0101-8011-4

Temescal

Model SFIH-270-2 Electron Beam Source Single Hearth

FerroTec

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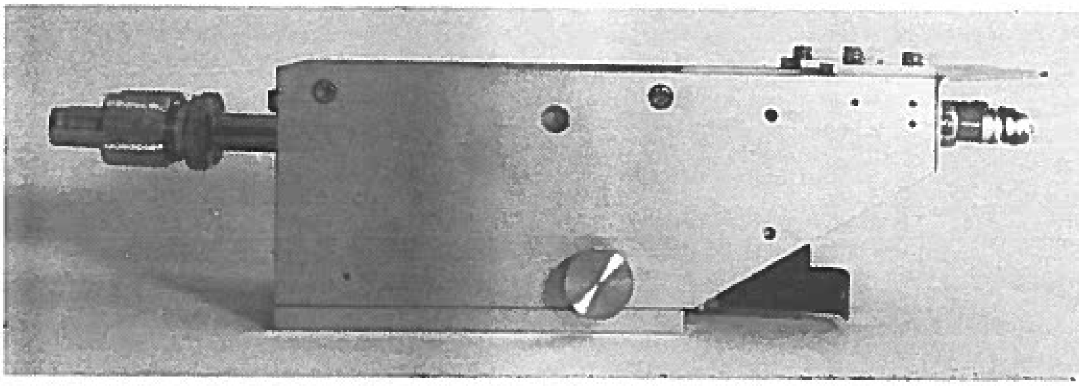
PATENT NOTICE

The Temescal Model SFIH-270-2 single-hearth electron beam source is protected by the following United States patents: 3,710,072; 3,883,679.

Temescal Model SFIH-270-2



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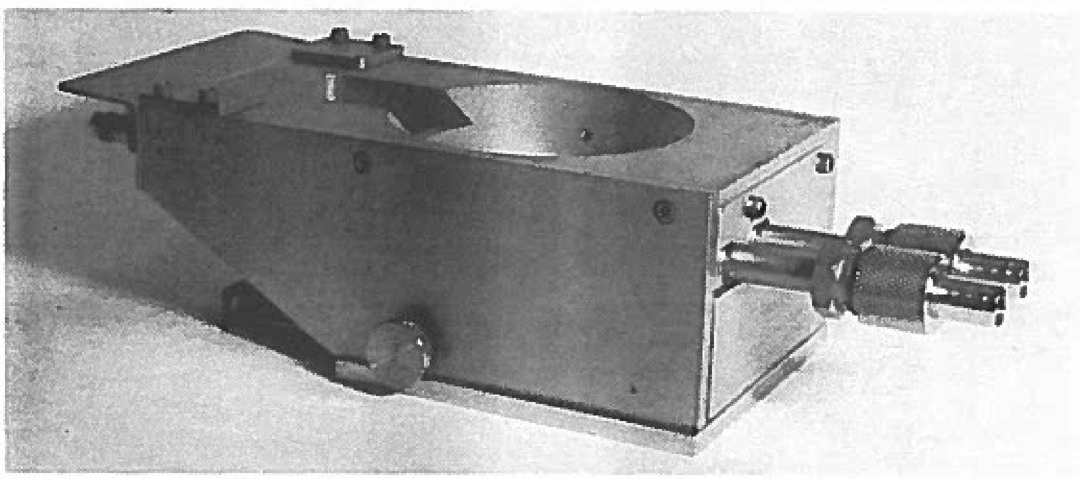

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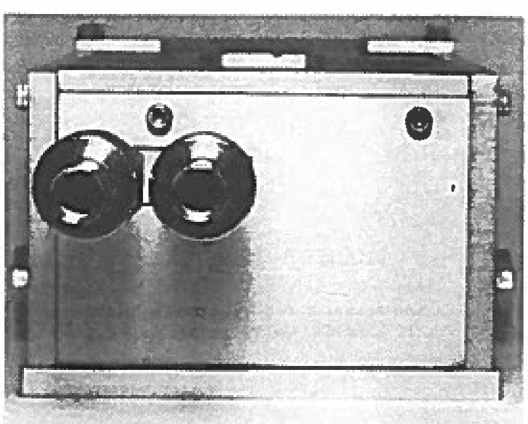

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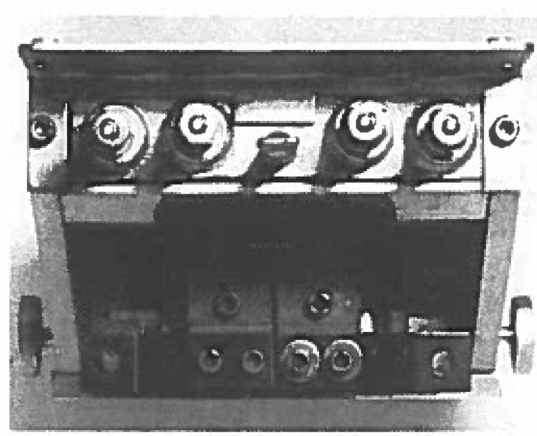

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Four views of the SFIH-270-2 Single Hearth
Electron Beam Source, part number 0303-3014-1

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SAFETY INSTRUCTIONS FOR OPERATING AND SERVICE PERSONNEL

Operators and service personnel should always wear safety glasses. Operators shall not enter areas intended for service access only. Only experienced service personnel should enter such areas, and only after taking the preliminary precautions described in paragraphs 1 through 6 below.

DANGER

Potentially lethal voltages may exist within this unit, even with the line power switched off. Service should only be attempted by qualified personnel. Failure to observe all safety precautions may result in personal injury.

This component is designed to operate as part of a system containing high-voltage equipment. Observe the precautions described below when servicing this system, especially when servicing components where high voltages may be present.

1. Before servicing or operating this equipment, read all the component manuals supplied with the system, paying special attention to safety instructions.
2. Post HIGH VOLTAGE WARNING signs in conspicuous locations within the service area.
3. Remove rings, watches, bracelets, and any other metal jewelry before working around high voltage.
4. DO NOT WORK ALONE!
5. Be sure that all equipment is connected to a power receptacle having the correct polarity and grounding, as prescribed by the local electrical codes. Refer to the power supply portion of the documentation to determine the proper electrical ground for high-voltage components.
6. Before servicing any high-voltage component, switch off the electrical power at the component's main power switch. This switch should have a lockout feature. Lock the power off and keep the key with you while you are working on the equipment.
7. Certain electrical parts (e.g., electrolytic capacitors) hold a lethal voltage even after the power is switched off. Before entering any service area, use a grounding hook to discharge such parts. Be sure that these parts are discharged before starting any repairs.
8. DO NOT touch high-voltage leads unless power is off and a grounding hook is connected to the parts to be serviced.
9. The high-voltage components of the system should be equipped with electrical interlocks to protect personnel from injury. DO NOT ATTEMPT TO DEFEAT, OVERRIDE, OR BYPASS THESE PROTECTIVE DEVICES!
10. Never leave loose ends on high-voltage connections.
11. Observe the following warning if the system employs Radio Frequency (RF) power.

DANGER

RF radiation—even at modest power levels—can cause serious injury. If any of the RF components (e.g., the RF power supply, the RF matching network, or the RF electrodes or shielding inside the product chamber) are moved or changed in any way, the RF energy may be radiated outside the equipment. Monitor the equipment to assure that external RF radiation is below the levels prescribed by any and all applicable safety codes.

Special Amendment for United Kingdom Users

All Electrical Power Sources: Safety Precautions

This component is designed to be used in an extra-high-voltage system. Only authorized personnel should be permitted to carry out work on this system.

Prior to any servicing, grounding hooks should be used to short out all high-voltage parts and conductors in both the vacuum system and the high-voltage power supply. Screens protecting extra-high-voltage conductors should be removed only if appropriate action has been taken to ensure that extra-high-voltage conductors are dead and cannot be reenergized inadvertently.

In addition, all personnel should be aware of:

1. The Electricity (Factories Act) Special Regulations (1908 and 1944), in particular, Regulations 18(d) and 28 of the 1980 Regulations, as amended; and

2. The employer's responsibility to set up suitable systems to safeguard the health and safety of employees, according to the Health & Safety at Work etc. Act (1974).

USER RESPONSIBILITY

This equipment will perform in accordance with the instructions and information contained in the user’s manual and its referenced documents when such equipment is installed, operated, and maintained in compliance with such instructions. The equipment must be checked periodically. Defective equipment shall not be used. Parts that are broken, missing, plainly worn, distorted, or contaminated, shall be replaced immediately. Should such repair or replacement become necessary, a telephone or written request for service should be made to Temescal, Livermore, CA, a division of Ferrotec (USA) Corp.

The equipment, or any of its parts, shall not be altered without the prior written approval of Temescal. The user and/or purchaser of this equipment shall have the sole responsibility for any malfunction which results from improper use, faulty maintenance, damage, improper repair, or alteration by any party other than Temescal.

GUIDELINES AND GOOD PRACTICES

1. Follow applicable clean room procedures (smocks, masks, gloves, etc.).
2. Do not expose the vent and purge valves to excessive pressures. The nitrogen line regulator is factory set at 15 psi and must not be adjusted above 20 psi.
3. Prevent oil, grease, water, sweat, etc. from getting into the vacuum chamber.
4. Replace the source tray shield correctly to ensure that the ceramic parts of the high voltage feedthroughs are protected from being coated.
5. Clean all mechanical parts and seals with lint-free paper/cloth soaked with isopropyl alcohol (IPA). Dispose of all IPA-exposed cleaning paper/cloth in a fireproof container, while ensuring proper safety precautions are being followed.
6. Polish scratched surfaces with Scotch-Brite, taking care not to produce any cross scratches.
7. Shaft seals are all ferromagnetic. No lubrication is required.
8. Check the chamber door’s seal and sealing surfaces each time before closing it.
9. Check and clean the source tray seals and sealing surfaces with IPA each time before raising the source tray into place.
10. Staff must be trained by competent personnel. DO NOT allow staff to operate the system or do maintenance and recovery work on it until they are trained by competent personnel.
11. Document all alarms, deviations, breakdowns, and servicings, either on hardcopy or on an electronic equipment-log system.

HEALTH HAZARD

The condensates deposited on the tank walls of a vacuum system are generally in the form of extremely fine particles. The nature, as well as the form, of the materials poses the following potential health hazards:

a) Inhaling fine particles (powder) may cause damage to the lungs. To help prevent this, wear a protective respirator mask with fine filter that has been approved by the National Institute for Occupational Safety and Health (NIOSH) and the federal Mine Safety and Health Administration (MSHA).

b) Some substances are toxic and inhaling them should be avoided. Take steps to ascertain whether or not the material being deposited is a known toxic substance. Refer to the Material Safety Data Sheet(s) covering the evaporant(s) in question.

c) Certain powders (titanium, for instance) can cause flash fires when exposed to oxygen or other oxidizers. Therefore, when opening the chamber door after a deposition cycle, exercise extreme caution and allow time for the coating surface to oxidize. Breakage of some of the more reactive condensates may be hazardous, even when the above precautions are observed. In this situation, fire-protective clothing should be worn.

d) Certain powders (platinum, for instance) are known to catalyze methyl alcohol vapors upon contact, generating heat in the process and possibly causing a fire to erupt. Therefore, never use methyl alcohol to wipe down or clean any internal tank surfaces of a vacuum system. Use isopropyl alcohol (IPA), instead. Dispose of all IPA-exposed lint-free paper/cloth into a fireproof container, while ensuring all proper safety procedures and precautions are being followed.

SAFETY INSTRUCTIONS FOR OPERATING AND MAINTENANCE PERSONNEL

DANGER: HIGH VOLTAGE!!

1. Before servicing or operating this equipment, read all the component manuals supplied with the system, paying special attention to any safety precautions.

2. Before servicing this equipment, disconnect the electrical power at the main power switch. This switch should have a lock-out feature. Lock the power off and keep the key with you while working on the equipment.

3. Before entering any service area, use the special grounding hook (provided) to short out all voltages from the various high voltage parts and conductors.

4. Certain electrical components (e.g. electrolytic capacitors) hold a lethal voltage even after the main power is turned off. BE SURE such components have been discharged by shorting the high voltage terminals to ground before starting any repairs.

5. Be sure the equipment is connected to a power receptacle having the correct polarity and grounding as prescribed by the National Electrical Code. Refer to the power supply section of the instructions to determine the proper electrical ground.

6. Never leave loose ends on high voltage connections.

7. DO NOT TOUCH high voltage leads unless power is off and a grounding hook has been connected to the parts to be serviced.

8. This equipment may contain electrical interlocks to protect personnel from injury. DO NOT DEFEAT, OVERRIDE OR BYPASS THESE PROTECTIVE DEVICES!!!

9. DO NOT WORK ALONE!

10. Wear safety glasses.

(continued)

11. Operators shall not enter areas of the equipment intended for service access only. Only experienced service personnel should enter such areas AFTER taking the various precautions described above.

12. POST HIGH VOLTAGE WARNING SIGNS conspicuously in the operating area.

13. Remove rings, watches, and bracelets before working around high voltage.

SAFETY (continued)

SPECIAL AMENDMENT FOR UNITED KINGDOM USERS

ALL ELECTRICAL POWER SOURCES: SAFETY PRECAUTIONS

These systems are all extra-high-voltage systems.

Screens protecting extra-high-voltage conductors should be removed only if appropriate action has been taken to ensure that extra-high-voltage conductors are dead and cannot inadvertently be re-energized.

All machines should be fitted with the special grounding hook provided. This should be used to short out all high-voltage parts and conductors in both the vacuum system and the high-voltage power supply prior to any work. Only authorized personnel should be permitted to carry out work on these systems.

Attention is drawn to the Electricity (Factories Act) Special Regulations (1908 and 1944)--in particular to Regulations 18(d) and 28 of the 1908 Regulations as amended--and to the employer's responsibility to set up suitable systems to safeguard the health and safety of employees under the Health & Safety at Work etc. Act (1974).

HEALTH HAZARD

The condensates deposited on the tank walls of a vacuum system are generally in the form of extremely fine particles. The nature, as well as the form, of the materials pose the following potential health hazards:

a) Inhaling fine particles (powder) may cause damage to the lungs. To help prevent this, wear a protective respirator mask with fine filter that has been approved by the National Institute for Occupational Safety and Health (NIOSH) and the federal Mine Safety and Health Administration (MSHA).

b) Some substances are toxic and inhaling them should be avoided. Take steps to ascertain whether or not the material being deposited is a known toxic substance.

c) Certain powders, titanium for instance, can cause flash fires when exposed to oxygen or other oxidizers. Therefore, when opening the chamber door after a deposition cycle, exercise extreme caution and allow time for the coating surface to oxidize. Breakage of some of the more reactive condensates may still be hazardous even with the above precautions. In this situation, fire-protective clothing should be worn.

SECTION 1

INTRODUCTION AND DESCRIPTION OF EQUIPMENT

1.1 INTRODUCTION

This manual describes the components, installation, operation, maintenance, and troubleshooting of the Model SFIH-270-2 single-hearth electron beam source. Illustrations and a parts list are also included. To avoid personal injury or damage to equipment, read the entire manual carefully before installation.

1.2 DESCRIPTION OF EQUIPMENT

1.2.1 General

The Temescal Model SFIH-270-2 electron beam gun has a single-pocket crucible designed to evaporate one material in long, uninterrupted runs. The crucible accommodates a volume of 40cc.

The magnetic fields that direct and focus the electron beam are provided by a main-field permanent magnet, a hermetically sealed deflection electromagnet, two pole pieces, and two pole piece extensions. The deflection coil is used to accomplish X-Y beam sweep. The wide frequency range of the SFIH-270-2 makes it a versatile evaporation tool. The field of the permanent magnet located at the inside back of the SFIH-270-2 source is used to maintain the beam on the hearth area. Refer to section 5 for further details.

WARNING

One function of the permanent magnet is to prevent the electron beam from deflecting into the chamber wall if a failure in the deflecting coil occurs. Do not slide, drop, or allow the magnet to experience extreme shock of any

kind or it will degauss. Also, do not allow the magnet to see high temperatures. The magnet should not be placed on or near other magnetic surfaces.

The lateral pole pieces supply the field to bend the beam toward the crucible. The pole piece extensions serve to defocus the beam and enlarge the size of the spot. When the extensions are removed the beam is tightly focused.

NOTE

The spare parts list at the end of the manual designates the materials used to make the parts. When cleaning, be certain to use a cleaning preparation that is compatible with the particular material.

1.2.2 Emitter Assembly

The emitter used to generate the beam in the Model SFIH-270-2 is a pluggable assembly. Location and shielding protect the unit from contamination and ion-filament erosion. The filament is easily adjusted and can be replaced when necessary. The assembly can be completely disassembled and cleaned.

1.2.3 Accessories

Accessories for the Model SFIH-270-2 electron beam gun include an installation kit comprising the necessary feedthroughs, wire feeder, shutter, several types of crucible liners, and the spare parts kit.

1.2.3.1 **Feedthroughs.** The 8-conductor current feedthrough (0402-7463-1 for the o-ring sealed bolt-through, and 0502-0093-0 for the metal-sealed) includes connectors and mating plugs.

Connecting pins are provided for o-ring models. The maximum temperature in which this assembly can be used is 125° C.

Use 12-kV, 70-ampere feedthroughs (o-ring type, 0718-8483-0, 1 in. x 1-1/8 in., or 0020-7572-1, 1-1/8 in. x 1-1/4 in.) to bring high voltage to the emitter with the shielding enclosure.

The water feedthrough (0902-0193-0, o-ring model, and 0902-0173-0, metal-seal) features an adjustable flow-through switch (0.4 to 1.8 gpm). The flow switch shuts off below 0.40 gpm. Maximum pressure for the feedthrough is specified at 100 psi.

1.2.3.2 **Crucible liners (See Table I).** Crucible liners are available in different materials for various applications. Temescal liners are designed to give increased evaporation rates at substantially lower levels. They will reduce spattering, and allow for the easy exchange of evaporants. Read the following to determine the proper liner for your materials. Section 5 contains further information on the use of liners.

INTERMETALLIC COMPOSITE (titanium diboride/boron nitride): The most common use of intermetallic inserts is for evaporating aluminum. In general, the intermetallic composite should not be used with materials that react with boron (nickel, silicon, iron, silicon monoxide, silicon dioxide, cobalt, and titanium) nor with metals of high melting temperatures such as tantalum, tungsten, etc. All intermetallic inserts have good thermal shock resistance up to 1800° C.

GRAPHITE: Made to Temescal specifications, these inserts are machined from ATJ-grade, solid rod graphite. Materials such as pure gold, silver, and copper do not alloy with graphite and are easily removed from the insert.

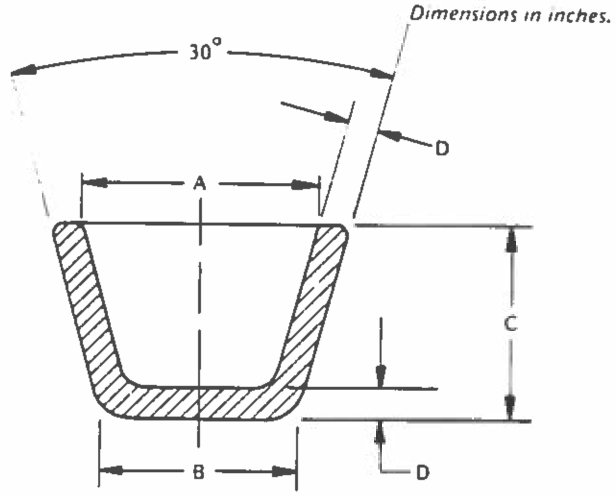
MOLYBDENUM: The inserts are machined from solid rod molybdenum. They are characterized by high strength and do not scratch easily. Some evaporant metals alloy with molybdenum. Molybdenum inserts are ideal for gold evaporation because of reduced spitting.

HOT-PRESSED GRAPHITE: These inserts are less porous than machined graphite. The manufacturing process is proprietary.

Table I 2-Inch Diameter Crucible Inserts

Dimensions and Capacities

MATERIAL	PART NO.	A TOP	B BASE	C HEIGHT	D WALL	VOLUME
Molybdenum	0203-6512-2	1.512	1.456	1.093	0.250	1.09 cu. in. 18cc
Inter-metallic	0303-6872-0	1.658	1.165	1.125	0.175	1.50 cu. in. 24.60cc
Graphite	0203-6512-1	1.512	1.025	1.093	0.250	1.09 cu. in. 18cc
Poco Graphite	9998-9006-0	1.846	1.025	1.062	0.093	1.93 cu. in. 31.6cc
	9998-9006-1	1.512	1.025	1.062	0.250	1.09 cu. in. 18cc
Vitreous Carbon	9998-9006-2	1.462	1.025	1.055	0.085	1.95 cu. in. 34cc



SECTION 2

SPECIFICATIONS AND INSTALLATION

The following specifications presume a power supply and a vacuum environment. The requirements called out for feedthroughs are minimum for products not manufactured by Temescal. We advise using the Temescal kit. It more than meets specifications. The part numbers for the kit can be found in the parts list section of the manual.

2.1 SPECIFICATIONS (Drawing 303-3014)

Crucible Top Diameter:	2 inches
Crucible Bottom Diameter:	1-1/2 inches
Crucible Depth:	1 inch
Crucible Volume (each):	40cc
Maximum Power:	14kW
Emission Voltage:	4 to 10kV (Normal operating voltage is 10kV; to use lower voltage, see page 47, figure 5, for the required shunts.)
Maximum Bakeout:	200° C (392° F)
Filament Voltage:	12V maximum
Filament Current: (Typical at 14kW)	to 50A maximum 5.5V/38A
Water Requirements:	2-1/2 gpm, at 20 C, 40 psi pressure differential minimum
Weight:	14 lb. (6.4 Kg)

2.2 UNPACKING

Remove the source from its shipping container. Do not destroy this container until you have verified that the gun is in good working order. While unpacking, check the components in the container against the packing list. Inspect all parts for possible shipping damage. Any damage should be reported immediately to the carrier and to Temescal Service Department. Discrepancies between the parts list and the parts received must be reported to Temescal representatives or to the factory.

2.3 INSTALLATION

The performance of the electron beam gun is affected by high voltage ion shielding; the position of the high voltage leads; pressure in the vacuum chamber; and adequate water flow. The gun must be installed on nonmagnetic material, such as SST grade 304, or the magnetic field generated by the permanent magnet can be severely changed. Certain materials and conditions can cause secondary beam emission off the crucible. A portion of the beam is re-emitted off the evaporant and arches across to the area behind the gun where the water lines attach. Thus, when evaporating materials which have a high atomic weight, such as tungsten or gold, it may be necessary to install a water-cooled shield at the rear of the gun. The shield should extend a maximum of 5 inches above the gun at the rear.

2.3.1 Installation Requirements

1) The gun must be properly positioned in respect to the planetary and must be positively grounded to the baseplace.

2) The supply of cooling water must maintain a flow-rate of 2.5 gallons per minute in the crucible.

3) The high voltage connection must be shielded as shown in figure 1.

4) Wire leads must be available to operate the electromagnetic coils.

5) The system must be properly protected by safety interlocking (flowswitch, chamber, et al).

6) The hazards resulting from the use of high voltage must be taken into consideration and adequate protection provided for the operators of the equipment. Consult the appropriate power supply instruction manual.

2.3.2 Installing The Gun (Figures 2, 3, 4, and 5)

1) Determine the optimum location of the gun in the chamber. The gun should be level and positioned to receive the feedthrough service; namely, each input must be considered in terms of the other to establish the direction the emitter will face. The operator must be able to see the beam and crucible through the viewing port. The viewing port should be set so that the viewer sees the emitter from the side. This port should never view the beam and crucible from the back of the gun.

2) Keep high voltage leads short (4 to 8 inches or 10 to 20 cm). Longer leads are more difficult to shield.

3) If a shutter is used to control deposition, it must be 2 inches or more above the hearth.

4) The water lines can be 3/8-inch o.d. No.304 stainless steel or copper tube. If stainless steel is used, the connections should be heliarc welded. Copper connections should be silver soldered. Make the necessary bends in the water

line. Then loosely bolt the source to the base-plate. Make the bends approximately 1/2 inch from the connections. The connections should be tension free. By leaving the source loosely bolted, the bends can be gradually adjusted until they are tension free. Then tighten the bolts. It may be necessary to alternately tighten the bolts and adjust the bends ultil the desired connections are achieved. Each source is supplied with RL gasket-sealed vacuum connections.

5) Before making the water line connections, remove the o-rings and put them in a clean place. The connecting surfaces should be bright clean. Use an abrasive if necessary.

NOTE

Put the connecting nut over the line before making the connections. The water lines should not be soldered while attached to the gun; otherwise the gun will have to be cleaned.

6) Remove the water lines and parts from the chamber to braze or weld them to the connectors. When brazing, be sure plenty of silver solder flux is used on the surface.

7) Wash the line connections thoroughly with hot water after brazing.

8) Coat the o-rings with vacuum-grade lubricant (Apiezon L or equivalent) and replace them.

9) Mount the gun to the chamber. Make a positive ground through the mounting bolts.

10) When the gun mounting bolts and water connections have been adjusted and mated, secure the baseplate and water line connections.

CAUTION

Inadequate water flow through the crucible can result in the formation of an alloy of the

crucible and the evaporants as well as other damage. Therefore, provide 2.5 gallons per minute flow. Provide an extermal flowswitch interlock system to activate below this level. Be sure the water line pressure to the gun never drops below the desired level. Do not share the gun water cooling supply with other equipment.

11) The electromagnetic coil is driven by 3 amperes (maximum). The coil feedthrough can now be connected. Pliable Teflon tubing, glass sleeves or ceramic beads can be used to insulate these leads. Be sure there are no shorts to the surrounding environment. The two coil leads on the right-hand side of the source are used to connect the electromagnetic deflection coil to the longitudinal sweep drive. Use No. 16 AWG wire to make these connections.

CAUTION

Keep the coil leads away from the filament leads. Do not run them parallel to the high voltage filament leads, as arcing can damage the coils and/or the beam positioning power supply.

NOTE

Be certain when connecting the deflection coil to the power supply that the polarity matches the polarity of the coil (positive grounded, negative common to control). Damage resulting from connecting these leads in reverse order is not covered by the warranty.

12) Connect the high voltage to the emitter assembly bus bar. Looking directly into these connections, the left-hand side is the common side of the cathode and the right-hand side is insulated. Use the No. 6 AWG flexible copper barewire leads supplied with the source to make the high-voltage connection (1/16-inch x 1/2-inch copper straps can be used as an alternative). These leads must be spaced at least 3/8-inch from any ground potential inside the vacuum system.

Loop the leads to the feedthrough terminals. Any bend in the high-voltage feedthrough should be gradual enough to compensate for heat expansion.

13) Install the high-voltage shielding as shown. The object is to protect the high-voltage leads from ion erosion and to protect the focus coil leads from the high voltages. To do this, enclose the area, but at the same time make it possible to remove the shield easily. Use No. 304 stainless steel for the shields. Place the shields at least 1/4 inch away from the high-voltage feedthrough. Keep grounded components out of the shielded area.

CAUTION

When making the holes in the shield to release captive air during pumpdown, place them so that they are protected from exposure to the electron beam.

(14) Connect all protective interlocks.

(15) Make the appropriate external connections for the low-voltage coil. Provide an external positive ground to the baseplate. Provide auxiliary ground between the baseplate and the power supply.

CAUTION

Consult the power supply manual for the description of how to make the

connections outside the vacuum chamber.

High-voltage leads installed outside the chamber must be No. 6 AWG copper wire with 10 kV rated insulation. Place these leads at least 1-1/2 inches from ground potential. Install the coil leads as specified above. Use No. 16 AWG insulated wire.

CAUTION

Be sure the earth ground to the building, and hence the system, is at zero resistance. Usually the water pipes in the building do provide the proper earth ground, but in some places in the world they do not. Their resistance should be measured and not assumed. When earth needs to be devised, two copper rods driven in the ground 6 feet apart, with either a copper sulfate or salt solution poured down around them, will provide a reference to establish ground. Measure the resistance between these rods. When the resistance measures zero, earth ground has been achieved. Refer to the power supply manual for the proper method of grounding.

DANGER: HIGH VOLTAGE

Be careful in routing high-voltage cables. They should be loose rather than taut and sharp bends must be avoided. Keep them away from heat-producing components in the system such as the substrate heaters. Make sure the ends of the high-voltage leads are tightly clamped. Loose high-voltage lead ends are potentially lethal.

(16) Recheck all the electrical connections made during installation. Note that they are fast and that none are grounded.

2.3.3 High-Voltage Discharge Hazards

The electron beam gun operates at high voltage with respect to earth ground. It has the ability to charge ungrounded elements within its vicinity to a dangerous electrical potential. This potential varies directly with coupling between the gun and the components and with impedance to ground.

DANGER

Anyone working on the components within the chamber must be aware that they might be at the same potential as the gun; namely, lethal. The operator should ground the equipment with a grounding hook.

Do not work alone.

2.4 MOUNTING THE SHUNT BAR

More than one Temescal source can be installed in one chamber. The combination can include two one-pocket sources or one four-pocket and one single-pocket source. Figure 3 illustrates two different sources installed in a single chamber. The essential requirement is to prevent the magnetic components in each source from affecting the operation of the other. Locate the bar as shown; the holding bracket is not intended to show exactly how the bar is to be mounted. Rather, it is to show that the water connections are being used to support the shunt. Since the design of the sources varies (i.e., the water connections are different), the way the shunt bar is installed must also vary. Any adaptation of the suggested method is effective.

SECTION 3

OPERATION

CAUTION
To avoid contamination, wear white linen gloves when handling any component used in the vacuum chamber.

Four controls on the power supply are used to vary emission voltage, emission current, filament current, and focus current, and to supply the means to operate the source.

NOTE
Damage to the crucible resulting from failure to assure that the proper amount of cooling water is flowing through the gun at the correct rate is not covered by the warranty.

The flow switch called out in the installation kit connects to the gun water-interlock in the (Temescal) power supply. The safe operation of the source depends on the use of this or an equivalent interlock circuitry.

Depending on the power supply used, the emission voltage may be fixed or variable. The longitudinal focus current moves the beam spot from the rear of the crucible into the center of the crucible and toward the coil.

3.1 STARTING AND OPERATING THE SOURCE (figure 6)

1) With the vacuum chamber at atmosphere, place the evaporant in the crucible.

CAUTION
To avoid damage to the crucible, be sure it is at least half full.

2) Check the gun water interlock to be certain that the cooling water is flowing through the crucible.

3) Evacuate the vacuum chamber to 1 x 10^{-4} torr (0.1 micron or less.)

4) Place the electron beam power supply main current breaker ON.

5) Turn the KEYLOCK to the ON position.

6) Push the HIGH VOLTAGE ON button. If the power supply has a variable emission voltage control, set the emission voltage to the operating level (usually about 10 kV).

NOTE

When the source is being operated at less than 10 kV, shunt bars must be used. (See figure 5 for the number of shunt bars required for various operating voltages.)

7) Turn the FOCUS CURRENT control counterclockwise to its lowest setting.

NOTE

At 0 ampere on the longitudinal coil, the beam is at the far (rear) edge of the crucible.

8) Turn the EMISSION CURRENT control completely counterclockwise to zero.

NOTE

This step is critical to avoid the possibility of excessive current when the FILAMENT ON button is pushed.

9) Push the FILAMENT ON button and adjust the EMISSION CURRENT control for a reading of 20 mA; a fluorescence should appear on or near the rear of the crucible.

DANGER

If no fluorescence appears, the polarity of the coils may be reversed. Looking at the emitter, verify the presence of fluorescence. The fluorescence will bend downward from the emitter when the polarity is reversed. If this appears to have occurred, bring the system to air. Be sure the power supply main switch is off and that all grounding procedures have been followed by observing all high voltage precautions. Reverse the coil leads and begin the start-up procedure again.

10) Adjust the FOCUS CURRENT longitudinal control for 0.750 to 1 ampere at 10 kV to bring the beam into the center of the crucible. Less current is needed for lower operating voltages. Increasing the focus current moves the beam away from the far edge of the crucible toward the coil assembly.

11) Readjust the FOCUS CURRENT control so that the fluorescence centers on the evaporant and not the wall of the crucible.

CAUTION

If the beam impinges on the crucible wall instead of the evaporant, copper will be evaporated in the chamber contaminating the run (figure 6).

12) Now increase the emission current very slowly until the beam spot appears in the fluorescent area. Better rates can be obtained by placing the beam slightly off center approximately 1/16 inch towards the rear of the crucible.

13) Check for centering of the spot on the evaporant. Readjust the focus current as needed.

14) Slowly increase the emission current until the proper evaporating level is reached. Do this slowly to allow the evaporant to gradually reach its vapor state. Operating procedures from this point on are based on following the proper techniques for the particular process.

The source is now ready to operate. If there is trouble, refer to the troubleshooting chart in section 4, Maintenance.

3.2 ADJUSTING THE BEAM SPOT SIZE (Figure 7)

The size of the electron beam spot can be changed by adding pole piece extensions. Adding extensions diffuses the beam. The size, shape, and position of the extensions affect the concentration of power on the material being evaporated. Temescal has designed the SFIH-270-2 for two operating states: concentrated and diffused. However, the pole extension pieces may also be moved inwards and outwards to gradually change the beam spot size to the desired size.

SECTION 4

MAINTENANCE AND TROUBLESHOOTING

Properly maintaining your model SFIH-270-2 single-hearth electron beam source will add to the lif of the product and provide better results during evaporation runs. Temescal sells a spare parts kit (Part No. 0304-4311-0) which contains:

Item	Part Number	Description	Qty
1	0020-4811-2	Union Gasket, 3/8 inch	4
2	0202-4121-0	Filament Location Gauge	1
3	0303-9402-1	Anode	1
4	0303-3131-0	Flanged Insulator	4
5	0303-6721-0	Locating Insulator	1
6	0303-9351-0	Filament	5
7	0303-9392-0	Beam Former	1
8	0418-4631-0	High-Voltage Spacing Insulator	2
11	1321-1252-0	Screw Soc. Hd. Cap. -SST #6-32 NC-2A x 1/4-inch LG	2
12	1321-1255-0	Screw, SOC. Hd. Cap. -SST #6-32 NC-2A x 1/2-inch LG	2
15	6642-0002-0	Shipping Container, Plastic	1

Part numbers for bulk quantities:

1) Box of five filaments, 7-1/2 turns: 0317-6871-0
2) Box of five filaments, 5-1/2 turns: 0515-5441-0
3) Box of ten H.V. spacing insulators: 0602-8781-0

These parts indicate the type of maintenance that may be required. See figure 10 series and paragraph 4.5 for the disassembly sequence.

Because the electron beam gun operates in the coating chamber, it will require cleaning. The method for cleaning is described in paragraph 4.6.

4.1 VENTING THE VACUUM CHAMBER CONTAINING THE SOURCE

The model SFIH-270-2 electron beam gun provides the many advantages of large-hearth operation, compared to small-pocket devices which must be brought to atmosphere after each evaporation run. Venting the system always introduces oxygen into the chamber. The emitter filament operates at very high temperatures and the components in the emitter assembly immediately adjacent to the filament operate at a red glow. The area at the clamp that holds the filament is especially vulnerable to contamination from oxide erosion caused by the wide variation in temperature encountered between vacuum and atmosphere.

4.1.1 After Each Vacuum Release

Each time the source is brought to atmosphere:

1) Inspect the pool level in the hearth. Add evaporant as required to maintain the pool at the normal level.

2) Look for loose flakes and other debris from previous evaporation runs.

CAUTION

Be sure to inspect the area around the emitter section, high voltage insulators, and feedthroughs. Debris and flakes blowing into these areas can cause short circuiting. Use an industrial vacuum cleaner to remove this material.

4.1.2 Periodic Component Checks (Figure 8)

1) Check insulators and feedthroughs for cracked or fouled components. Replace cracked insulators and clean fouled feedthroughts. The two high voltage spacing insulators and the four flanged insulators of the emitter assembly can be inspected without taking them apart.

2) Check the filament. Look for erosion in its center area. If it is eroded, replace it. Another common failure is sagging which is caused by running the filament at high temperature for long periods. If the filament has sagged, replace it. Excessive beam leak may

burn away the edge of the anode. If the anode is also burned, replace the filament and the anode. See paragraph 4.3.1.

NOTE
Operating at continually high pressure (above 5 x 10^{-4} torr) drastically reduces filament life.

3) Examine the emitter assembly for buildup of evaporant. Be sure to clean the emitter clamp tracks. Use 240 grit or finer emery paper.

CAUTION
Coarser sandpaper than 240 grit can raise the metal surface enough to cause arcing in the chamber.

4) Examine the crucible for residual waste from the previous evaporation run. Materials left in the crucible can cause thermal shorts and reduce the evaporation rate.

4.2 WORKING SAFELY

Before working inside the chamber, it is necessary to review what you are about to do in order to avoid hurting yourself.

DANGER
The electron beam gun operates at potentially lethal voltages. Therefore,

1) Never override the safety interlocks.

2) Be sure the power supply used to drive the source has a lockable main power switch.

3) When working on components inside the chamber, turn off and lock the power supply before beginning any maintenance or work

procedure. Secure the key so that no one can turn on the power supply while someone else is working inside the chamber.

4) Use the grounding hook provided with the power supply to ground all high voltage leads and connections before touching or attaching any components.

4.3 FAILURE OF EMITTER FILAMENT AND REPLACING IT

There are several reasons for changing the filament. The most obvious of these are:

1) Catastrophic failure; the filament has burned apart.

2) The filament has not burned through completely, but has thin places in it that cause hot spots at the crucible.

3) The filament has sagged in the center and is causing damage to the anode.

4) The filament is installed improperly and is functioning poorly.

5) The filament appears to be in good condition but the gun is not working. This may mean the contact areas around the legs of the filament have oxidized so much that an insulation layer has formed on the contact surfaces; i.e., the clamps, the back surface on which the filament clamps, and the filament legs.

6) The filament is obviously defective.

4.3.1 Replacing or Adjusting The Filament (Figures 9 and 10)

NOTE

Wear white linen gloves to handle components such as the source and emitter assembly. Handling

components with bare hands drastically reduces their effective life.

1) Be sure the power supply main switch is off and that all grounding procedures have been followed.

2) Disconnect the filament leads from either the high voltage feedthrough or the filament bus bars.

3) Separate the emitter assembly from the source assembly by removing two thumbscrews located on the sides of the source. Carefully pull the emitter assembly straight out of the source.

4) The filament is held in place by two screws which tighten two grooved clamps against the legs of the filament. Set the emitter assembly on a clean surface and remove the two filament clamps by unscrewing the two filament clamp screws.

5) Remove the filament from the filament cavity. If necessary use tweezers. Remove any broken filament material from the filament clamps and filament cavity.

6) Using 240-grit emery paper (or finer, since coarser paper may leave enough surface roughness to cause arcing) clean any oxide off the grooves in the clamps. Check the surface at the back of the filament cavity, against which the filament clamps, for signs of oxide and clean with emery paper if necessary.

CAUTION

Be careful not to leave extraneous particles on the emitter assembly after removing the oxide with the emery paper. Do not handle the new filament with bare hands. Salt and oil from the skin will shorten filament life.

7) Wear linen gloves and place the new filament in the filament cavity. Replace the filament clamps. Make sure that the filament legs are seated in the slots in the filament clamps, bottomed against the cathode blocks, and are loosely clamped in place. Now tighten each clamp against the filament legs, tightening first one then the other in a gradual manner. The object is to clamp the filament in place so that approximately one-third of the filament winding is exposed beneath the beam former. Figure 8 (3) shows ideal views of the filament. Looking at the cavity from the front, the bottom edge of the filament should be parallel with the bottom edge of the beam former. Viewing the assembly from the bottom, the front edge of the filament winding must be parallel with the back edge of the beam former.

8) Electrically check to insure filament continuity between the cathode blocks.

9) Insert the emitter assembly into the source assembly. Before tightening the thumbscrews, make sure that the emitter assembly is snug against the mounting blocks. The anode plate of the emitter assembly should be flush with the beam opening in the crucible.

10) Reconnect the filament leads.

11) Should the source fail to operate, it may be that the components have oxidized, eroded, and become coated with evaporant to such a degree that cleaning is necessary. Refer to paragraph 4.6 for the cleaning procedure.

4.4 REPLACING A DAMAGED CRUCIBLE

An Ⓢ marked on the crucible indicates a model with a more efficient water cooling system and the presence of a magnetic suppressor ring. When ordering a replacement crucible for an older model, the new Ⓢ model with the suppressor will be supplied. However, a new magnet with the strength of 475 gauss must also be installed. Either order a new magnet with the correct charge or return the old magnet to Temescal for recharging.

4.5 DISMANTLING THE MODEL SFIH-270-2 (Figures 11 (1-9) and 12)

Each component shown in the dismantling procedure for the SFIH-270-2 and its subassemblies is replaceable. Ordinarily, only those parts included in the spare parts kit will be needed. However, the assembly does contain magnetic and electromagnetic parts that, on occasion, must be replaced. Therefore, should a part need to be replaced, refer to the disassembly instructions.

CAUTION

Sliding the permanent magnet on another magnetic surface will degauss it. Dropping or other sudden shock will also cause it to degauss. Since the field of the permanent magnet directs the beam onto the crucible, damage to the magnet could cause the beam to deflect behind the source and into the crucible wall or surrounding equipment, resulting in damage.

4.5.1 SFIH-270-2 Disassembly Sequence (Figure 11)

NOTE

Salt and oil from the skin can cause contamination of the run. If the source is being removed for cleaning, it is not necessary to wear gloves to take it apart. If, however, it is to be returned without cleaning, wear white lint-free gloves to handle the assembly.

CAUTION

As in the case of the emitter, be sure the power supply main switch is off, grounding hooks in place, and that the power supply lock-switch key is secured to prevent accidentally turning on the power while someone is working inside the chamber.

1) Remove the shielding for the high voltage leads.

2) Using the supplied balldriver, disconnect the filament leads and the coil leads (either at the source or the insulator).

3) Turn off the water and force compressed air through the lines to blow out any remaining water. Disconnect the water lines.

4) Remove the two baseplate bolts.

5) Remove the thumbscrews and emitter assembly.

6) Remove the source from the chamber.

7) Remove the coil shield.

8) Remove the coil from the assembly.

9) Remove the pole extensions.

10) Remove the magnet shield.

11) Remove the pole pieces.

12) Remove the crucible brazement.

13) Remove the magnetic supressor.

14) Remove the permanent magnet.

CAUTION
Sliding the permanent magnet over a magnetic surface or sharp blows can cause the magnet to degauss, thereby changing the behavior of the electron beam and its characteristics.

15) The source is now ready for cleaning.

4.6 CLEANING THE SOURCE AND EMITTER ASSEMBLY

1) The parts list at the back of the manual gives the material out of which each part in the source and emitter assembly is made. The preferred method for cleaning most of these parts is by air blasting them with glass bead honing powder. They may also be wet scrubbed with an abrasive cleaner or by chemical cleaners.

The American Society of Metals, Metals Park, Ohio, publishes the Metals Handbook. Volume 2 is called Heat Treating, Cleaning and Finishing. It should be consulted for the best method to clean the various materials comprising the source and emitter.

When glass bead honing is used as the cleaning method, residue from the honing powder becomes positively charged and collects in the recesses of the parts. After the honing process is completed, place the parts in an ultrasonic cleaner and clean thoroughly before reassembling.

CAUTION
Do not reassemble a source that has been bead honed without ultrasonically cleaning it. Wear white lint-free gloves to reassemble the parts.

2) Painting a weak (3-5%) solution of hydrogen peroxide on the hopper and crucible of the copper source enhances the formation of copper

oxide and provides a more suitable thermal barrier. It also helps prevent the evaporant from adhering to the hopper.

4.7 REASSEMBLING THE SOURCE

The source is assembled in reverse of the disassembly instructions. All the screws used to assemble the Model SFIH-270-2 should be coated lightly with molydisulfide, ROCOL, type DSM or its equivalent.

SECTION 5

THEORY OF OPERATION

5.1 INTRODUCTION

An electron beam is a stream of electrons moving under the influence of electrostatic or magnetic fields (or both) in an evacuated or rarefied atmosphere. Since its discovery, many applications for the electron beam have been found. Temescal electron beam sources operate on principles similar to those of a cathode ray tube (CRT) in which the cathode is placed at a high potential and electrons are leaked in a stream to the anode. The resulting stream is allowed to pass through the anode and continue through deflecting plates, or electromagnetic deflecting coils. Because the electrons are sensitive to a magnetic field, the beam emanating from the source can be precisely formed, focused, and swept.

Temescal electron beam guns are energy sources capable of producing enough heat to melt any known material to the point of evaporation. The cathode is operated at a high negative potential. A tungsten filament is mounted in a cavity and is surrounded on the back and sides by blocks and a beam-forming cavity that are at cathode potential. When the filament is heated to a bright glow, thermionic emission of randomly generated electrons takes place. An anode at ground potential accelerates the electrons out of the front of the emitter assembly cavity as an electrostatic field and focuses the electrons into a beam.

The degree of vacuum in which the guns operate should be so free of residual gas molecules that, although they may strike the bounding surfaces, they will seldom collide with one another. This free-flow molecular phenomena occurs in typical systems at pressures of more than 10^{-4} atmosphere. Heat transfer in this environment is almost entirely by radiation; even between objects touching each other. Thus, by this method, great variations of temperature can be maintained and heated materials can be supported in cooled containers.

The electron beam gun comprises a water-cooled, brazed hearth supported by permanently magnetized pole pieces attached on each side to the base. This completes the four sides of the assembly. Sandwiched between the brazed heatsink and the baseplate (across the back of the gun) is a permanent magnet. An electromagnetic coil inserts at an opening in the front of the hearth. At the back is a water inlet and drain. The top of the hearth contains a depression to hold the material being evaporated. The beam emitter plugs into the front of the electron beam gun.

5.2 GENERAL OPERATION

When the emitter and coil leads are connected to load, the filament glows, and an electron beam emanates from the emitter. The cavity on the side and the one at the back of the filament are at the same negative potential as the filament. The cavities produce an electrostatic field which forms the beam. The emitter faces away from the area of the crucible. In the vacuum environment electrons are directed to the ground potential of the material in the crucible. The electromagnetic coil directs the beam, and the surrounding magnetic fields -- consisting of the pole pieces, pole piece extensions, and the permanent magnet -- guide and focus the beam on the target. The energy of the beam is so intensely concentrated on the surface of the evaporant that it forms a pool of molten evaporant. Therefore, the crucible must be water cooled.

The beams emitted from Temescal electron beam sources are capable of melting any material, provided the beam generates enough energy to compensate for heat losses associated with maintaining the material at high temperature. Beams are generated at power and intensities of 5,000 to 20,000 volts (V). Guns are made with output powers as high as 300 kilowatts (kW). Even small electron beam guns are rated at 10 kW.

5.3 TEMESCAL 270° BEAM DESIGN

The design of the Temescal electron beam gun utilizes a beam geometry of 270 degrees. It is protected by several patents, and is proprietary. The design concept places the beam emitter out of the range of gross particle contamination. Ion bombardment will erode exposed filaments in about eight hours whereas filament lives of 200 hours are not uncommon using Temescal electron beam sources. It should be noted, however, that filament life is also affected by pressure; the higher the vacuum, the longer the life of the filament.

5.4 ELECTRON BEAM EVAPORATION

Evaporation consists of adding sufficient heat to a material to vaporize its atoms. Electron beam evaporation offers a unique opportunity for heat to be applied to the top surface of a material in a vacuum environment. This results in a lower temperature at the boundary between the material and the container. An extreme example is evaporation from a water-cooled crucible in which high boiling point materials remain in a solid "skull" at the interface with the crucible. This is called cold-hearth containment and makes possible the evaporation of any known substance.

The thermal efficiency of any evaporator is the percentage of energy that goes into the latent heat of vaporization. To maximize this percentage, certain strategies of electron beam heating should be followed.

There are many mechanisms for energy to be dissipated at the impact point of an electron beam. These mechanisms are conduction, convection, radiation, vaporization, ionization, the production of secondary electrons, and X-rays. The object of electron beam evaporation is to maximize the energy loss through vaporization while suppressing the other losses.

Under high vacuum, the most important parameter for electron beam vaporization is the temperature of the surface, because surface temperature dictates the energy flow. The simplest method of heat transfer is thermal transfer through the evaporant to the cooled hearth. In materials that are molten when evaporating, but skull at the hearth, the mechanism is a combination of conduction and convection. Examples of such materials are iron, tantalum, and nickel. Materials that sublime are subject to heat transfer by conduction only. Examples of these are chromium, silica, and zinc sulfide. Some materials are molten all the way to the hearth under normal evaporation conditions; their dominant heat transfer mechanism is convection. Aluminum and tin are examples of materials that behave this way. The many heat transfer processes sound complex, but from a mechanistic view they are simple because the magnitude of heat flow is proportional to the first power of temperature.

Ionization occurs when an incoming primary electron collides with a neutral atom being evaporated. Ionization involves a transfer of energy from the electron to the atom, raising its energy level. It is difficult to establish the magnitude of this energy loss because it depends on localized atom density in the vapor directly over the area of beam impact. Qualitatively, however, the higher the concentration of atoms through which the electron beam moves, the greater the degree of inefficiency.

The electron beam enables great variation in the amount of power directed to a surface. With a fixed total power input, energy can be adjusted to vary the temperature of the electron impact point. At low energy and at low temperature, the first-power losses (conduction and convection in the evaporant) predominate. As energy and temperature increase, heat losses through radiation and vaporization become more significant. (The fourth-power radiation loss is eventually overtaken by the logarithmic vaporization rate.) For every material there is a temperature at which the energy transfer by radiation equals that by vaporization. Some of these temperatures are shown in Table II. At higher temperatures vaporization dominates.

It would seem that the highest possible beam density and temperatures are desirable, but there are qualifications. As beam density increases, so does vapor density directly above the source. Ionization in the vapor occurs, resulting in a loss of efficiency.

The beam density at which ionization losses become dominant varies with the evaporant, the total power, and the method of containing the evaporant. No simple formula can be evolved. In general, lower boiling point materials require lower beam density.

5.5 ELECTRON BEAM HEATING USING A COLD HEARTH

Focusing the heat keeps energy losses low. By employing sweep circuits, the electron beam can be programmed in a wide variety of sweep patterns, achieving control of vapor distribution at the source. Such flexible control of power input also means control of evaporation rates.

Water-cooled copper is a reliable crucible for problem-free evaporation of many metals, oxides, and semiconductors. Copper creates a remarkably effective heat barrier at the interface of the copper crucible and the molten material. This barrier consists of the copper surface, copper oxide on the surface, the oxide of the molten material, and sometimes the solid skull in which the melt is contained. The thermal impedance of the barrier is highly sensitive to the presence of the oxide layers; fortunately, they are inherent to the environment, but may be enhanced by painting the surface of the hopper and crucible of the copper hearth with a 3 percent solution of hydrogen peroxide (H_2O_2). Allow the hydrogen peroxide to dry before using the crucible.

5.6 CRUCIBLE LINERS FOR ELECTRON BEAM SOURCES

Evaporation rates of high thermal conductivity materials can be increased by a factor of several times for the same power input by using a crucible liner to reduce heat exchange between the molten evaporant and the water-cooled crucible. Spatter or spitting from the evaporant is reduced sometimes by using a liner.

Crucible liners should be selected on the basis of their compatibility with the evaporant. If a thermal insulating liner is used when evaporating aluminum, the interface temperature between the melt and the liner approaches that of the molten aluminum. This means that any thermal degradation of the liner creates an impurity in the aluminum melt. If coatings of the highest purity are required, the water-cooled copper crucible must be used without any liner. On the other hand, a crucible material such as boron nitride enables high evaporation rates for aluminum. However, because of its excellent electrical insulating property, it is difficult to use without first grounding the evaporant so that the initial electron beam will ground and heat the aluminum and the crucible. Intermetallic liners such as composites of boron nitride and titanium diboride can be used to overcome this particular problem.

Applications of electron beam sources cover a wide range, from sophisticated microelectronics work where impurities measured in parts per million are intolerable, to decorative coatings where large impurity levels are acceptable. Use of liners is therefore usually determined empirically. Liners sometimes crack when a molten pool solidifies or a previously used crucible is heated.

Many crucible liners are available, but liners manufactured by different companies often perform quite differently, particularly with respect to their life. A discussion of crucible liners and their recommended usage is found at the back of section 1.

TABLE II

HEAT OF VAPORIZATION AND RADIATION HEAT BALANCE

Element	Melting Temperature K	Crossover Temperature K	Crossover Heat Flux kW/in^2
Zn	693	598	0.0013
Mn*	1517	1327	0.034
Al	932	1663	0..85
Cu	1357	1789	0.113
Sn	505	1812	0.12
Cr*	2176	1885	0.14
Au	1336	2049	0.20
Fe	1809	2102	0.22
Co	1768	2119	0.22
Ni	1725	2121	0.22
Ti	1940	2412	0.39
Zr	2125	3457	1.6
Mo	2890	3680	2.0
Nb	2740	3860	2.5
Ta	3269	4525	4.6
W	3650	4738	5.6

*Sublime in vacuum

6. DIAGNOSTIC TROUBLESHOOTING GUIDE

The symptoms are numbered for reference. No sequence is implied.

Power supply nominal operating values are listed in the appropriate power supply instruction manual. *

Apply molybdenum disulfide to all threads whenever a fastener is removed and reinserted. **

NO.	SYMPTOM	PROBABLE CAUSE	CORRECTION
1	Beam power voltage is normal but there is no beam power current and no filament current. (Power supply nominal operating values are listed in the appropriate power supply instruction manual.)	(1) Filament is broken, loose or high resistance due to oxide buildup on filament clamps.	(1) Ensure that the filament is good and the filament clamp screw is clean and tight. (Apply molybdenum disulfide to all threads whenever a fastener is removed and reinserted.)
		(2) Break in filament circuit or power supply.	(2) Check the filament circuit and power supply.
2	There is no beam power voltage. Emission current will be fully pegged, with zero high voltage.*	(1) There is a high-resistance ground in the source or system. (2) There is a high-voltage breakdown.	Check system for shorted emitter, filament leads, and/or feedthroughs, broken insulators.
3	Emission voltage and current move up and down and there is visible arcing or heating at the high-voltage insulators.	(1) The high-voltage insulators are fouled or have failed.	Examine insulators:** (1) If fouled by conductive deposits, clean by glass-bead honing. If they are physically damaged, replace them.
		(2) The filament current lead is dirty and is making intermittent contact.	(2) Clean lead by glass-bead honing.
4	Beam power voltage and current are normal; filament current is high.*	Filament winding is shorted.	Replace the filament. Do not repair it.
5	Beam power voltage and current are normal; filament current is normal* but longitudinal current is excessive.	(1) The main field permanent magnet is weak.	(1) Remagnetize the permanent magnet** or replace it.
		(2) The focus coil is partially shorted.	(2) Replace the focus coil.
		(3) The filament is warped.	(3) Replace the filament.
6	Beam voltage and current are normal; filament current is normal.* The beam is not centered in the longitudinal direction.	(1) Coil current improperly adjusted.	(1) Adjust the focus current.**
		(2) The permanent magnet is weak.	(2) Remagnetize the magnet.
7	Beam voltage and current are normal; filament current is normal.* Beam spot is not centered in the lateral direction or the spot tails on one side of the spot.	(1) Parts are not correctly aligned. The center line of the emitter filament is not aligned exactly between the pole pieces.	(1) Ensure that all parts fit snugly, that** the filament is positioned correctly and is not warped or sagging.
		(2) Pole pieces or other parts are damaged.	(2) Repair or replace damaged parts.
		(3) Interference from another source.	(3) Install magnetic shield between the two magnetic fields.
		(4) Air gap between permanent magnet and pole pieces.	(4) Readjust pole pieces.
8	Beam voltage and current are normal; filament current normal.* There is melt wetting or eroding in the crucible.	(1) Beam is off center and/or focus is too close to the edge of the crucible.	(1) Readjust the focus current so that the beam is centered in the crucible.
		(2) There is insufficient water flow.	(2) Ensure that the cooling water is flowing through the crucible at required rate. See Installation.
		(3) The emitter is out of adjustment. The filament may be out of alignment.	(3) Ensure that the emitter is adjusted as shown in Fig.
9	Water boiling.	(1) Inadequate flow.	(1) Increase flow.
		(2) High inlet temperature.	(2) Chill water.
		(3) Weak permanent magnet.	(3) Check beam position with zero longitudinal coil current. Remagnetize or replace permanent magnet.
		(4) Distorted filament.	(4) See following symptom.
		(5) Aluminum alloyed with copper crucible.	(5) See following symptom.

NO.	SYMPTOM	PROBABLE CAUSE	CORRECTION
10	Aluminum alloying (wetting) with crucible. The alloying crucible cannot be reused until it has been glass-bead honed.	(1) Inadequate cooling (flow) or badly warped filament. (2) Beam spot position is too far in or out, too far right or left, at high power operation.	(1) Check flow rate and water temperature. Replace warped filament. (2) Center beam in the longitudinal or lateral direction as indicated.
11	Warped beam former and/or gun emission is limited.	(1) Beam former is shorted to righthand cathode block. (2) Filament emission is limited because the: (a) filament is installed backwards, or (b) not enough filament is exposed, or (c) there are shorted turns on filament, or (d) filament is badly warped, or (e) the anode is too far from the filament. (3) Badly coated flanged insulator 0303-3131-0. (4) Loose connection or oxidized surfaces at connections. (5) Low filament voltage.	(1) Clean or replace locating insulator** 0303-6721-0. (2) Replace the beam former if the warp is extreme. If filament is warped or has shorted turns, replace it. If it is installed incorrectly, reposition filament. (3) Clean or replace insulator. (4) Clean and reconnect. (5) Check for proper transformer connections. Check output of gun controller.
12	Short filament life.	(1) Filament emission limited because the filament is installed backwards, or not enough filament exposed, or there are shorted turns on filament, or the filament is badly warped, or the anode is too far from the filament. (2) Improper use of rate control. (3) Poor vacuum pressure in gun area (above 5×10^{-4} Torr).	(1) Refer to drawing 304-1914 for proper adjustments of the emitter assembly. (2) Refer to "rate range" adjustment procedure in power supply manual. (3) Leak-check vacuum chamber. Clean system. Change pump oil.
13	There is a rapid loss of field strength in permanent magnet.	(1) There are strong ac fields coming from an external source.	(1) Reroute ac leads away from permanent magnet. CAUTION Do not slide magnet on magnetic material.
14	There is no lateral or longitudinal movement of the beam.	(1) No coil current. (2) Shorted leads to focus coils.	(1) Coil leads disconnected. (2) Check resistance of lateral and longitudinal coils for shorts.
15	There is a pronounced loss of evaporation rate.	(1) Beam density may be too high, causing cavitation of molten pool. (2) The permanent magnet is too weak. The beam is not centered laterally. (3) There is interference by other electron beam source magnets or other magnetic fields. (4) The filament may be warped.	(1) Expose more filament or vary the distance between the pole extensions.** (2) Use zero coil current to determine the beam spot position at low power. (3) Install magnetic shield between the two magnetic fields.

NO.	SYMPTOM	PROBABLE CAUSE	CORRECTION
16	There is a loss of all lateral and longitudinal beam control.		(1) Check voltages on electromagnet. If there is voltage then check coil resistance. Longitudinal: 2.2 to 2.4 ohms Lateral: 3.0 to 3.2 ohms Change coil assembly.
17	Electron beam spot changes position as source is heated.	(1) The evaporant may be a magnetic material such as Ni or Fe which when heated passes the curie point becoming nonmagnetic.	(1) For automatic cycling, heat evaporant at low power levels with beam spot in such a position that when the evaporant is through the curie point, the beam spot is centered in the crucible.
18	Electron beam spot shifts position as relatively large quantities of the material is evaporated.	(1) The evaporant is magnetic material which builds up around the hopper causing a magnetic shunt.	(1) Remove deposit from around the hopper.
19	Electron beam spot cannot be moved out along the longitudinal axis.	(1) The source is being operated at lower than 10kV.	(1) Use appropriate permanent magnet shunts (see table).
20	Anode plate burned through.	(1) Anode plate directly exposed to the filament.	(1) a. Adjust height of anode plate.** b. Beam former shorted to cathode causing beam former to emit electrons and burn hole through anode.
		(2) Power supply voltage not remaining constant.	(2) a. Check power supply manual for proper rate control adjustments. b. Check power supply for proper voltage regulation.
21	No filament current.	Oxide buildup on the filament clamp blocks.	(1) Remove oxide.**
22	The maximum beam power attainable is 5kW.	(1) The filament is installed backwards causing space charging.	(1) Reverse filament.
		(2) The anode is positioned too far from the filament.	(2) Realign the anode.
23	Emission current drifts after a long period of operation.	Pancake insulator has become cracked.	Replace the insulator #0303-3131 0.
24	Cannot sweep complete area using tight beam.	The permanent magnetic field is too strong.	Use a shunt bar or bars as needed.
25	Filament burns out when energized.	Possible 12 volts is being applied to the filament indicating a transistor or SCR(s) is burned out on the gun controller.	Replace the SCR(s) or transistor(s) and the filament.**
26	After long usage there is a loss of evaporation rate; there is a slight space charging and sometimes the cooling water boils when opetating above 12kW beam power.	Filament has become warped.	Clean the emitter assembly. Replace the filament and adjust (filament 1/3 of the filament winding diameter is exposed below beam former).** NOTE Alignment of the emitter assembly is critical.

SECTION 7

FINAL ASSEMBLY PARTS LIST

Item	Description	Part No.	Mat'l	Qty
	NOTE: Numbers in parentheses refer to drawing 0304-1914-B All other item numbers refer to drawing 303-3014F			
1	Union Gasket, RL #3/8	0020-4811-2	Viton	2
2	Union Knurled Nut, RL #3/8	0020-4911-2	304-SST	2
3	Solder Nipple, RL #3/8	0020-5611-2	304-SST	2
4	Pole Piece, L.H.	0303-3024-1	E-Brite	1
5	Pole Piece, R.H.	0303-3024-2	E-Brite	1
6	Base Plate	0303-3032-0	304-SST	1
7	Magnet	0303-3232-0	Alnico-5	1
8	Emitter Support Block	0303-3242-0	304-SST	2
9	Pole Extension	0315-0011-0	416-SST	2
10	Coil Shield	0303-3262-0	304-SST	1
11	Crucible Brazement	0215-8754-0	OFHC-Copper	1
	Magnetic Suppressor	0312-6871-0	304-SST	1
	Screw Soc. Hd. #6-32NC2A	1321-1252-0	18-8-SST	1
12	Filament Lead X.25LG	0303-3292-0	Copper	2
13	Magnet Shield	0303-3371-0	OFHC-Copper	1
14	Emitter Assembly	0304-1914-0		1
	(1) Filament Buss Bar,L.H.	0303-3122-1	Tantalum	1
	(2) Filament Buss Bar,R.H.	0303-3122-2	Tantalum	1
	(3) Flanged Insulator	0303-3131-0	Alumina	4
	(4) Emitter Support Bracket	0303-3152-0	304-SST	1
	(5) Support Stud	0303-3161-0	304-SST	2
	(6) Locating Insulator	0303-6721-0	Alumina	1
	(7) Filament	0303-9351-0	Tungsten	1
	(8) Cathode Block, L.H.	0303-9362-0	Moly	1
	(9) Cathode Block, R.H.	0303-9372-0	Moly	1
	(10) Filament Clamp	0303-9382-0	Moly	2
	(11) Beam Former	0303-9392-1	Moly	2
	(12) Anode	0303-9402-0	Tantalum	1
	(13) Mounting Bar	0303-9412-0	304-SST	1
	(14) H-V Spacing Insulator	0418-4631-0	Alumina	2

Item	Description	Part No.	Mat'l	Qty
	(15) Screw, Soc. Hd. #6-32 NC-2A x 3/16	1321-1251-0	18-8 SST	3
	(16) Screw, Soc. Hd. #6-32, NC-2A x 1/4	1321-1252-0	18-8 SST	4
	(17) Screw, Soc. Hd. #6-32, NC-2A x 3/8	1321-1254-0	18-8 SST	2
	(18) Screw, Soc. Hd. #6-32, NC-2A x 1/2	1321-1255-0	18-8 SST	2
	(19) Lock Washer, #6	1374-1200-0	18-8 SST	2
	(20) Washer, #6	1378-1200-0	18-8 SST	4
15	Spare Parts Kit	0304-3211-0		1
	Union Gasket, RL #3/8	0020-4811-2	Viton	2
	Flanged Insulator	0303-3131-0	Alumina	4
	Locating Insulator	0303-6721-0	Alumina	1
	Filament	0303-9351-0	Tungsten	5
	Filament Location Gauge	0202-4121-0	304-SS	1
	Beam Former	0303-9392-1	Moly	1
	Anode	0303-9402-0	Tantalum	1
	H-V Spacing Insulator	0418-4631-0	Alumina	4
	Screw, Soc. Hd., #6-32, NC-2A x 1/4	1321-1252-0	18-8 SST	2
	Screw, Soc. Hd., #6-32, NC-2A x 1/2	1321-1255-0	18-8 SST	2
	Shipping Box	6642-0002-0	Plastic	1
16	Shunt Bar	0312-6861-0	416-SST	3
17	Coil Assembly	0312-6923-0	304-SST, Alumina	1
18	Instruction Manual	0101-8011-3	Paper	1
19	Screw, Soc. Hd., #6-32, NC-2A x 1/4	1321-1252-0	18-8 SST	6
20	Screw, Soc. Hd., #6-32, NC-2A x 3/8	1321-1254-0	18-8 SST	14
21	Thumb Screw, #10-32 x 1/2, PIC #4045	1349-4045-0	303 SST	2
22	Nut, Machine Hex, #6-32 NC-2B	1360-1200-0	18-8 SST	2
23	Bondhus Ball Driver, 7/64 Hex	6990-0015-0		1
24	Bag, 8" x 9"	8121-0608-0	Plastic	1
25	Bag, 12" x 24"	8121-1224-0	Plastic	1
26	Shipping Box, SFIH-270-2	8130-1070-0	Cardboard	1
27	Pad, R.H.	8130-1070-4	Ethafoam	1
28	Pad, L.H.	8130-1070-5	Ethafoam	1

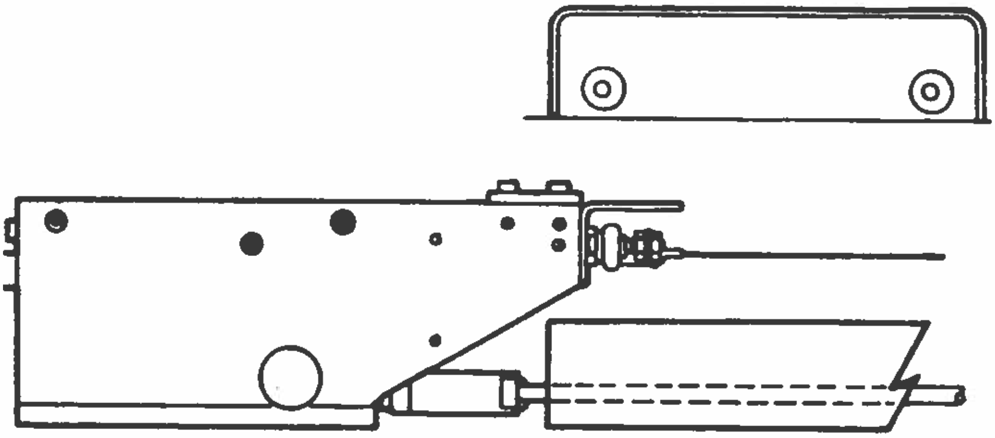


Figure 1. Schematic diagram of the high voltage shielding layout

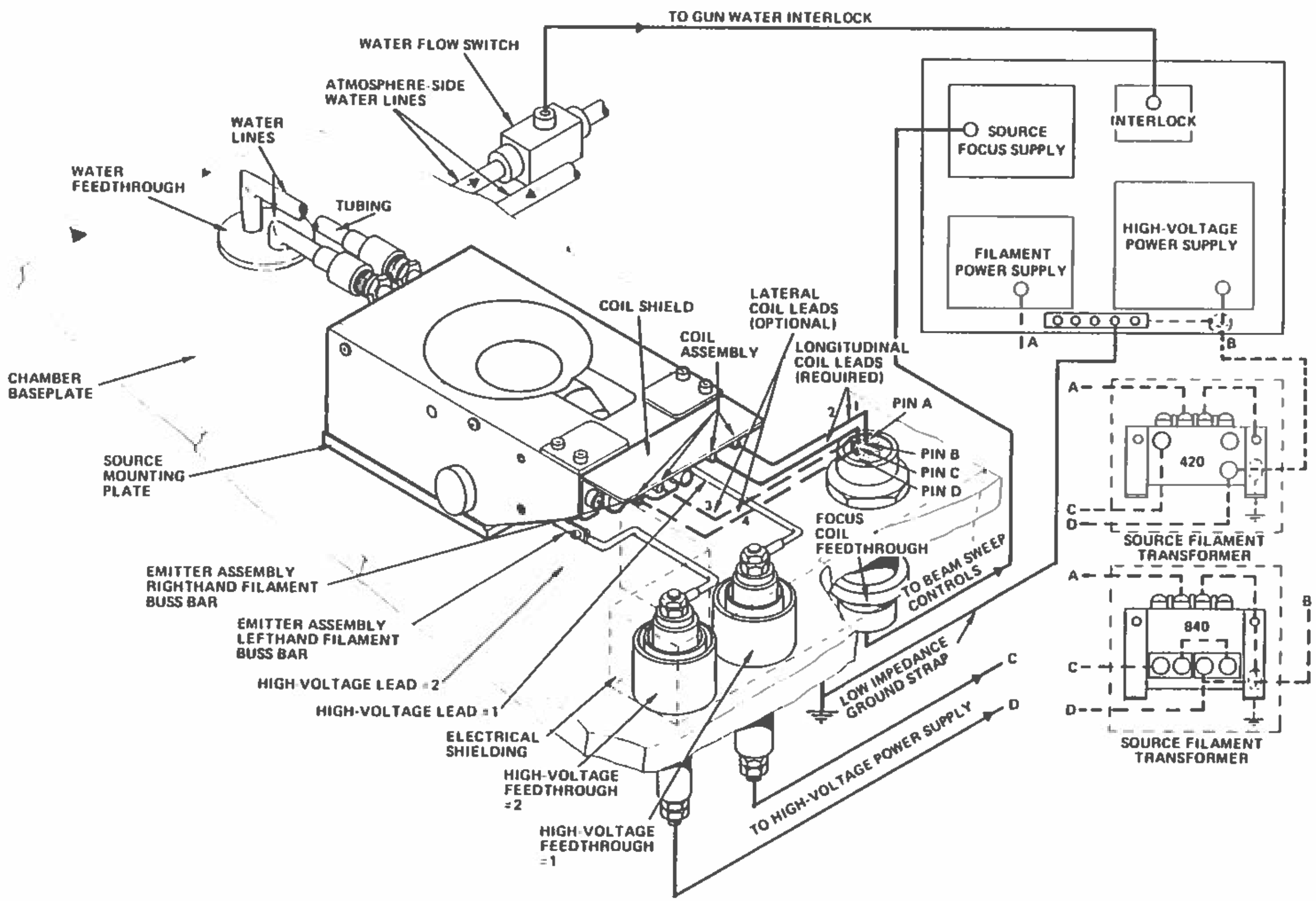


Figure 2. Installation details and interconnect block diagram for the SFIH-270-2

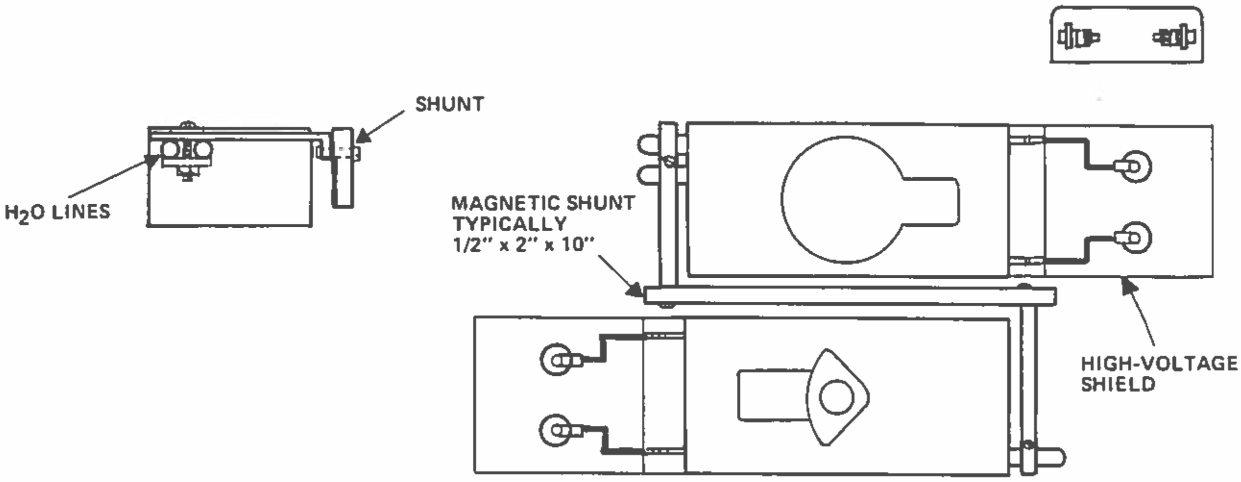


Figure 3. Schematic diagram of a typical chamber layout using two sources

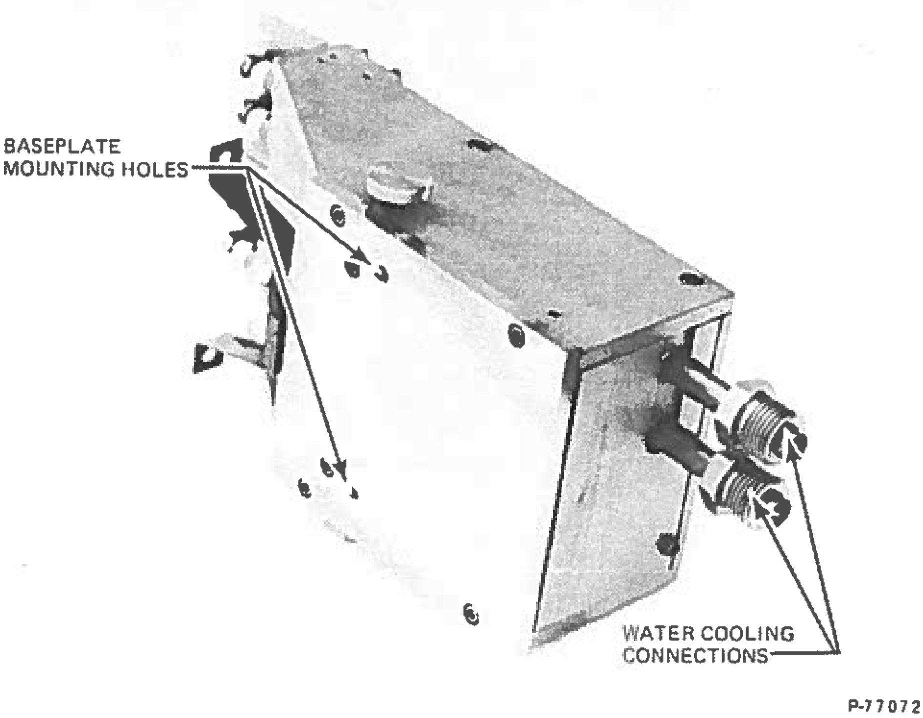


Figure 4. Bottom view of the SFIH-270-2 showing the mounting holes and water cooling connections

0101-8011-2

DRAWING NO.	REV.	CHK. DATE	APPV. DATE	AIRCO Temescal PARTS LIST	1/2	TOTAL NO. OF UNITS	ENG. RELEASE BY-DATE	PROJ./WORK ORDER NO.
0303-3014-1	F							
DWG. TITLE SFIH-270-2 E.B. SOURCE ASSY.				2-24-75 SAP			PLANNER-DATE	NEXT ASS'Y W/O NO.
JOB TITLE SFIH-270-2 E.B.S.				NEXT ASS'Y FINAL			ACCT. / PLANN. / STORES / STAGE / I.C.	OTHER

DESCRIPTION	ITEM	PART/STOCK NO.	SUB	UNIT QUAN.	TOTAL REQ.	STORES ISS.	STORES CODE	DEC. FT.	P.O. NO.-VENDOR-DATE REMARKS-NOTES-MISC.
UNION GASKET RL#3/8-VITON	1	0020-4811-2		2					
UNION KNURLED NUT,RL#3/8-SST	2	0020-4911-2		2					
SOLDER NIPPLE,RL#3/8-SST	3	0020-5611-2		2					
POLE PIECE,L.H.	4	0303-3024-1		1					
POLE PIECE, R.H.	5	0303-3024-2		1					
BASE PLATE	6	0303-3032-0		1					
MAGNET	7	0303-3232-0		1					
EMITTER SUPPORT BLOCK	8	0303-3242-0		2					
POLE EXTENSION	9	0315-0011-0		2					
COIL SHIELD	10	0303-3262-0	X	1					
CRUCIBLE BRAZEMENT	11	0215-8754-0	X	1					
FILAMENT LEAD	12	0303-3292-0	X	2					
MAGNET SHIELD	13	0303-3371-0	X	1					
EMITTER ASSY.	14	0304-1914-0	X	1					
SPARE PARTS KIT	15	0304-3211-0	X	1					
SHUNT BAR	16	0312-6861-0		3					

0101-8011-2

DRAWING NO.	REV.	CHK. DATE	APPV. DATE	AIRCO Temescal PARTS LIST	2/2	TOTAL NO. OF UNITS	ENG. RELEASE BY-DATE	PROJ./WORK ORDER NO.
0303-3014-1	F							

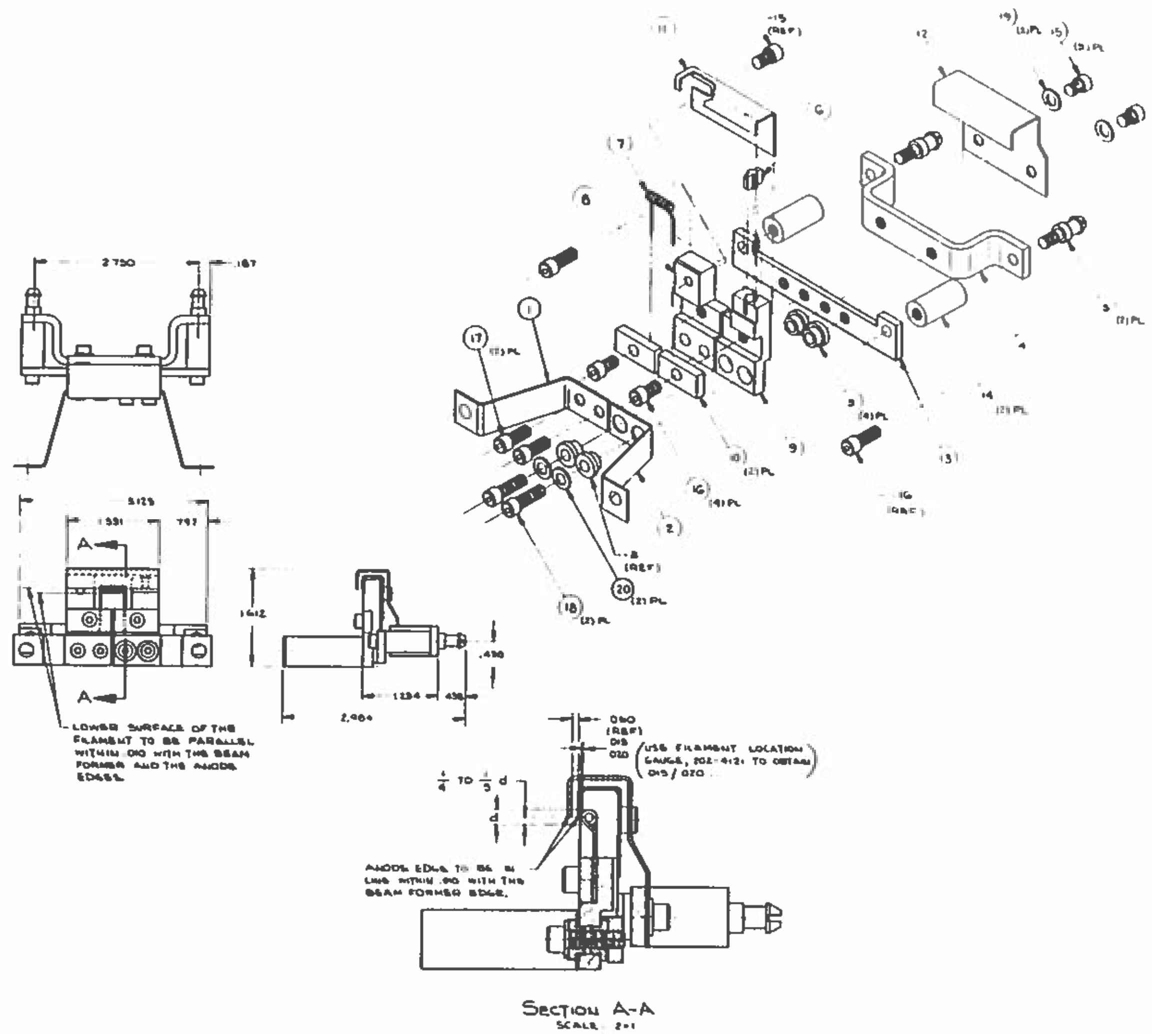
DWG. TITLE: SFIH-270-2 E.B. SOURCE ASSY. — 2-24-75 SAP

PLANNER-DATE | NEXT ASS'Y W/O NO.

JOB TITLE: SFIH-270-2 E.B.S. — NEXT ASS'Y: FINAL

ACCT. | PLANN. | STORES | STAGE | I.C. | OTHER

DESCRIPTION	ITEM	PART/STOCK NO.	SUB	UNIT QUAN.	TOTAL REQ.	STORES ISS.	STORES CODE	DEC. FT.	P.O. NO.-VENDOR-DATE REMARKS-NOTES-MISC.
COIL ASSY.	17	0312-6923-0	X	1					
INSTRUCTION MANUAL	18	0101-9821-0		1					
SCREW, SOC HD, #6-32NC-2A x 1/4" LG SST	19	1321-1252-0		6					
SCREW SOC HD, #6-32NC-2A x 3/8" LG, SST	20	1321-1254-0		14					
THUMB SCREW #10-32NF-2A-SST PIC P/NO. 4045	21	1349-4045-0		2					
NUT MACHINE HEX #6-32 NC-2B, SST	22	1360-1200-0		2					
BONDHUS BALL DRIVER 7/64" HEX	23	6990-0015-0		1					
POLY BAG 8" x 9" x .003	24	8121-0608-0		1					
POLY BAG, 12" x 24"	25	8121-1224-0		1					
SHIPPING BOX SFIH-270-2	26	8130-1070-0		1					
PAD R.H. ETHAFOAM	27	8130-1070-4		1					
PAD L.H. ETHAFOAM	28	8130-1070-5		1					



NOTES:
1. CHECK FOR ELECTRICAL ISOLATION BETWEEN ANODE AND FILAMENT SUPPORTS, AND FOR FILAMENT CONTINUITY BETWEEN FILAMENT SUPPORTS.
2. ALL DIMENSIONS SHOWN ARE FOR REFERENCE ONLY

B	RENUMBERED ITEMS NUMERICALLY REMOVED PARTS LIST	
A	ECN	

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED

505-5014

AIRCO Temescal — BERKELEY, CALIFORNIA — A DIVISION OF AIR REDUCTION COMPANY INCORPORATED

SFIH-270-2 & 6 SOURCE ASS'Y

WARNING AIRCO ... CONTROL

EMITTER ASS'Y — 0804-1914 — B

PARTS LIST "0804-1914 0" APPLIES

DRAWING NO.	REV.	CHK. DATE	APPV. DATE	AIRCO Temescal PARTS LIST	1/2	TOTAL NO. OF UNITS	ENG. RELEASE BY-DATE	PROJ./WORK ORDER NO.
0304-1914-0	B							
DWG. TITLE EMITTER ASS'Y.				2-24-75 SAP			PLANNER-DATE	NEXT ASS'Y W/O NO.
JOB TITLE SFIH-270-2 E.B.S.				NEXT ASS'Y 0303-3014-0			ACCT. / PLANN. / STORES / STAGE / I.C.	OTHER

DESCRIPTION	ITEM	PART/STOCK NO.	SUB	UNIT QUAN.	TOTAL REQ.	STORES ISS.	STORES CODE	DEC. FT.	P.O. NO.-VENDOR-DATE REMARKS-NOTES-MISC.
FILAMENT BUSS BAR, L.H.	1	0303-3122-1		1					
FILAMENT BUSS BAR, R.H.	2	0303-3122-2		1					
FLANGED INSULATOR	3	0303-3131-0		4					
EMITTER SUPPORT BRACKET	4	0303-3152-0		1					
SUPPORT STUD	5	0303-3161-0		2					
LOCATING INSULATOR	6	0303-6721-0		1					
FILAMENT	7	0303-9351-0		1					
CATHODE BLOCK, L.H.	8	0303-9362-0		1					
CATHODE BLOCK, R.H.	9	0303-9372-0		1					
FILAMENT CLAMP	10	0303-9382-0		2					
BEAM FORMER	11	0303-9392-1		1					
ANODE	12	0303-9402-0		1					
MOUNTING BAR	13	0303-9412-0		1					
H.V. SPACING INSULATOR	14	0418-4631-0		2					
SCREW SOC HD, #6-32 NC-2A, x 3/16 LG, SST	15	1321-1251-0		3					
SCREW SOC HD, #6-32NC -2A x 1/4 LG SST	16	1321-1252-0		4					

0101-8011-2

AIRCO Temescal

PARTS LIST

2/2

DRAWING NO.	REV.	CHK. DATE	APPV. DATE	TOTAL NO. OF UNITS	ENG. RELEASE BY-DATE	PROJ./WORK ORDER NO.
0304-1914-0	B					

DWG. TITLE: EMITTER ASSY.

2-24-75 SAP

JOB TITLE: SFIH-270-2 E.B.S.

NEXT ASS'Y 0303-3014-0

PLANNER-DATE

NEXT ASS'Y W/O NO.

ACCT.	PLANN.	STORES	STAGE	I.C.	OTHER

DESCRIPTION	ITEM	PART/STOCK NO.	SUB	UNIT QUAN.	TOTAL REQ.	STORES ISS.	STORES CODE	DEC. FT.	P.O. NO.-VENDOR-DATE REMARKS-NOTES-MISC.
SCREW,SOC HD, #6-32NC-2A x 3/8 LG,-SST	17	1321-1254-0		2					
SCREW SOC HD, #6-32NC-2A x 1/2 LG-SST	18	1321-1255-0		2					
LOCKWASHER INT. TOOTH- #6,SST	19	1474-1200-0		2					
WASHER FLAT CUT #6, SST	20	1378-1200-0		4					