index mark at the 12 o'clock position and the upstream (index mark) surface facing you. The accelerator connection hole is the small one at the one o'clock position.
2. Place the alumina grid spacer on top of the accelerator grid, aligning the accelerator connection holes.
3. Insert a 0-80 screw through the accelerator connection hole from the downstream side, and install a 0-80 lock washer and nut as shown in Figure 4. Center the grid space on the accelerator grid and tighten the 0-80 nut.

CAUTION

The 0-80 nut should be tightened only enough to compress the lock washer. **DO NOT OVERTIGHTEN** as this may fracture the grid or the ceramic spacer.

4. Assemble the grid mount ring, screen grid, grid spacer, and accelerator grid in the order shown in Figure 4, taking care that the index marks are aligned and on the upstream surface.
5. Place the grid insulator on the grid stack, aligning the relief for the accelerator connection over the head of the accelerator post screw as shown in Figure 4.
6. Center the grid mount ring on the assembly.
7. Install three (3) 4-40 screws to hold the assembly loosely together, but do not tighten.
8. Insert a #46 (0.081 inch; 2.06 mm) grid alignment pin (supplied) into each of the grid alignment holes.
9. With all of the pins held carefully in parallel alignment, firmly tighten the three (3) 4-40 screws.
10. Remove the alignment pins.
11. Thread the accelerator post bushing on to the 0-80 post, as shown in Figure 4, and finger tighten.
12. Reassemble the grids to the ion source following the procedure in the SOURCE REASSEMBLY section beginning on page 7-4.

INSULATORS

1. Use the OHMMETER CHECK on page 6-7 to determine if any of the insulators are coated with conductive material and to identify which insulators need to be serviced.
2. Remove the coated insulators by following the procedure in the SOURCE DISASSEMBLY section beginning on page 7-1.
3. Clean or replace the coated insulators.
4. The insulators can be cleaned by bead blasting, using the following procedure:
 - a) Bead blast using 50 micron silicon carbide abrasive, or equivalent.
 - b) Rinse the insulators in hot water, then ultrasonic clean them in a hot water and detergent solution for 30 minutes changing the solution at least once. (We have found that "Ivory[®]" brand liquid detergent works well and leaves little residue.)
 - c) After cleaning, wear gloves or finger cots when handling the insulators.
 - d) Rinse thoroughly in very hot water.
 - e) Blow off water using a clean dry gas such as nitrogen.

f) Dry using a heat lamp or an oven for at least 15 minutes at 150° C.

5. Reassemble the source following the procedures in the SOURCE REASSEMBLY section beginning on page 7-4.

DISCHARGE CHAMBER

1. Inspect the discharge chamber for conductive coatings on either the inner or outer surface.
2. If the chamber has either a conductive coating, or an insulating coating which is loose and flaking, clean by bead blasting or by sanding with 600 grit silicon carbide paper and then follow cleaning Steps 4b through f in the INSULATOR Section above.
3. If the chamber has a conductive coating which is not easily removed with the above procedure, then it should be replaced.

NOTE: A conductive coating on the outer surface of the discharge chamber is an indication of a glow discharge in the region between the chamber and the shroud. This is usually due to operation at too high of a pressure.

PLASMA BRIDGE NEUTRALIZER

1. Disassembly and reassembly is per the exploded view shown in Figure 5.

2. Inspect the orifice plate and replace if the orifice is eroded to a diameter greater than .050 inches.
3. Inspect and either clean or replace the insulators as necessary. The insulators can be cleaned following instructions in Step 4 of the INSULATOR Section above.
4. Using 220 to 400 grit silicon carbide paper, remove any loose or flaking material, or any insulating coating, from the cathode support plate, body, or orifice plate.
5. Wipe clean with acetone followed by isopropyl alcohol, allow to dry thoroughly, then reassemble.
6. Inspect the joints between the body and the orifice plate and the body and cathode support plate by holding the assembled unit up to a light and sighting along the joints. These joints need to be tight to prevent excess gas leakage. If light is visible through the points during inspection, check for proper assembly. If necessary the joint surfaces can be sanded flat with 220 to 400 grit silicon carbide paper mounted on a hard flat surface.
7. Replace the PBN filament using the procedure in the MAINTENANCE Section 4.

LIMITED WARRANTY STATEMENT

ION TECH, INC.

2330 E. Prospect, Fort Collins, CO 80525, 303-221-1807

Supercedes All Previous Limited Warranty Statements

WARRANTY

Products manufactured by seller are warranted against defects in materials and workmanship for twelve (12) months from date of shipment thereof to customer, and seller's liability under valid warranty claims is limited, at the option of seller, to repair, replacement, or refund of an equitable portion of the purchase price of the product. Items expendable in normal use are not covered by this warranty. All warranty replacement or repairs of parts shall be limited to equipment malfunctions which, in the sole opinion of seller, are due or traceable to defects in original materials of workmanship. All obligations of seller under this warranty shall cease in the event of abuse, accident, alteration, misuse or neglect of the equipment. In-warranty repaired or replacement parts are warranted only for the remaining unexpired portion of the original warranty period applicable to the repaired or replaced parts. After expiration of the applicable warranty period, customer shall be charged at the then current prices for parts, labor, and transportation.

Reasonable care must be used to avoid hazards. Seller expressly disclaims responsibility for loss or damage caused by use of its products. Except as stated herein, seller makes no warranty, express or implied (either in fact or by operation of law), statutory or otherwise: and, except as stated herein, seller shall have no liability under any warranty, express or implied (either in fact or by operation of law), statutory or otherwise. Statements made by any person, including representatives of seller, which are inconsistent or in conflict with the terms of this warranty shall not be binding upon seller unless reduced to writing and approved by an officer of seller.

WARRANTY REPLACEMENT AND ADJUSTMENT

All claims under warranty must be made promptly after occurrence of circumstances giving rise thereto, and must be received within the applicable warranty period by seller or its authorized representative. Such claims should include the product serial number when available, the date of ship-

ment, and a full description of the circumstances giving rise to the claim. Before any products are returned for repair and/or adjustment, written authorization from seller or its authorized representative for the return and instructions as to how and where these products should be returned must be obtained. Any product returned to seller for examination shall be sent prepaid via the means of transportation indicated as acceptable by seller. Seller reserves the right to reject any warranty claim not promptly reported and any warranty claim on any item that has been altered or has been returned by non-acceptable means of transportation. When any product is returned for examination and inspection, or for any other reason, customer shall be responsible for all damage resulting from improper packing or handling, and for loss in transit, notwithstanding any defect or nonconformity in the product. In all cases seller has sole responsibility for determining the cause and nature of failure, and seller's determination with regard thereto shall be final.

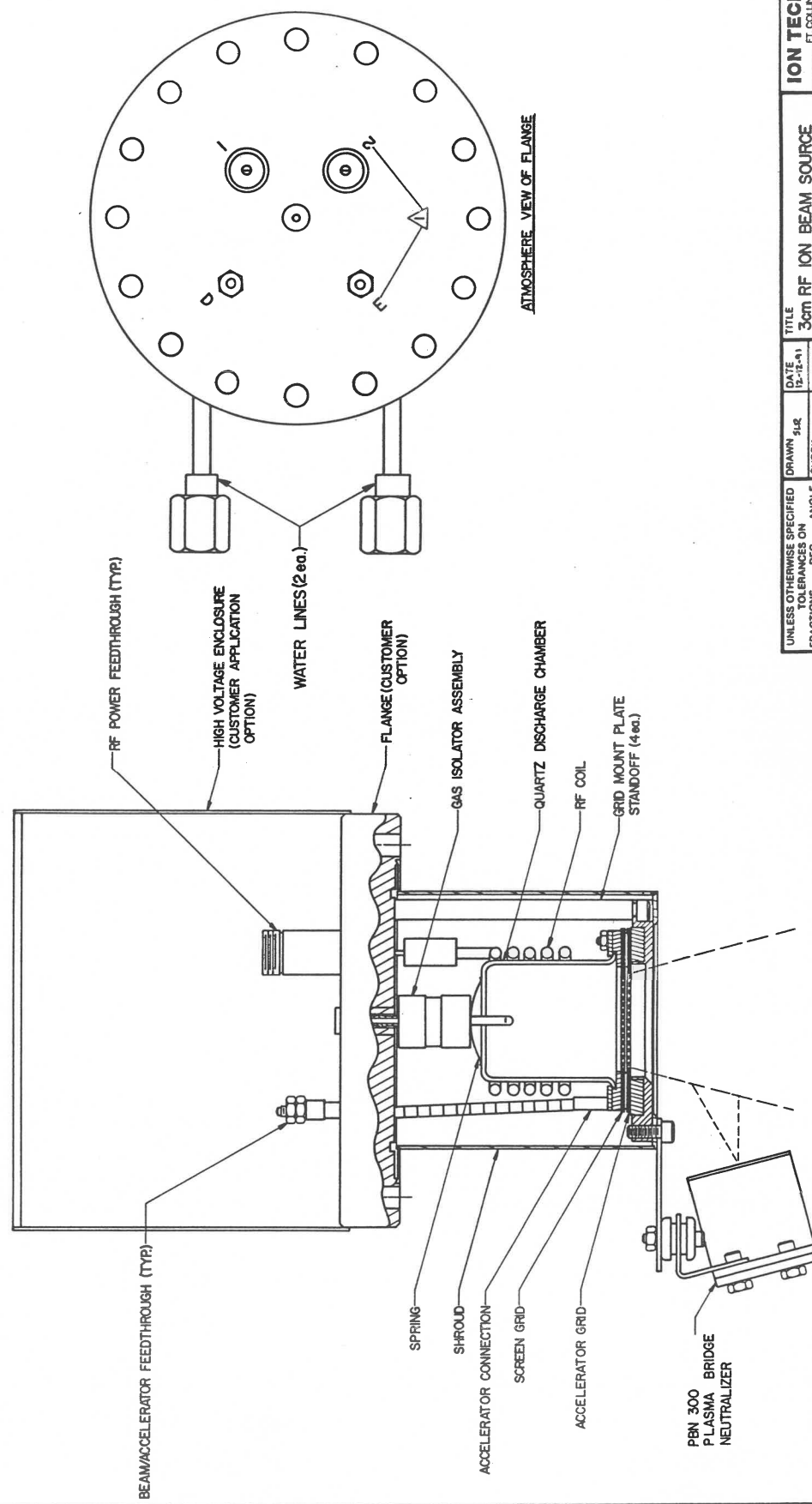
If it is found that seller's product has been returned without cause and is still serviceable, customer will be notified and the product returned at customer's expense; in addition, a charge for testing and examination may be made on products so returned.

DAMAGES AND LIABILITY

Seller's liability for damages shall not exceed the amount seller actually receives for the product furnished or to be furnished, or service rendered, or to be rendered, as the case may be, which is the subject of claim or dispute, and in no event shall seller be liable for incidental, consequential or special damages. Liability to third parties for bodily injury, including death from seller's performance shall be determined in accordance to law and the total liability limitation stated above shall not be construed as a limitation on seller for damages for any such bodily injury, including death.

ITEM	DRAWING NO.	PART DESCRIPTION	FINISHED PART NO.	UNFINISHED PART NO.	SPECIFICATIONS	MATERIAL (MATERIAL LISTED IN FINISHED DIMENSIONS EXCEPT AS NOTED)	RECD
							(MANUFACTURER)

NOTE:
 △ TYPICAL LEAD DESIGNATIONS.



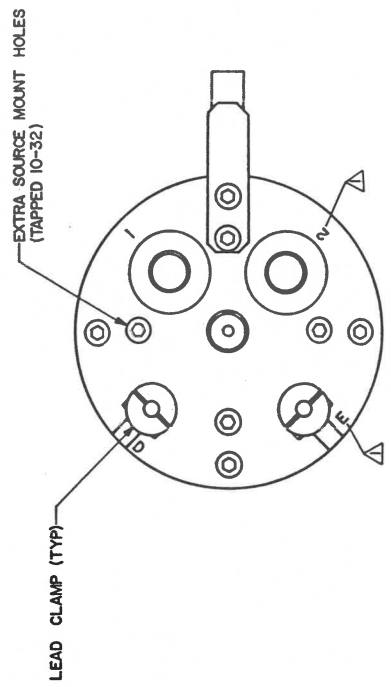
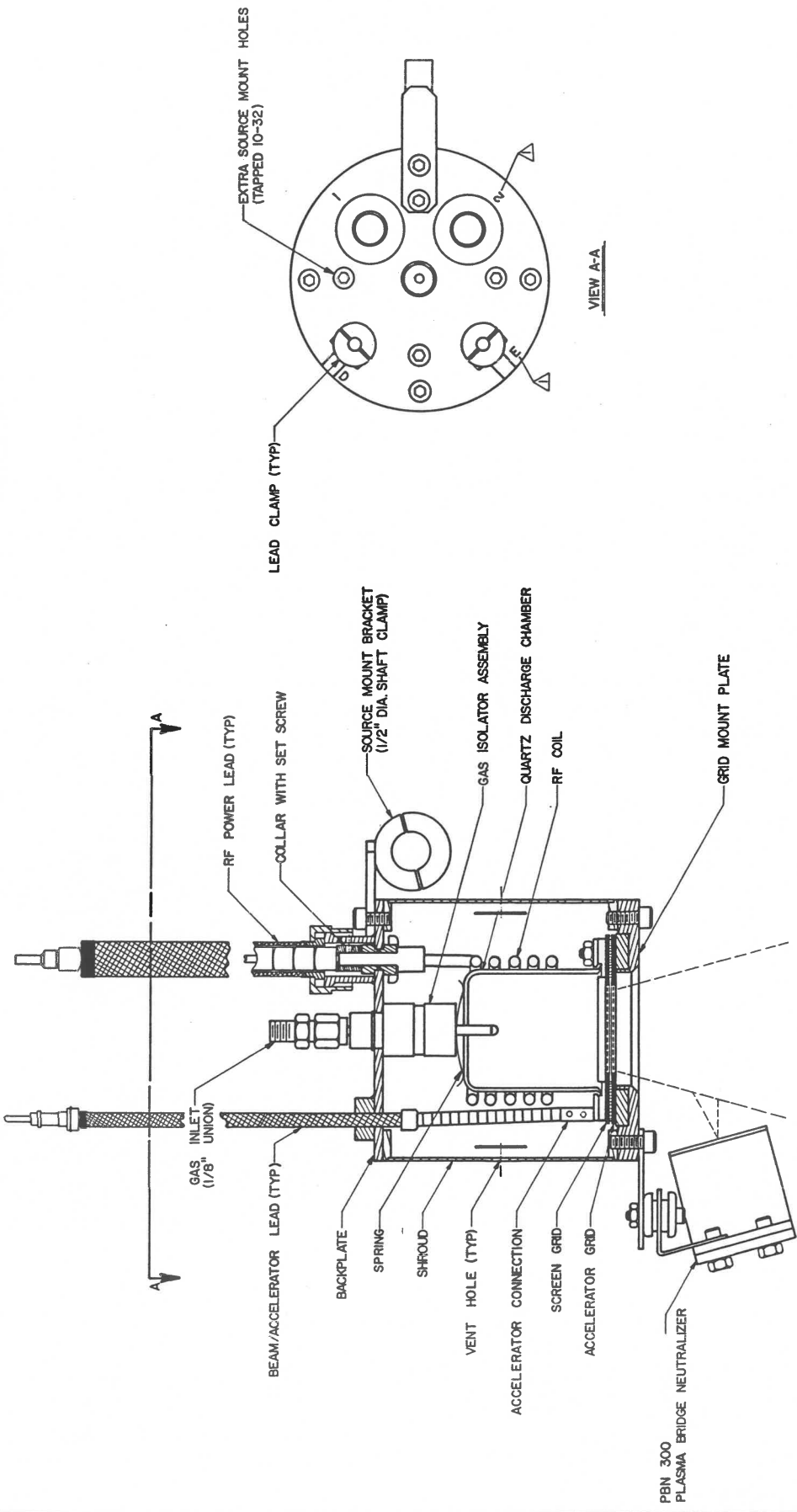
UNLESS OTHERWISE SPECIFIED	DRAWN	DATE	TITLE
FRACTIONS ON ANGLES	2/16	12-12-91	3cm RF ION BEAM SOURCE
TOLERANCES ON DEC	±.008	12-12-91	— FLANGE MOUNT
DEC	±.008		
ANGLE	2		
SURFACE FINISH	ENGR		
REMOVE ALL BURRS AND SHARP EDGES	QC MGR		
ALL THREADS CLASS 2	PROD MGR		
DO NOT SCALE DRAWING	APPD	12-12-91	USED ON
	DWG		SCALE
			NEXT ASSY
			SHEET OF
			REV
			C
			DWG NUMBER
			91-6375-1

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FIGURE 1A

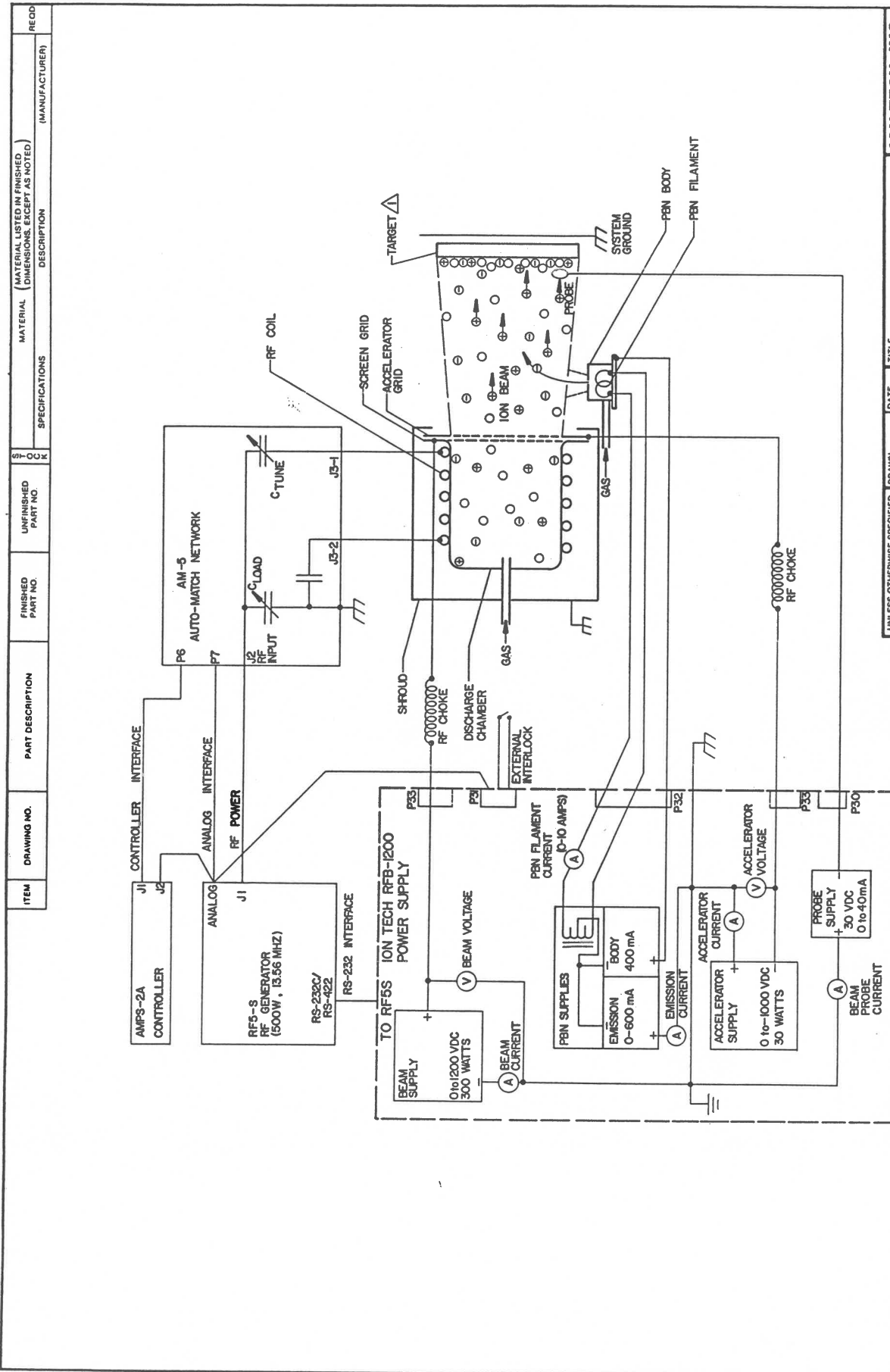
ITEM	DRAWING NO.	PART DESCRIPTION	FINISHED PART NO.	UNFINISHED PART NO.	STOCK	SPECIFICATIONS	MATERIAL (MATERIAL LISTED IN FINISHED DIMENSIONS, EXCEPT AS NOTED)	(MANUFACTURER)	REV
------	-------------	------------------	-------------------	---------------------	-------	----------------	--	----------------	-----

NOTE: Δ TYPICAL LEAD DESIGNATIONS. LABELS ARE ALSO MARKED ON FEEDTHROUGH END OF LEADS.



UNLESS OTHERWISE SPECIFIED		DRAWN		DATE		TITLE	
TOLERANCES ON FRACTIONS	DEC 2:104	5:12	CHECK	4-23-91	30CM RF ION BEAM SOURCE	ION TECH, INC.	
ANGLE	2	ENGR	OC MGR	4-23-91	-INTERNAL MOUNT	THIS DRAWING IS THE PROPERTY OF ION TECH INC AND MAY NOT BE USED, REPRODUCED, PUBLISHED OR DISCLOSED TO OTHERS WITHOUT EXPRESS AUTHORIZATION BY ION TECH, INC.	
SURFACE FINISH	✓	PROD MGR	APPD			C	
REMOVE ALL BURRS AND SHARP EDGES.						REV	
ALL THREADS CLASS 2.						91-6142-2	
						A	

E/C	BIBO	CHANGE	DATE
64	2/23		11-14-91
CHUCK			
DO NOT SCALE DRAWING			
USED ON	NET ASSY	SHEET	OF
91-6142-2			



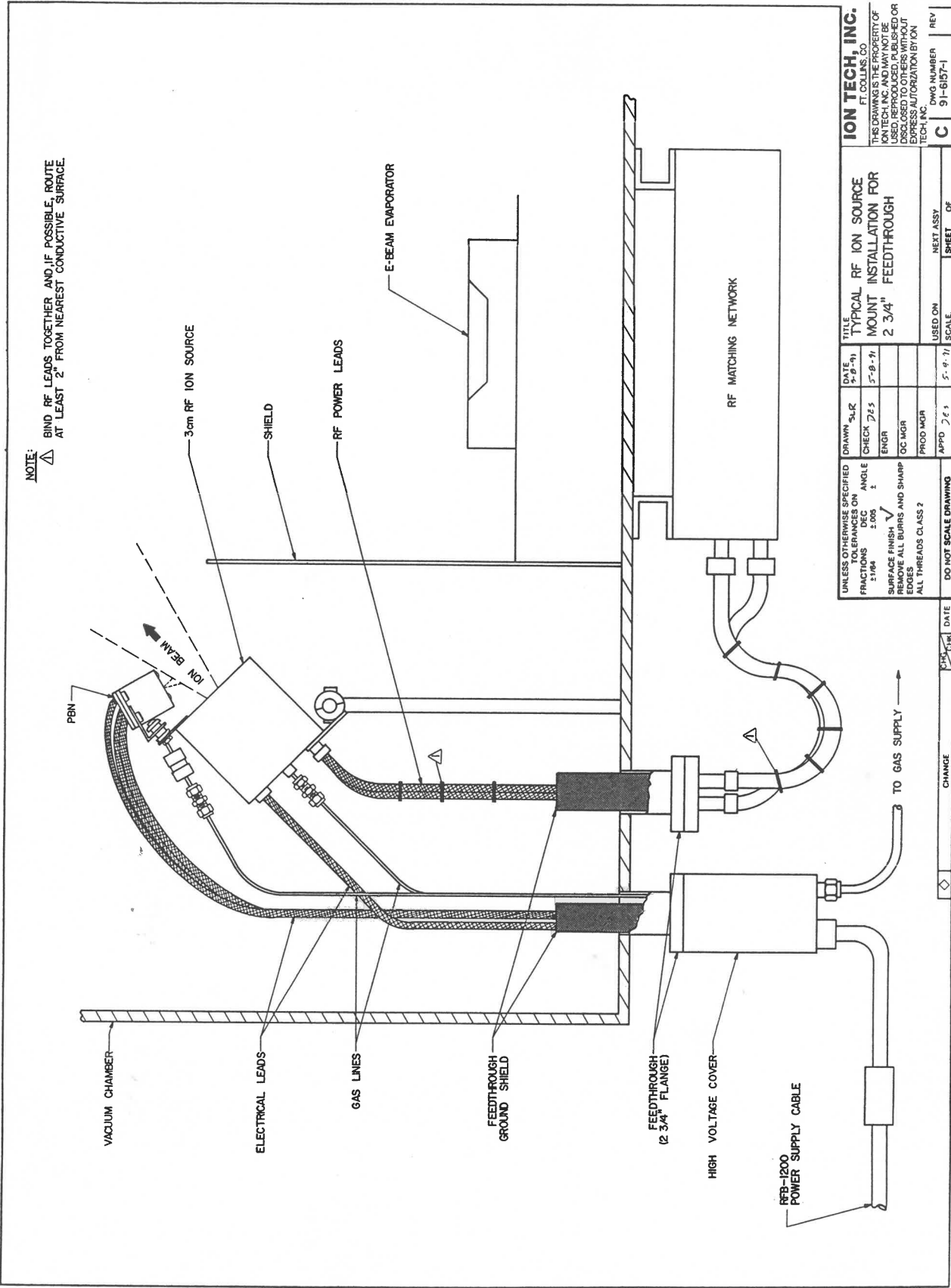
ITEM	DRAWING NO.	PART DESCRIPTION	FINISHED PART NO.	UNFINISHED PART NO.	SPECIFICATIONS	MATERIAL (MATERIAL LISTED IN FINISHED DIMENSIONS, EXCEPT AS NOTED)	(MANUFACTURER)	RECD

UNLESS OTHERWISE SPECIFIED		DATE
FRACTIONS ON DRAWING ON ANGLE	3/16 4	4-12-91
DECIMALS	2.005 2	
SURFACE FINISH	✓	
EDGES	ALL BURRS AND SHARP EDGES TO BE REMOVED BY CUTTING	
ALL THREADS	CLASS 2	
PROD. INGR.		
APPR. DATE	4-12-91	
CHK. DATE		
CHG.		
CHANGE	E/C B180	
USED ON	NEXT ASSY	
SCALE		
DWG NUMBER	91-631-1	A

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TITLE	RF ION SOURCE ELECTRICAL BLOCK DIAGRAM WITH PLASMA BRIDGE NEUTRALIZER
DRAWN	J.E.S.
CHECKED	J.E.S.
ENGR.	OC MGR

NOTES:
 1. TARGET MAY OR MAY NOT BE CONNECTED TO SYSTEM GROUND.
 2. REFER TO THE INSTALLATION SECTIONS OF THE RFB-1200 POWER SUPPLY MANUAL FOR SPECIFIC CABLE CONNECTION INSTRUCTIONS. (J & P DESIGNATIONS REFER TO JACK & PLUG LABELS ON POWER SUPPLY BACK PANEL).

FIGURE 2



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 DWG NUMBER 91-6157-1
 REV C

UNLESS OTHERWISE SPECIFIED	DATE	TITLE	DATE	DATE	DATE
TOLERANCES ON FRACTIONS	5-9-71	TYPICAL RF ION SOURCE MOUNT INSTALLATION FOR 2 3/4" FEEDTHROUGH	5-9-71	5-9-71	5-9-71
ANGLES	2/25				
SURFACE FINISH	ENGR				
REMOVE ALL BURRS AND SHARP EDGES	DC MGR				
ALL THREADS CLASS 2	PROD MGR				
	APPD				

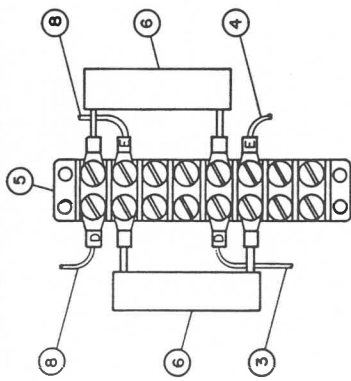
DO NOT SCALE DRAWING	DATE	SCALE	REV	OF

CHANGE	DATE	BY	REASON

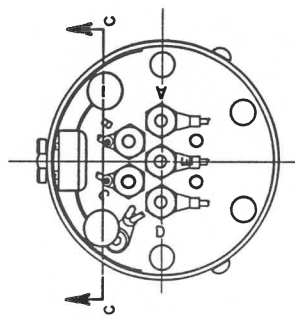
FIGURE 3A

NOTE:

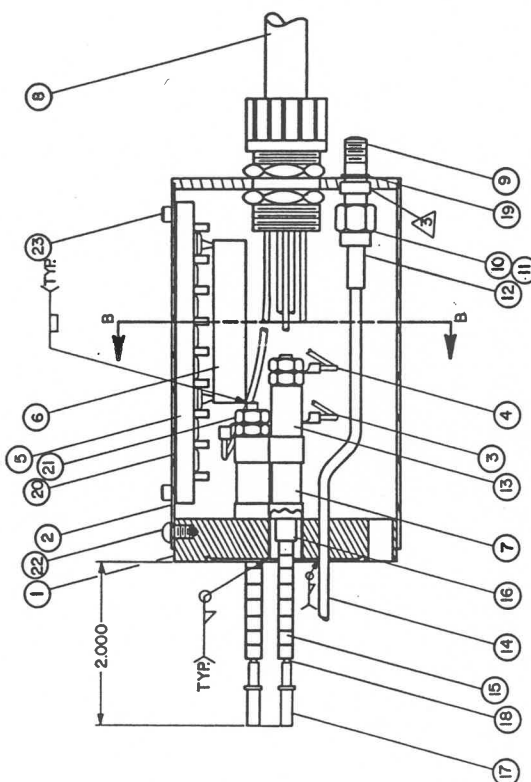
1. ASSEMBLE HARNESS (ITEM 8) TO HVC (ITEM 2) AND CONNECT HARNESS STRIP (ITEM 5) AS SHOWN IN SECTION C-C.
2. BEFORE INSTALLING HVC AND LEADS TO THE FLANGE (ITEM 1), COIL THE BUNDLE OF TIE-WRAPPED LEADS COUNTER-CLOCKWISE (AS VIEWED FROM THE OPEN END OF THE HVC) APPROX. ONE FULL TURN, THEN BEND THE B & C LUGS AT 90° AS SHOWN IN SECTION A-A.
3. WHEN ASSEMBLING THE HVC (ITEM 2) TO THE FLANGE (ITEM 3), MAKE SURE THAT THE HEX FLATS ON ITEM 9 ARE ALIGNED WITH THE MILLED SLOTS ON THE INSIDE OF THE HVC. TAKE CARE NOT TO SCRATCH THE SEAL SURFACE ON ITEM 9 DURING ASSEMBLY.



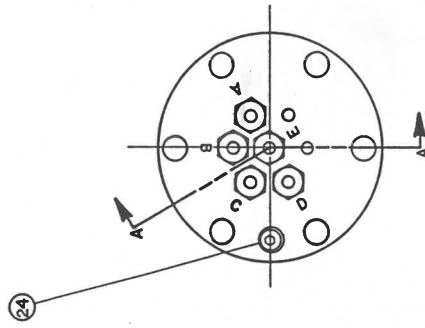
SECTION C-C



SECTION B-B

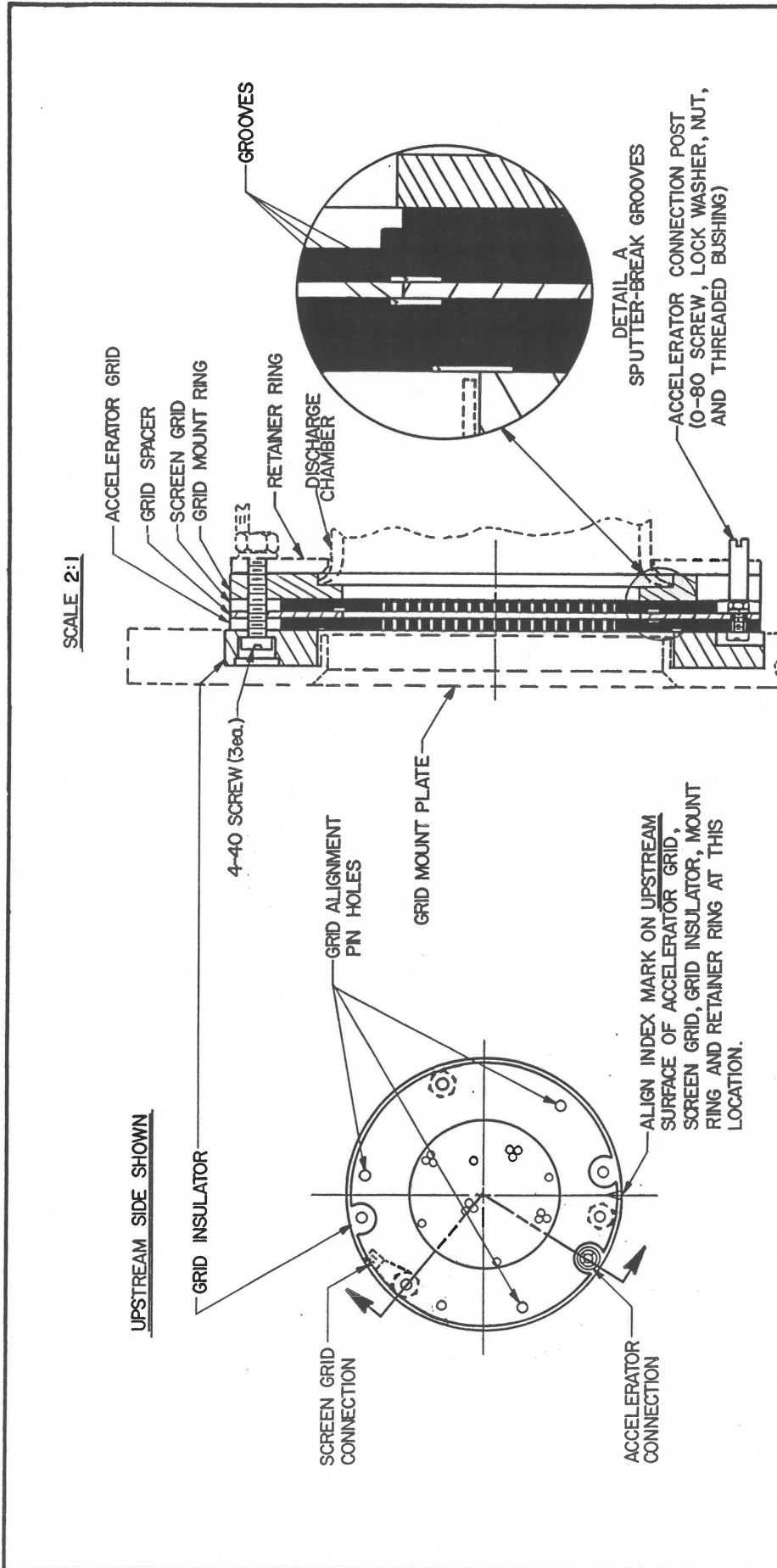


SECTION A-A



ITEM	DRAWING NO.	PART DESCRIPTION	FINISHED PART NO.	UNFINISHED PART NO.	SPECIFICATIONS	MATERIAL (MATERIAL LISTED IN FINISHED DIMENSIONS, EXCEPT AS NOTED)	DESCRIPTION	RECD
1	91-614-4	2.75" 7-PIN FLANGE	504-011					1
2		HVC WELDMENT	700-504-017					1
3		BODY JUMPER (D)	700-504-016					1
4		ACCELERATOR JUMPER (E)	700-504-015					1
5		TERMINAL STRIP ASSY	700-504-018					2
6		CHOKE ASSY	700-504-019					5
7		CABLE TERMINATION HARNESS	6270-126					2
8		1/8" VCR FITTING	504-012					2
9		1/8" VCR NUT	201-SS-823					2
10		1/8" VCR GLAND	201-SS-820					2
11		1/8" VCR GASKET	201-SS-825					2
12		STANDOFF CENTER POST	201-SS-430					1
13		1/8" GAS TUBING	202-226					A/R
14		ALUMINA BEAD, SMALL	500-067					45
15		ALUMINA BEAD, LARGE	500-068					5
16		CONN. CRIMP, SKT, #12	1620-102					5
17		WIRE, 12GA COPPER	650-101					20
18		RETAINER RING	110-052					2
19		TERMINAL STRIP INSUL	504-042					1
20		NUT, 10-32 HEX	201-SS-586					10
21		6-32 X .250 BUTTON HD.	201-SS-550					3
22		4-40 X .500 SOC HD CAP	201-SS-545					4
23		10-32 X .250 SOC HD CAP	201-SS-615					1
24								

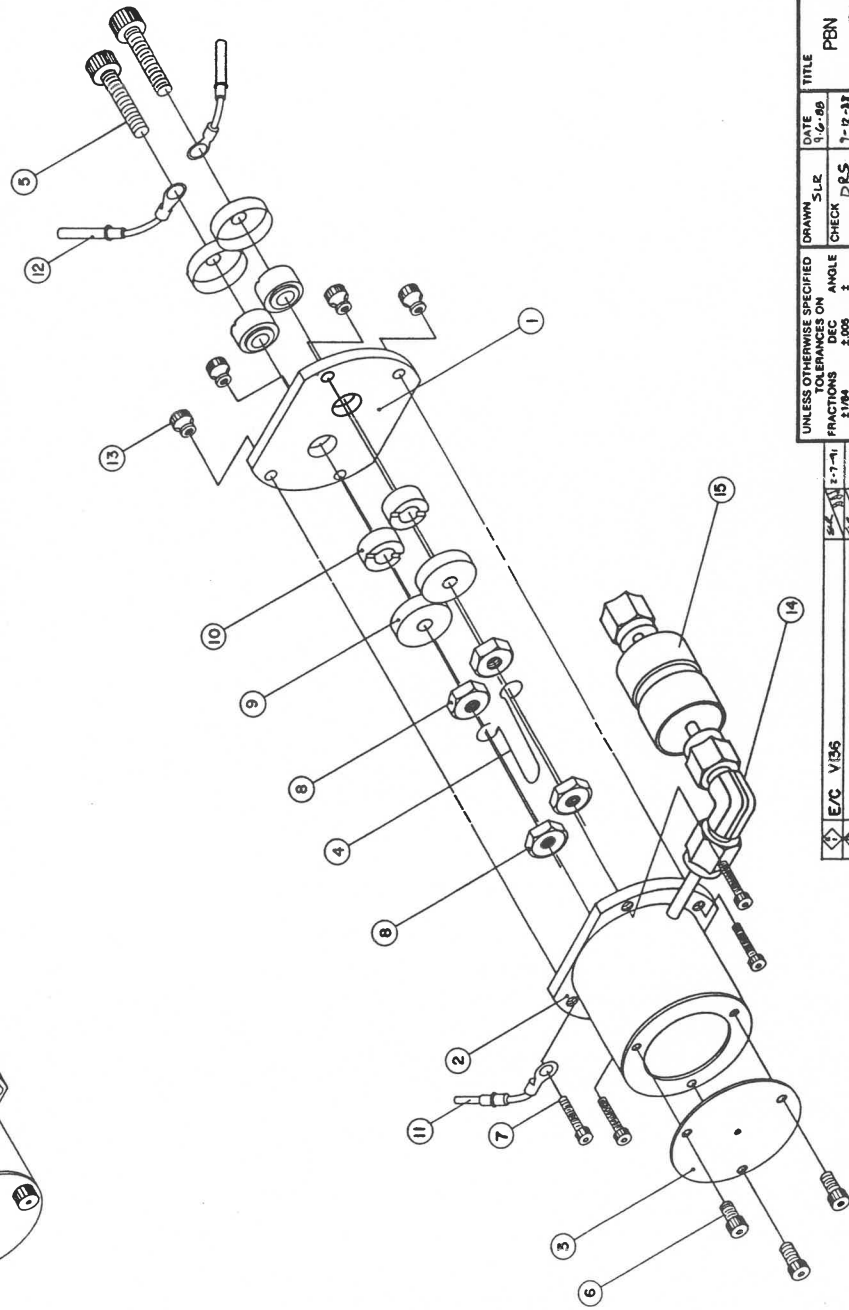
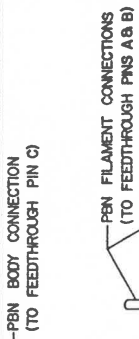
DRAWN 5/42		DATE 5-29-91	TITLE 2 3/4" FEEDTHROUGH ASSEMBLY FOR 3cm RFIS	ION TECH, INC.
CHECK P/E 5	ENGR	6-20-91	P/N 700-504-013	71 COLLINS, CO
OC MGR	PROD MGR		USED ON 91-6178-1	THIS DRAWING IS THE PROPERTY OF ION TECH, INC. IT IS NOT TO BE REPRODUCED, PUBLISHED OR DISCLOSED TO OTHERS WITHOUT EXPRESS AUTHORIZATION BY ION TECH, INC.
APPD P/E 5	SCALE:	6-20-91	REVISION	DWG NUMBER
			NEXT ASSY	91-6178-1
			SHEET	REV
			OF	C



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GRID ASSEMBLY		FOR 3cm. RF ION SOURCE		DWG NUMBER	9I-6156-2
TITLE		DATE		USED ON	NEXT ASSY
DATE		5-7-91		SCALE	5-8-91
DRAWN		SLR		OF	SHEET
CHECK		DES			
ENGR					
OC MGR					
PROD MGR					
APPD		DES			
UNLESS OTHERWISE SPECIFIED TOLERANCES ON FRACTIONS		DEC ANGLE		DO NOT SCALE DRAWING	
±1/64		±		DATE	
SURFACE FINISH		REMOVE ALL BURRS AND SHARP EDGES.		11-8-91	
ALL THREADS CLASS 2.				DATE	
E/C B180		CHG		CHK	
CHANGE					

FIGURE 4

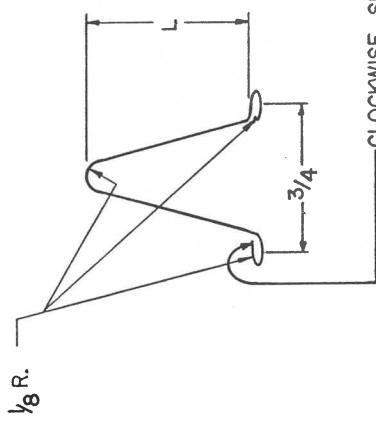
ITEM	DRAWING NO.	PART DESCRIPTION	FINISHED PART NO.	UNFINISHED PART NO.	SPECIFICATIONS	MATERIAL (MATERIAL LISTED IN FINISHED DIMENSIONS, EXCEPT AS NOTED)	(MANUFACTURER)	REV	DWG NUMBER
1	86-4329-1	CATHODE SUPPORT PLATE	400-302						
2	87-4629-2	PBN 300 BODY ASSY.	700-PBN-301						
3	86-4309-8	CRIFICE PLATE	400-316						
4	85-4079-1	PBN FILAMENT	400-07						
5		10-32x1/8 SOC. HD. SCREW	20-SS-620						
6		6-32x1/8 SOC. HD. SCREW	20-SS-575						
7		4-40x1/2 SOC. HD. SCREW	20-SS-545						
8		10-32 HEX NUT	20-SS-516						
9	85-3862-7	13/64 HOLE CUP	500-01						
10	87-4602-4	#10 INSULATOR MALE	500-35						
11		CONN/LUG ASSY.	700-03-09						
12	87-4909-6	4-40 THUMB NUT	700-03-05						
13		1/8" UNION ELBOW	20-SS-773						
14		GAS ISOLATOR ASSY.	700-500-013						
15									



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---	--	---	--	---	--	--	---	--	--	--

FIGURE 5

MATERIAL - .010 DIA. TUNGSTEN



CLOCKWISE SPIRAL WHEN VIEWED FROM THIS DIRECTION (2 PLACES)

NOTE : AVOID SHARP BENDS AND KINKS .

MODEL NO.	LENGTH - L -	ION TECH. PART NO.
PBN-200	1 1/4	400-06
PBN-300	1	400-07

UNLESS OTHERWISE SPECIFIED TOLERANCES ON FRACTIONS DEC ANGLE + 1/64 .005 .		DRAWN DRS CHECK DES ENGR QC MGR PROD MGR APPD PDR	DATE 8-29-85 9-12-85	TITLE FILAMENT FOR PLASMA BRIDGE NEUTRALIZER	ION TECH, INC. FT COLLINS CO THIS DRAWING IS THE PROPERTY OF ION TECH, INC. AND MAY NOT BE USED REPRODUCED PUBLISHED OR DISCLOSED TO OTHERS WITHOUT EXPRESS AUTHORIZATION BY ION TECH, INC.
SURFACE FINISH ✓ REMOVE ALL BURRS AND SHARP EDGES ALL THREADS CLASS 2		USED ON SCALE	NEXT ASSY SHEET OF	DWG NUMBER 85-4079-1	REV
DO NOT SCALE DRAWING					

FIGURE 6

