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This manual presents descriptive data and the procedures to be employed in the assembly, test, and disassembly operations of SNAP 13 generators at the Government's Oak Ridge National Laboratory.

For convenience the manual has been divided into three parts and supporting appendices.

Part I. Fueling and Assembly of Generator.

This part deals with the fueling fixture, brazing equipment, and related consoles and support items.

Part II. Radioisotope Fueled Generator Operation.

This part of the manual provides generator and support equipment descriptive data, past performance data of electrically-heated prototypes, generator operating procedures, and safety precautions.

Part III. Disassembly, Radioisotope Fueled Generator.

The use of the cutting tools and fueling fixture are described to permit the safe disassembly of the generator to permit examination of the thermionic diode and other parts.

(Page 1 Deleted)

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It is highly recommended that personnel involved in the performance of the work related to SNAP 13 covered by this manual become completely familiar with this document. Additional background data on the overall SNAP 13 program are available in the Thermionic Development Program, Quarterly Reports. The initial report covers the period 1 October through 31 December 1961. Subsequent reports have been released every three months since that period.
MAJOR WARNINGS AND CAUTIONS

It is imperative that all fixture and generator components which are enclosed within the vacuum environment (fueling fixture bell jar) be thoroughly cleaned. Ultrasonic cleaning is preferred, but at a minimum, the components should be cleaned with acetone.

During the manual ("MAN") mode of fueling fixture operation, it is possible to override the micro-switches that limit shaft travel during the automatic ("AUTO") mode of operation. Do not override these micro-switches since component damage will result.

After fueling the generator, the system must be operated under short circuit conditions for 40 days with the one exception outlined in the outgassing procedure (Chapter 4, Step 28).

The nuclear radiation hazards and the complete accident analysis of all fueling fixture operations are presented in detail in MND-3060-19.

Consult Chapter 10 herein for a summary of safety precautions related to performing work in accordance with the procedures of this manual.
Major Warnings and Cautions

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The SNAP 13 thermionic generators, as delivered to the laboratory for assembly, will each be in three parts (ref. Figure I-2a and I-2b).

1) **The generator base** including the sealed, operationally verified thermionic diode assembly.

2) **The fuel capsule** containing 2.75 grams of curium $^{242}$, or an electric heater element to simulate the radioisotope.

3) **The generator closure cover.** The electrically heated models have the heater connection penetrating the top of the cover, as shown in Figure I-2b. The fueled generator models will have no penetrations through this cover.

The assembly operation consists of 5 basic steps.

1) Positioning the fuel capsule within the generator base,

2) Brazing the fuel capsule to the diode assembly and removing the thermal shield,
KEY

1. Fixture proper (see Figure I-2a for details)
2. Bell Jar (lowers on support ring (3) to form vacuum chamber)
3. Support Ring
4. Base Plate
5. PS-40A Pumping System (brings vacuum chamber pressure down to $10^{-5}$ mm Hg absolute)
6. Four inch vacuum line
7. Vac-Ion Pump (brings vacuum chamber pressure down to $10^{-6}$ mm Hg absolute)
8. Four-inch high-vacuum valve, i.e., Vac-Ion isolation valve.

FIGURE I-1
Overall View of Fixture

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FIGURE I-1
Overall View of Fixture
3) Positioning the generator cover onto the generator base,
4) Seal brazing the generator case for final closure,
5) Generator outgassing, leak check and tubulation pinch-off operations.

Since the assembly of radioisotope fueled generators must be accomplished remotely, a Fueling and Assembly Fixture has been provided to facilitate the operations within the laboratory hot cell. (ref. Figures I-1 and I-2a.)

This device when properly interconnected with its associated consoles, support equipment and services is designed to perform the final assembly operations on a thermionic generator. Some use of the hot cell manipulating tools is required.

Procedures are presented in this part of the manual for performing the assembly operation of:

1) Radioisotope Fueled Generators
2) Electrically-Heated Test Generators
3) Thermal Mock-Up Generators

The latter two operations may be accomplished outside of the hot cell since a radioisotope is not involved.

Also included in this part of the manual are special handling precautions, a physical description of the fixture and its service requirements, and the control fixture preparations for a fueling operation.
KEY

1. SNAP Generator Base (See Figure I-2b)
2. SNAP Generator Fuel Capsule (place in fixture by remote operation - see Figure I-2b)
3. SNAP Generator Closure Cover (see Figure I-2b)
4. Capsule Pick-Up Arm (transfers capsule from chill block to generator base; also removes capsule braze shield (8))
5. Wedge Release Bellows (drives capsule pick-up arm wedge that actuates pick-up jaws)
6. Capsule Braze Filament (brazes capsule to emitter back-up plate)
7. Capsule Braze Filament Shaft (Shaft B positions filament for braze operation)
8. Capsule Braze Shield (provides thermal insulation during brazing; removed after brazing)
9. Casing Braze Filament (brazes generator cover to generator base forming seal)
10. Argon Line (driving force to wedge release bellows)
11. Transfer Chill Block (provides cooling for fuel capsule in an oxidizing environment)
12. Thumb Screw (holds and releases generator cover)
13. Arm Lock Screw (allows rotation of generator cover support arm)
14. Cover Weight (ensures proper seating of cover on base during casing braze)
15. Generator Base Support (holds generator base and provides auxiliary cooling by water coils during braze operations)
16. Generator Output Lead (one of the two electrical output leads)
17. Generator Casing Heater Leads
18. Cesium Heater Leads

FIGURE I-2a

Fixture: Front View Upper

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SNAP 13
THERMIONIC
GENERATOR
BASE

GENERATOR COVER
WITH ATTACHED
EB HEATER

FUEL CAPSULE
A. Fueling Fixture Components

The fueling fixture is composed of many components and subsystems. For descriptive purposes, the assembly is subdivided into the three units described below.

1. Basic Fueling Fixture - Included in this category is all hardware attached to or supported by the fixture base plate. Figures I-1 through I-4 show this assembly and include descriptive labels for all pertinent components.

2. Vacuum Pumping Systems - The fueling fixture assembly contains three vacuum pumping units. Two are located (see Figure I-1) in a standard PS-40A packaged pumping system manufactured by Consolidated Vacuum Corporation. This pumping system includes a type PMC-720 oil diffusion pump, a Welch type 14-2B mechanical pump for roughing and backing and a type GS100 liquid nitrogen level control. The third pumping (Figure I-1) system is a 40 L/S Ion pump, Model No. 911-5404, manufactured by Varian Associates, Vacuum Products Division. A control
KEY

1. Support Ring

2. Wedge Release Bellows (drives capsule pick-up arm wedge that activates pick-up jaws)

3. Chill Block Cooling Coils (water-cooled coils for cooling fuel capsule)

4. Capsule Push Rod Mechanism (elevates capsule in transfer chill block to provide better grasp by capsule pick-up arms)

5. Generator Cover Support Arm

6. Generator Cover Holder Plate

7. Generator Cover Shaft

8. Casing Braze Filament Leads (leads for the filament that brazes the generator cover to the generator base)

9. Capsule Pick-up Shaft (allows pick-up arms to remove capsule from chill block and transport it to the generator base)
KEY

1. Base Plate
2. Generator Evacuation Tube (connects the Vac Ion pump to the generator interior)
3. Casing Braze Filament Leads (leads for the filament that brazes the generator cover to the generator base)
4. Drive Motor (Capsule Pick-Up Shaft)
5. Drive Motor (Capsule Braze Filament Shaft)
6. Drive Motor (Generator Cover Shaft)
7. Capsule Loading Shaft "CCW" Limit Switch
8. Limit Switch Actuating Lever
9. Generator Cover Support Shaft (C) Low Limit Switch
10. Capsule Braze Filament Leads
11. Capsule Brazing Filament Shaft "CCW" Limit Switch

FIGURE I-4
Fixtures: Left Side-Lower
KEY

1. Base Plate
2. Ionization Vacuum Gauge (measure vacuums less than $10^{-4}$ mm Hg inside bell jar)
3. Argon Inlet (40 psi argon for capsule pick-up arm to release capsule)
4. Argon Inlet (80 psi argon for capsule pick-up arm to engage capsule brazing shields)
5. Argon Inlet (80 psi argon to move rear wedge between capsule pick-up arms)
6. Water Inlet (cooling water to generator base support coils)
7. Water Inlet (cooling water to transfer chill block coils)
8. Water Outlet (from chill block and generator base support)
9. Water Valve
10. Capsule Release Bellows (operated by 40 psi argon)
11. Solenoid (rear wedge release)
12. Solenoid (shield pick-up)
13. Solenoid (capsule release)
14. Capsule Loading Shaft High Limit Switch
15. Capsule Loading Shaft Low Limit Switch

FIGURE 1-5
Fixture: Right Side-Lower
unit (Figure 1-7), 921-0012, and a leak detector unit. Model No. 975-0000, are required for use in conjunction with the Vac Ion pump. A schematic of the vacuum systems is given in Figure 1-6.

Operating instructions for the above listed vacuum systems and associated hardware are presented in Appendix A.

3. Control Systems - Fueling fixture control during a fueling operation includes:
   a. Shaft Activation Control Panel - Regulation of all shaft motion in the fueling fixture is provided at this panel (see Figure 1-7). An illustration and detailed description of this panel is given in Appendix B.
   b. Vacuum System Controls - Controls for operating the vacuum pumping systems are located on this control panel (Figure 1-7). Operating instructions with illustrations of these control systems are given in Appendix A.
   c. Braze Control Console - Controls required for accomplishing both the capsule-to-emitter and generator casing closure brazes are provided on this
Argon operated valve which isolates gen. interior from PS-40A Pumping System.
Shaft Activation Control Panel and Vacuum System Control Panel
B. Service Requirements

Operation of the fueling fixture requires several services. These include electrical power, helium gas, argon gas, liquid nitrogen, and water. The required services and the applicable fueling fixture components are listed below.

1. **Electricity** - A 120 volt, 60 cycle, single phase power supply is required for the following equipment:
   
   a. Type PS-40A vacuum pumping system (see Appendix A)
   b. Vac Ion vacuum pumping system Model Number 921-0012 (see Appendix A)
   c. Vac Ion pump leak detector power supply (see Appendix A)
   d. Shaft activation control panel power supply (contains power input for shaft drive motors)
   e. GS-100 liquid nitrogen level control (used in PS-40A vacuum pumping system)

   A 440 volt, 60 cycle, three phase power supply is required for the braze control console.
FIGURE I-8
Braze Control Console
PRELIMINARY
2. **Water**

   a. Chill block support cooling coils and generator support cooling coil requires tap water at city line pressure and temperature.

   b. Type PS-40A vacuum pumping system requires 0.2 gallons of water per minute (tap water quality) at an inlet temperature of 20°C for adequate cooling. See Appendix A for allowable deviation.

3. **Nitrogen (liquid)** - Type PS-40A vacuum pumping system requires a supply of liquid nitrogen. The nitrogen may be supplied from a standard 50-liter or 100-liter pressurized liquid nitrogen Dewar flask. Be sure bottle has 1/2" male flare fitting.

4. **Argon** - Both bellows on the capsule pickup shaft, the He bleed valve and the Vac Ion valve require a supply of pressurized argon for operation. Both bellows may be supplied from the same source since each is provided with a separate pressure regulator. The storage container must supply argon at a pressure in excess of 100 psi.

5. **Helium** - A supply of helium must be provided at a pressure that will insure complete back-filling of the bell jar subsequent to braze operations.
CHAPTER 3

FIXTURE CHECKOUT PRIOR TO FUELING GENERATOR

A. General

1. Utilities - It is assumed that ORNL facilities personnel have made available to the fixture those services outlined in Chapter 2 B. Further details in this area are beyond the scope of this procedure.

2. Special Tools - To perform the steps of this checkout procedure the special tools outlined in Table I-1 are required. Other standard tools (ref. Appendix F will also be required for mechanical adjustment of limit switch positions and for generator installation.

3. Switch Control Nomenclature - The Fixture shaft control console panel layout is shown in Figure I-7 and Appendix Figure B-1. Shaft control procedures presented in this manual will use the switch nomenclature established on the console layout Figure B-1.

CAUTION

Prior to performing this checkout procedure, the operator should become familiar with the Shaft Actuation Control Panel - Read Appendix B attached hereto.
### Table I-1

**SPECIAL TOOLS FOR LIMIT SWITCH CHECKOUT**

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<td>432-2572075-001</td>
</tr>
<tr>
<td>Capsule to Emitter Plate Shim</td>
<td>432-2572085-001</td>
</tr>
<tr>
<td>Capsule to Emitter Plate Braze Form</td>
<td>432-2572075-003</td>
</tr>
<tr>
<td>Capsule Vertical Height Adjusting Tool</td>
<td>432-2572086-009</td>
</tr>
</tbody>
</table>
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4. General Checkout Sequence - Fixture checkout consists of setting and/or checking the limit switches of shafts C, A, and B (see Table 1-2 for shaft functions, motion and limit switches), and a pre-brazing check. The detailed procedures are presented below.

NOTE
Three limit switches are factory set (see Table 1-2). They should require no further adjustment.

5. Frequency of Checkout

a. Limit Switch - This checkout is utilized after fixture dismantling and reassembly, after prolonged periods of non-use, and after failure of a limit switch control.

b. Pre-Braze - This checkout serves as a final mechanical checkout. It is performed prior to every generator fueling operation.
## TABLE I-2

**FUELING FIXTURE SHAFTS**

<table>
<thead>
<tr>
<th>SHAFT</th>
<th>FUNCTION</th>
<th>MOTION</th>
<th>LIMIT SWITCHES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>UPPER</td>
</tr>
<tr>
<td>A</td>
<td>Control Capsule Loading</td>
<td>Vertical</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rotational</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Manipulate Capsule Brazing Element</td>
<td>Rotational</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Generator Cover Loading</td>
<td>Vertical</td>
<td>X</td>
</tr>
</tbody>
</table>

- Normal rest position - green light on
- Factory Set
- Direction of rotation is determined by viewing shaft from above the fixture
D. Detailed Checkout Procedure - Limit Switches

1. Initial Set-Up Procedure

**NOTE**
Check all wires to the micro switches for sound connections.

a. Check that the generator base support (ref. Dwg. No. 432-2572042) is level by placing a bubble type gage on top of upper surface. If adjustment is necessary use hex nuts (ref. P/N 1/4-20NC Hex nut) and studs (ref. P/N 432-2572043-023). The lower surface of the copper generator base support should be about 4-3/64" above the base plate.

b. Place the bottom half of the generator model into the generator base support making sure that the base lower surface is in contact with the three provided supports. The lower edge of the supports should be about 6-1/2" above the base plate. When the generator is resting on the supports, the braze ring surface should be about 8-7/64" above the base plate.

c. Tighten both clamp screws (ref. Dwg. 432-2572075-001) in the groove at the upper end of the generator lower half as shown in Figure I-9.

d. Energize the shaft control console by placing the "POWER" toggle switch, switch number (Figure B-1), to the "ON" position. Bring all shafts to their terminal position as follows:
FIGURE I-9

Mechanical Model of Generator and Capsule
(1) Place "MODE" key switch in "AUTO";
(2) Hold "A-V" key switch in "V" position until the green indicating light comes on;
(3) Hold "A-R" key switch in "CCW" position until its green indicating light comes on;
(4) Hold "B-R" key switch in "CW" position until its green indicating light comes on; and
(5) Hold "C-V" key switch "V" position until its green indicating light comes on.

2. **Shaft C-Lower Limit Switch Adjustment**

   a. Place dummy capsule (P/N 432-2572050) on the emitter plate, then place the top half of the generator model on top of the bottom section of the model.

   b. Loosen the lock screw (ref. Dwg. 432-2572027, P/N #10-24 screw) on the back side of the generator cover shaft by unscrewing.

   c. Unscrew the three cover holding screws (ref. Dwg. No. 432-2572027, P/N's #10-24NC thumb screw, two #10-24NC hex lock nut and two allen set screws #10-24NC) so that their ends are flush with the inside surface of the cover holder.

   d. Drive the generator cover holder down by turning key "C-V" to the "D" position, until the support

---

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rests upon the top half of the model generator and 1/8 inch clearance is provided between the arm and the cover holder plate (see Figure I-3). This is the lower limit of travel and the limit switch red indicating light should come on. If the proper clearance is not attained loosen the allen head screws (see Figure I-4) that attach the microswitch to the cover holder drive shaft. Move the cover holder drive shaft until the proper clearance is obtained. Position the microswitch at the stop and tighten the allen head screws.

e. Raise the cover holder drive shaft to the upper terminal position by holding "C-V" keyed switch to "U" (WARNING - the cover shoulder plate should contact the shoulders of the three screws simultaneously. If it does not, the cover will cock and not seat properly when lowered. The screws should be adjusted to prevent cocking.) until the green indicator light comes on and then lower, by switching to "D" position, to the newly established lower limit. Check 1/8 inch clearance between arm and plate. If satisfactory continue with step f. If incorrect repeat steps d and e.

f. Adjust and tighten the arm lock screw and the three cover holding screws (ref. steps b and c) so that the generator cover is held firmly and is centered on the generator lower half.
g. Repeat step e and check the centering ability of the generator cover to determine whether the thermal shields will clear the capsule. If the shield does not clear the capsule, the screws which hold the generator cover plate require adjustment.

h. Raise the generator cover to the upper terminal position by turning and holding switch "C-V" to "U" until the green indicator lights. Remove dummy capsule.

3. Shaft A - Limit Switch Adjustments

a. Place the capsule-emitter plate spacer shim (see Figure I-9 and P/N 432-2572085-001) on the simulated emitter plate which is attached to the inside lower surface of the generator lower section. Rotate the capsule loading mechanism to the full clockwise position by turning and holding switch "A-R" to "C-V" until the red indicator light comes on.

b. Place the transfer chill block in the water cooled chill stand with the pin on the transfer chill block aligned with the slot on the chill stand and un latch the chill block by moving the latch in a clockwise direction. (See Figure I-2.)

c. Rotate the capsule loading mechanism to the full counter clockwise position by turning and holding switch "A-R" on "CC-W" until the green indicator light comes "on".

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d. Open the capsule pick up arms to the capsule pickup position by turning switches "2-A" and "2-B" "OFF" and "ON" three times, then leave "ON".

e. Lower the capsule loading mechanism so that the lower surface of the mechanism is just above the upper capsule surface.

f. Check that clearance exists between the capsule pickup arms and the capsule so that the arms could be lowered below the capsule upper surface without interference.

PRECAUTION

Do not override micro switch with mode of operation in "MAN". If over driven damage to micro switch and/or shaft may occur.

If an off-center condition exists the counter clockwise rotational limit switch (see Figure 1-4) must be reset; this is done by loosening the screws that attach the limit switch to its support structure and backing the limit switch away from the shaft actuating arm. Adjusting the capsule pickup arms by manipulating switch "A-B" in either a "CW" or "CCW" direction.

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When the off-center condition has been eliminated, bring the limit switch in contact with the shaft actuating arm and tighten the screws that attach the limit switch to its support structure.

g. Raise the capsule loading mechanism to its upper limit of travel by turning and holding switch "A-V" on "U" until the green indicator lights.

h. Rotate the pickup arms in a clockwise direction through approximately 20 degrees by turning and holding switch "A-R" on "CW".

i. Rotate the pickup arms in a counter clockwise direction to their terminal position by turning and holding switch "A-R" on "CCW" until the green indicator lights.

j. Lower the pickup arms to a level just above the capsule upper surface by turning and holding switch "A-V" on "D".

k. Verify visually that the pickup arms are centered over the capsule; if they are centered, lower the pickup arms over the capsule by turning and holding switch "A-V" on "D" until the red indicator lights. If an off-center condition exists, raise the pickup
arms to their upper terminal position by turning and holding switch "A-V" on "U" until the green indicator lights and repeat steps 2 through 5.

1. Raise the pickup arms to their normal rest position by turning and holding switch "A-V" on "U" until the green indicator lights.

2. By hand, remove the capsule from the capsule chill block and place it in the generator so that it rests on top of the capsule-emitter plate spacer shim (see Figure 1-9).

3. Rotate the capsule loading mechanism clockwise to a position over the center of the generator model by turning and holding switch "A-R" on "CW" until the red indicator lights.

4. Lower the capsule loading mechanism to a position just above the capsule by turning and holding switch "A-V" on "D". Visually check that the arms are centered over the capsule; if they are not the limit switch must be re-set.

PRECAUTION

Do not override micro switch with mode of operation in "MAN". If over driven, damage to micro switch and/or shaft may occur.
This switch is reset by loosening the screws attaching the limit switch to its support structure and backing the switch away from the shaft actuating arm. Locate the shaft by manipulating switch "A-R" in either a "CW" or "CCW" direction. When the off-center condition has been eliminated, bring the limit switch in contact with the shaft actuating arm and tighten the screws that attach the limit switch to its support structure.

2. Insert the vertical height adjusting tool (ref. Figure I-9, P/N 432-2572086-009) in the capsule pickup arms from above, so that it is supported by the top of the arm assembly.

3. Lower the capsule pickup arms over the capsule by turning and holding switch "A-V" on "D" until the red indicator lights. At this point the vertical adjusting tool (Figure I-9) should have just come in contact with the capsule upper surface; if it has not, re-adjust the lower limit switch on the capsule pickup arms (ref. Chapter 3.3f) so that it does. This is the lower limit of travel position.

4. Grasp the capsule with the capsule pickup arms by turning switches "2-A" and "2-B" to the "OFF" position.
s. Raise the capsule pickup mechanism to its upper limit by turning and holding switch "A-V" on "U" until the green indicator lights.

t. Rotate the capsule pickup arms to their normal rest position by turning and holding switch "A-R" on "CCW" until the green indicator lights.

u. Lower the capsule push rod mechanism (see Figure I-3) by making the following adjustment. Loosen the locking nut (ref. Dwg. No. 432-2572937, P/N #10-24NC-2B) with an adjustable crescent wrench by turning counterclockwise. Turn down the push rod (ref. P/N 432-2572937-005) by screwing in a clockwise direction approximately 6 turns.

v. Lower the capsule pickup mechanism to its lower limit of travel by turning and holding switch "A-V" on "D" until the red indicator lights.

w. Adjust the capsule push rod mechanism by screwing counter clockwise to a point where the push rod just makes contact with the lower capsule surface. Lock the capsule push rod mechanism in this position.

x. Open the capsule pickup arms by turning switches "2-A" and "2-B" to the "ON" position.
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1. Raise the capsule pickup mechanism to its upper limit of travel by turning and holding switch "A-V" on "U" until the green indicator lights.

2. Remove vertical height adjusting tool from the pickup arm assembly.

NOTE

If it was necessary to shift the generator base support during the checkout of Shaft A Section 3, it will be necessary to repeat the checkout of Shaft C, Section 2.

4. Shaft B - Limit Switch Adjustment
   a. Remove the capsule-emitter place spacer shim (ref. P/N 432-2572075-003) on the generator emitter plate.
   b. Place the capsule to emitter plate braze from (ref. P/N 432-2572075-003) on the generator emitter plate (see Figure 1-9).
   c. Remove the capsule from the chill block and place it on top of the braze form in the generator model base.
   d. Rotate the capsule brazing filament mechanism to its counter clockwise limit by turning and holding switch "B-R" on "GC#" until the red indicator lights.
   e. Check that the capsule brazing filament is centered over the capsule. If it is not centered, bend the copper leads to adjust.
   f. Check that a gap of 0.1 inch exists between the capsule braze filament and the capsule upper surface; if not, adjust by bending the copper leads.
   g. Rotate the capsule brazing filament mechanism to its clockwise limit by rotating the holding switch "B-R" on "GC#" until the green indicator lights.

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5. Final Limit Switch Operation Check

Perform the full sequence of operation for the three moving mechanisms: the capsule loading mechanism, the generator cover mechanism, and the capsule brazing mechanism as outlined in section C, Detailed Checkout Procedure - Pre-Brazing. Observe the control panel lights during the operations. The green light indicator, for each control switch, should be illuminated when the mechanism is in the normal rest position. The red indicator lights should be illuminated whenever the mechanism has reached the other terminal point of travel. This is separately applicable to rotation and translation.
C. Detailed Checkout Procedure - Pre-Brazing

This procedure is applicable for checkout prior to brazing any of the following generator assemblies:

i. Thermal mockup generator (ref. P/N 432-2572053-009)

ii. Electrically heated generator (ref. P/N 483-100 Rev. G)

iii. Fueled generator (ref. P/N 483-1000 Rev. G)

The checkout procedure for any of the three generator assemblies shall use the capsule mechanical model (ref. P/N 432-2572052-001).

1. Initial Set-Up Procedure

a. Insert the bottom half of the generator into the generator base support making sure that the base lower surface is in contact with the three provided supports. For the various generator assemblies use the following procedures:

(1) Thermal mockup generator: see Chapter 4.C.1.

(2) Electrically-heated or fueled generator: see Chapter 4.A, Step 1.

b. Place the capsule braze form (ref. P/N 432-2572075-003) on the simulated emitter plate which is attached to...
the inside lower surface of the generator lower half.
Condition the capsule braze form by cleaning with 600
grit sandpaper and acetone. Prepare and place the
casing braze ring (ref. P/N 432-2572075-001) in the
groove at the upper end of the generator lower half.
Instructions for preparing the casing braze ring for
insertion are as follows.
(1) For thermal mockup generator only (ref. P/N
432-2572053-009). Clean the generator cover,
casing, and braze groove thoroughly with acetone.
(2) For thermal mockup generator and electrically-
heated and fueled generators.
(a) Torch heat the braze ring to dull red;
allow to cool.
(b) Clean braze ring with 600 grit sandpaper
and acetone.
(c) Shape braze ring by inserting into the cover
groove, and press to fit.
(d) Remove the braze ring and place it in lower
half of the generator.
Place the applicable generator cover on top of the
generator base.

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d. Energize the shaft console by placing the "POWER" toggle switch, switch number 1 (Figure B-1), on the "ON" position.

e. Bring all shafts to their terminal positions as directed in Chapter 3.B.1g.

**CAUTION**

Do not override micro switch with mode of operation in "MAN". If over driven, damage to micro switch and/or shaft may occur.

f. Place the mode of operation switch on "AUTO" if during the conduct of step g an unusual event required manual operation.

g. Unscrew the lock screw and the three cover holding screws (ref. Dwg. No. 432-2572027, P/N's 10-24 NC thumb screw) so that their ends are flush with the inside surface of the cover holder.

h. Lower the generator cover holder to its lower limit of travel by turning and holding switch "C-V" on the "D" position until the red indicator lights.

i. Adjust the three cover screws (ref. step g) so that the generator top is held firmly and is centered on the generator lower portion. Tighten the lock screw.

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1. Raise the generator cover to the upper terminal position by turning and holding switch "C-V" to "U" until the green indicator lights.

k. Place the capsule braze heat shield (ref. P/N 432-2572071-009) into the generator base so that it is supported by its six protruding arms and the upper edge of the generator base. The heat shield should be centered on the emitter backup plate.

l. Rotate the capsule pickup mechanism to its clockwise limit by turning and holding switch "A-R" on "CW" until the red indicator lights.

m. Place the capsule chill block, containing the capsule model, into the chill block support stand by use of a remote manipulator and the chill block handling tool (ref. P/N 432-2572003-009) so that the pin on the chill block is lined up with the slot on the chill stand.

n. Unlatch the chill block with a remote manipulator.

o. Lower the capsule pickup arms to their lower limit of travel by turning and holding switch "A-V" on "D" until the red indicator lights.

p. Position the capsule braze heat shield so that the two pins on the pickup arms coincide with the two holes in the heat shield.

**NOTE**

For the thermal mockup generators, it may be necessary to rotate the generator base to get the pins on the pickup arms to align with the holes on the heat shield.

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a. Check the position of the two pins and holes by:
   turning switches "2-A" and "2-B" to "ON" turning
   switch "3" to "ON", and push button "k". The pins
   should now be moved out and fitted into and through
   the two heat shield holes.

b. Release button "k".

c. Turn switches "2-A" and "2-B" to the "OFF" position.

d. Turn switch "3" to the "OFF" position. Turn switches
   2A and 2B to the "ON" position.

e. Raise the capsule pickup mechanism to its upper limit
   by turning and holding switch "A-V" on "U" until the
   green indicator lights. If the pins do not clear the
   shield, repeat steps a through e.

f. Rotate the capsule pickup mechanism to its normal rest
   position by turning and holding switch "A-R" on "CCW"
   until the green indicator lights. Turn switches 2A and
   2B to the "OFF" position. Place bell jar guides in posi-
   tion. Remove tools from fueling fixture base.

g. Lower the bell jar down onto the base plate support ring
   after cleaning the mating surfaces and applying a new
   layer of vacuum grease.

h. Introduce a vacuum inside the bell jar by activating
   the type PS-40-A vacuum system (ref. Appendix A).

2. Pre-Brazing Checkout

   The fixture is now prepared for the pre-
   brazing mechanical checkout. While

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performing the following operations, an observer should be visually checking each movement inside the bell jar to assure correct operation. If any operation is not successfully completed, the checkout procedure is to be stopped. If the operation failure is due to a faulty limit switch setting, the checkout procedure for setting the limit switches, ref. Chapter 3, para. B.1, must be repeated.

a. Open the capsule pickup arms by turning switches "2-A" and "2-B" to the "ON" position. Open and close pickup arm three times; leave open.

   NOTE

   This step pressurizes the bellows that actuate the capsule pickup arms.

b. Lower the capsule loading mechanism to its lower limit of travel by turning and holding switch "A-V" on "D" until the red indicator lights.

c. Close the capsule pickup arms onto the capsule by turning switches "2-A" and "2-B" to the "OFF" position.

d. Raise the capsule loading mechanism to its upper limit of travel by turning and holding switch "A-V" on "U" until the green indicator lights.

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2. Rotate the capsule loading mechanism to its clockwise limit by turning and holding switch "A-R" on "CW" until the red indicator lights.

3. Lower the capsule loading mechanism to its lower limit of travel by turning and holding switch "A-V" on "D" until the red indicator lights.

4. Release the capsule by turning switches "2-A" and "2-B" to the "ON" position. The upper surface of capsule should be below the heat shield.

5. Raise the capsule loading mechanism to its upper limit of travel by turning and holding switch "A-V" on "U" until the green indicator lights.

6. Rotate the capsule loading mechanism to its counter clockwise limit by turning and holding switch "A-R" on "CCW" until the green indicator lights.

7. Rotate the capsule brazing element over the capsule by turning and holding switch "B-R" on "CCW" until the red indicator lights.

8. Rotate the capsule brazing element to its clockwise limit by turning and holding switch "B-R" on "CW" until the green indicator lights.

9. Rotate the capsule loading mechanism to its clockwise limit by turning and holding switch "A-R" on "CW" until the red indicator lights.
m. Lower the capsule loading mechanism to its lower limit by turning and holding switch "A-V" on "D" until the red indicator lights.

n. Bring the capsule pickup arms to the capsule braze heat shield pickup position as follows: turn switch "3" to "ON", push and hold number "4" control button.

NOTE
Control button number 4 is spring-loaded to the "OFF" position; thus, it must be depressed and held until release of the heat shield is desired, i.e. Step f.

o. Raise the capsule loading mechanism to its upper limit of travel by turning and holding switch "A-V" on "U" until the green indicator lights.

p. Rotate the capsule loading mechanism to its normal rest position by turning and holding switch "A-R" on "CCW" until the green indicator lights.

q. Lower the capsule loading mechanism until the lower end of the capsule braze heat shield is approximately 1/8 inch above the chill block upper surface by turning and holding switch "A-V" on "D" and visually observing the operation.
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1. Release the heat shield by releasing push button number 4.

2. Depressurize the capsule pickup arms as follows:
   first turn switches "2-A" and "2-B" to the "OFF" position, then turn switch 3 to the "OFF" position.

3. Raise the capsule loading mechanism to its normal rest position by turning and holding switch "A-V" on "U" until the green indicator lights.

4. Lower the generator cover down onto the generator lower half by turning and holding switch "C-V" on "D" until the red indicator lights.

NOTE

After performance of the pre-braze mechanical checkout procedure, the fueling fixture is fully prepared for the assembly of a capsule containing fuel and a generator (see Chapter 4A).

For the assembly of an electrically-heated generator and its capsule, or the thermal mock-up generator, additional fixture preparations are required due to:
(1) hookup of the capsule Joule heater for the thermal mockup generator, and (2) hookup of electrical connections for the capsule heater and placement of a special braze filament for the electrically heated generator. Instructions for installing these additional components are given in Chapter 4B and 4C respectively.

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CHAPTER 4
GENERATOR ASSEMBLY PROCEDURES

A. Radioisotope Fueled Generator

The principal operations required in the radioisotope fueling procedure are outlined in Figure I-10. For the assembly of a radioisotope fueled thermionic generator, the fuel capsule (containing Cm-242) in its transfer chill block (ref. P/N 432-2572002-009) must be located in a shielded container within the hot cell or on the conveyor belt external to the hot cell. The checks in Appendix D must be carried out. The following procedure must then be followed to complete the generator assembly operation:

1. Manually install and correctly position the following generator components:

   - casing braze ring P/N 432-2572075-003
   - generator base P/N 483-1000-1015 (Rev. G)
   - generator cover P/N 483-1000-1011 (Rev. G)
   - fuel capsule braze form P/N 432-2572075-003

The details of installation follow:

a. Casing Braze Ring - This ring must first be formed to fit the provided groove in the generator base joint face. This may be done on a bench using the generator cover and the...
braze ring as follows. Place the braze ring into the groove in the cover joint face; manually press the ring into the joint to achieve the proper curvature; then remove it; torch heat the braze ring to dull red; allow to cool; clean braze ring with 600 grip sandpaper and acetone; place it into the generator base joint face groove.

b. Generator Base – (ref. Figure I-11) Attach lugs 432-2572045-001 and -003 to generator electrical leads using 1/4 - 20 NC screws through top holes of leads.

Install insulator washer 432-2572045-013 and two bolt insulators 432-2752045-015 on 1/4 - 20 NC screw and with insulator assembly 432-2572045-019 between lugs tighten screw finger tight so that insulator assembly can be removed.

Insert generator base into the fixture, after bench assembly, while bending the 5/16 inch diameter evacuation tube as necessary for installation. Seat the generator base on the three ears of the base support; tighten the base clamp screws and fit the 5/16 inch diameter evacuation tube to the swagelock.

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NOTE: All detail and assembly numbers are for Drawing 432-2572045.

FIGURE I-11
View of Generator Terminal Assembly

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fitting in the base. Tighten the swagelock fitting 1-1/4 turns past "thumb-tightness".

Attach terminals 432-2572045-005 to the generator electrical leads, with slots facing up to clear the lug attaching screws, using bolt assemblies 432-2572045-009.

**WARNING**

Check, using an ohm meter, that the leads are not shorting to the fueling fixture base.

d. **Generator Cover** - (Ref. Figure I-2a) The generator cover is attached to the generator cover support arm (Figure I-3) by three thumb screws only. The vertical position of the cover is dictated by its relative position to the generator base when the cover holder drive shaft is at its lower limit of travel. For the setting-up adjustment, see Chapter 3.B.

d. **Fuel Capsule Braze Form** - This disc (ref. P/N 432-2572075-003) is placed on the emitter backing plate after it is cleaned with 600 grip sandpaper and acetone.

2. Open-circuit the transistorized load which is located outside the bell jar (ref. Chapter 7.D). Figure II-8 is a photograph of this load. Figure II-9 is an-

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Electrical schematic of the load showing the switch for opening the circuit.

3. Connect the cesium heater leads to the base plate electrical leadthroughs (ref. Figure I-2).

4. Connect the casing heater leads to the base plate electrical leadthroughs (ref. Figure I-2).

5. Connect the two casing and the two cesium reservoir thermocouples to the 12-pin connector on the base plate. See Appendix G for sketch showing the location of the thermocouple leads.

6. Initiate the required utility services to the fueling fixture (ref. Chapter 3.A.1). Connect the ignition power supply to the generator with its switch open. The details of this connection are in Chapter 7.C.

7. Activate the shaft control console by placing the power toggle switch, switch number 1, on the "on" position and bring all shafts to their normal rest position (ref. Appendix B, AUTO). Install the casing braze filament support ring (P/N 432-2572044-009). Adjust the filament so that it will line up with the braze joint and be spaced radially from the generator as shown in Figure C-3, Appendix G.

8. Place and adjust the capsule braze heat shield (ref. P/N 432-2572071-009) in the fixture by following steps k, l, and n through y as given in Chapter 3.C.1. Clean the ceramic insulator for the capsule braze filament and the ceramic heat shield to assure the removal of metallic deposits.

9. Remove the vacuum line plug assembly (P/N 432-2572059-019) and place the screen assembly (P/N 432-2572059-009) over the opening.

CAUTION

At this time all personnel shall leave the hot cell.

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10. By the manipulator, remove the clamp on the transfer chill block and place the block into the water-cooled chill block stand (item no. 3 - Figure I-3). The transfer chill block should be placed in the fueling fixture with the latch on the right-hand side as shown in Figure I-2A with the reference pin lined up with the notch in the chill block stand. The chill block handling tool (ref P/N 432-2572003-007) shall be used for this operation.

11. By using the manipulator, unlatch the transfer chill block.

12. Place the bell jar guides in position; then gently lower the bell jar onto the base plate reinforcing ring.

13. Introduce a vacuum of at least $3 \times 10^{-6}$ mm Hg inside the bell jar and generator by activating the type PS-40A vacuum system (ref. Appendix A for procedures). This step will require from 30 minutes to 1 hour. Be sure that Vac-Ion valve is open (switch up). Shut the Vac-Ion valve before starting step 14, introduce a "small water flow rate" through the generator support stand. "Small water flow rate" is defined as that quantity that will prevent "slug" flow, i.e. unstable two-phase flow.

14. Over a 20 minute period, gradually apply approximately 3 amps - 90 volts to the casing heater with the variac on the generator heater control console (ref. Figure II-3, II-4, and Chapter...
7.B) in order to preheat the cesium seal in the generator base. Reduce the power input to 50 volts - 1.8 amps to stabilize the casing at 215°C.

15. Rotate the capsule pickup mechanism to its normal rest position by turning a holding switch "A-R" on "CCW" until the green indicator lights.

16. Bring all components into position to make the capsule braze by following steps a through j as given in Chapter 3.C.2.

17. (Deleted)

18. (Deleted)

19. Make the capsule braze (for procedure see Appendix C).

Turn on the Vac-Ion pump (for procedure see Appendix A, Section C). Open the Vac-Ion valve when stable Vac-Ion pump operation is achieved.

20. Short circuit the transistorized load by turning the coarse and fine potentiometers shown in Figure II-9 full clockwise and then closing the circuit switch shown on the same figure.

21. Rotate the capsule braze element to its clockwise limit by turning and holding switch "B-R" on "CW" until the green indicator lights.

22. Remove the capsule heat shield by following steps 1 through t as given in Chapter 3.C.2.
23. a. Adjust the casing temperature to 650°F by adjusting the casing variac shown in Figures II-3 and II-4, and the water flow to the generator base.

b. Adjust the cesium temperature to 550°F by adjusting the coarse and fine cesium variacs shown in Figures II-3 and II-4. Allow the automatic cesium temperature control system to maintain the desired temperature.

c. Lower the cover by holding switch "C-V" on "D". This must be done at a uniform rate over a 1-hour period. (12 equals distances from where the radiation shield assembly begins to cover the capsule to where the cover rests on the casing of the generator). At 5 minute intervals, activate the ignition power supply. (Ref. Chapter 7.c for procedure). Continue this procedure until the generator ignites, at which time the activation of the ignition power supply is discontinued.

The generator may ignite spontaneously between one of the 5 minute intervals. Ignition is characterized by a sudden increase in both current and voltage. The casing and cesium reservoir temperature must be maintained within ±10°F of those temperatures stated in 23-a and b above. Record output current and output voltage at 5 minute intervals. Record casing heater currents, cesium heater currents, and water flow.
Part I
Chapter 4

SNAP 13 TECHNICAL MANUAL

Optimize the cesium temperature and the casing temperature (i.e. to produce maximum output from the generator) by varying the fine cesium variac and the casing variac. The procedure is to first vary the casing temperature in intervals of $\pm 10^\circ C$ ($\pm 18^\circ F$) from the previous setting until the optimum point is found. Record the time, all heater currents and voltages, generator output, all temperatures, and the isotope input.

WARNING
At this time it will be necessary to establish if the capsule braze was accomplished successfully. This is accomplished by comparing the results realized during step 23.d with those given in Figures 11-12 through 11-20.

If the capsule braze was successful, proceed to the casing braze (step A.24). If the capsule braze was unsuccessful, remove the generator cover over a 1 hour period (reverse procedure given in step 23.e). Re-establish the capsule braze and repeat steps 23.a, 23.b, and 23.d.

NOTE
Do not activate the ignition power supply. The generator will de-ignite during this procedure due to insufficient emitter temperature.

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24. Make the casing braze (ref. Appendix C for procedure). The water supply to the generator base support should be adjusted to maintain a 650°F casing temperature. The cesium reservoir must be maintained near optimum at all times.

25. Allow the generator to come to equilibrium and compare the output voltage and current with that recorded in step 23.d.

26. Switch operation of Vac-Ion pump from Vac-Ion pump power supply to Vac-Ion leak detector. Allow system to outgas for two hours and then close the Vac-Ion isolation valve. Perform a leak check of the generator casing closure braze as outlined in Appendix A, Section C.3.b. The cesium heater and casing heater must be adjusted for optimum performance to compensate for the cooling of the generator by helium used in the leak check.

27. If a leak is detected, re-establish the vacuum (Appendix A, Section B.b), repeat the casing braze (step A.24), and repeat leak check (step A.24 and A.25). If the casing is leak-tight, proceed with step A.28.

28. Re-establish the vacuum in the bell jar to $8 \times 10^{-6}$ mm Hg (ref. Appendix A, Section B.b). Outgas the generator by opening the Vac-Ion valve and elevating the emitter temperature.
to 1950°K by switching the load from short circuit to 0.5 volt (see Figure II-26) in increments of 50 millivolts (ref. Section 7.6 for procedure). At each plateau, the cesium temperature must be optimized. After each incremental change, do not proceed until the CVC ion gage indicates that outgassing is complete, i.e., until equilibrium is obtained. As the diode outgasses at each level, the diode performance will improve due to lower parasitic heat losses. Consequently, a rise in emitter temperature (and, consequently, output, voltage, and current) is expected. The 50 millivolt incremental increase was selected to prevent thermal shock and to facilitate optimum cesium temperature setting. The emitter should remain at 1950°K until a vacuum of $5 \times 10^{-6}$ mm Hg or better is obtained but outgas for a minimum of 5 days. After 3 days, isolate the generator interior from the PS 40A pumping system by closing the Vac-Ion isolation valve. This is done by switching the Vac-Ion isolation valve to closed position (Fig. A-3). With the Vac-Ion Leak Detector Power Supply operating, evacuate the generator interior to $5 \times 10^{-7}$ mm Hg or better. Then, return the generator to short circuit operation by reversing the incremental procedure presented above.
29. Perform the leak check again by repeating Step A.26 and, if necessary, Step A.27.

30. Backfill the bell jar with air in increments (crack the AIR INLET valve momentarily on right side of cabinet). The cesium and casing heaters must be concurrently energized using the procedure established in Step A.26.

When the bell jar is at atmospheric pressure, remove the bell jar and bell jar guides. Remove the screen assembly (P/N 432-2572059-009) from the 4 inch vacuum line inlet and replace with the plug assembly (P/N 432-2572059-019) before any further operations are performed in the fixture.

The assembled generator is removed from the fixture as follows:

31. Loosen the thumb screw on the generator cover holding arm to release the cover.

32. Raise the cover loading shaft by turning switch "C-Y" to "U" until the green indicator lights.

33. Loosen the cover loading shaft arm by unscrewing the lock screw (ref. Dwg. 432-2572027, P/N 10-24 screw) and rotate the arm assembly for clearance.

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34. Using the portable hydraulic press, crimp the 5/16" diameter evacuation lines at a point just below the lower surface (about 1.5 inches from the generator bottom) of the generator base support. Apply and maintain pressure until the evacuation tube separates. Monitor generator short-circuit current to insure steady-state operation. Monitor Vac-Ion pump pressure to insure that a good pinch-off was attained on the pump lines. (This is indication of good pinch-off on the generator.) After this pump observation period, turn off the Vac-Ion pump.
35. Remove the insulator assembly 432-2572045-019 at the base of the generator and tighten 1/4-20 screw. The generator is now on a direct short circuit.

36. Remove two (2) bolt assemblies 432-2572045-009, which will disconnect the output terminals 432-2572045-005.

37. Loosen the two support base clamp screws to allow the generator to be removed from the support base by use of the heavy duty cell bridge.

38. Remove the casing braze element and the capsule braze element.

39. Raise the generator out of the base support with the manipulator. As the generator is being raised, feed the cesium reservoir heater wires and casing heater wires through the base support until power can be switched to auxiliary source.

40. Connect the second set of cesium heater leads to the generator.

41. Connect the second set of casing heater leads to the generator.

42. Reduce the casing heater power on the first casing heater to zero while simultaneously increasing the power on the second casing heater. During this procedure, adjustments should be such that the casing temperature remains constant.

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43. Reduce the cesium heater power on the first cesium heater to zero while simultaneously increasing the power on the second cesium heater. Adjustments should be such that the cesium temperature remains constant.

44. Disconnect the cesium and casing thermocouples from their fueling fixture connectors. Reconnect all thermocouples to the test stand connectors.

45. Transfer the generator to the test stand with the manipulator.

46. Connect the output terminals 432-2572045-005 with the two-bolt assemblies 432-2572045-009 (see Figure I-11). Insert the insulator assembly 432-2572045-019 and tighten the 1/4-20 screw. The generator will now be connected to the external load which should be preset to short circuit.

47. Perform the parametric and performance testing as directed in Chapter 9.B.


B. Electrically Heated Generator

The assembly of this generator differs partially from that of an isotope fueled generator due to the presence of an electrical diode heater in lieu of the isotope. First carry out the checks in Appendix D. The following steps should then be performed.
SNAP 13 TECHNICAL MANUAL

NOTE

Assume that the generator will be heated by a heater in the generator cover ( EB or resistance).

1. Install the generator base and braze forms as described in step 1 of Chapter 4.A.
4. Manually position the capsule onto the emitter back-up plate.
5. Manually lower the special thermal brazing shields over the capsule.
6. Rotate the capsule brazing filament shaft to its counterclockwise limit by turning and holding switch "B-R" on "CCW" until the red indicator lights. Manually position the special capsule braze element inside the capsule. Insure that screws are tight; then center the filament by bending the copper leads.
7. Clean the ceramic insulator for the capsule braze filament and the ceramic heat shield to assure the removal of metallic deposits.
8. Remove the vacuum line plug assembly (P/N 432-2572059-019) and place the screen assembly (P/N 432-2572059-009) over the opening.

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11. Perform the capsule braze (ref. Appendix C, Section B).

12. (Deleted)

13. Allow generator to cool to 200°F; then backfill the bell jar with helium to relieve the vacuum (ref. Appendix A, Section B.a., but open the flood valve in step 4 instead of AIR INLET.

14. (Deleted)

15. Manually remove the special capsule braze element.

16. Manually remove the thermal braze shield and rotate the capsule brazing filament shaft to its clockwise limit by turning and holding switch "B-R" on "CW" until the green indicator lights.

17. Manually place cover onto generator base. (If EB heated, connect the diode heater leads to the capsule braze filament leads; then connect the power supply to the external wires. If resistance heated, connect one lead to the lead-through in the base of the bell jar ring and the other lead to the emitter lead-through of the generator.) Connect the proper power supply leads to the external connections. Place weight on the generator cover. This may require swinging the generator cover holder out of the way. Do not rotate cover until it interferes with the lowering of the bell jar.

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    Turn on Vac-Ion Pump (Ref. Appendix A, Section C.3).


20. Gradually apply 120 - 140 watts (net) to the diode heater.

21. Ignite the generator with the 1 volt - 100 amp power supply (ref. Chapter 7.C. for procedure).

22. Gradually increase the diode heater to 282.5 watts (net).
    The cesium heater must also be adjusted for optimized performance during this increase in diode heater power.

23. Perform step 4.A.24. Allow the generator to come to equilibrium and compare the output power at various voltages to that in Figure II-20. Record the date, time, all heater currents and voltages, generator output, all temperatures, and the isotope input.


25. (Deleted)

27. Over a 1-hour period, gradually reduce the diode heater, cesium heater, and casing heater to zero power.

28. Disconnect the leads to the diode heater at the generator cover.


30. Reconnect the diode heater leads so that the generator will be free for transferral to the test stand.


C. Electrically Heated Mockup Generator

Several thermal mockup generators with electrically heated capsules are provided for making practice casing and capsule brazes. The purpose of electrically heating the capsule is to thermally simulate the isotope heat output.

To provide additional experience in the mechanics of the fueling operation, this assembly procedure will commence from the beginning of the fueling cycle, but will deviate from a normal fueling operation about mid-way through to electrically connect the capsule heater and insert the capsule heat shield.
1. Prior to the braze procedure performance, the Pre-Braze Mechanical Checkout (ref. Chapter 3.C.) must be completed; then the following generator components shall be installed and correctly positioned in the fueling fixture: generator base (ref. P/N 432-2572054-009), generator cover NOTE: Insure that heater holes clear the cover and capsule transfer shafts, (ref. P/N 432-2572054-039), casing braze ring (ref. P/N 432-2572075-001), and the capsule braze form (ref. P/N 432-2572075-003). See section 4.A.1. for installation instructions. Install and position the casing braze element (ref. Appendix C, Fig. C-3).

   It is assumed that the fueling fixture is located in a hot cell and that the capsule model (ref. P/N 432-2572002-009), is also located inside the hot cell stored in a shielded container.


3. Place the capsule onto the generator base by following steps a through i as given Chapter 3.C.2. NOTE: Manually line up heater holes in capsule with holes in casing.

4. Manually install the capsule heater assembly (ref. P/N 432-2572076-009) and connect electrical leads. Install insulators through casing into capsule. Slide heater...
through the insulators. Connect one heater lead to the emitter output lead and the other to the collector input lead.

5. Perform steps k, l, and o through x, Chapter 3.C.1. Remove the vacuum line plug assembly (P/N 432-2572059-019) and place the screen assembly (P/N 432-2572059-009) over the opening. Perform steps 4.A.12, and 4.A.13.

6. Gradually raise the diode heater (ref. P/N 432-2572076-009) to 282.5 watts (net) by turning the thermal mockup variac shown on Figures II-3, II-4, and II-5. Gradually raise the casing temperature to 350°F by adjusting the No. 1 casing heater variac shown in Figures II-3, II-4, and II-5.

7. Rotate the capsule brazing element over the capsule by turning and holding switch "B-R" on "CCW" until the red indicator lights.

8. Make the capsule braze (for procedure, see Appendix C).

9. Rotate the capsule braze element to its clockwise limit by turning and holding switch "B-R" on "CW" until the green indicator lights.

10. Open the capsule pickup arms by turning switches "2-A" and "2-B" to the "ON" position.

11. Remove the capsule heat shield by following steps 1 through 1 as given in Chapter 3.C.2.

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12. Lower the generator cover onto the generator base by holding switch "C-V" on "D" until the red indicator lights on the Shaft Activation Control Panel. Wait 40 minutes to allow the cover to reach thermal equilibrium. Perform step 4.A.24.

13. Terminate input power to the thermal mockup heater and the casing heater. Both braze operations have now been completed. When the generator has cooled to 150°F, bring the interior of the bell jar to atmospheric pressure, raise the bell jar from the fixture base plate and remove bell jar guides and remove the generator from the fueling fixture. The required tests for evaluating the quality of both the casing and capsule brazes may now be performed. Remove the screen assembly (P/N 432-2572059-009) from the 4" vacuum line inlet and replace with plug assembly (P/N 432-2572059-019) before any operations are performed in the fixture.

CHAPTER 5
INTRODUCTION

This part of the manual contains the instructions for safely operating and testing a SNAP 13 (12.5-watt) thermionic generator fueled with the radioisotope curium-242. This part also presents a description of the generator, associated instrumentation, control, and other support equipment, operational restrictions, anticipated performance data observed on electrical prototypes, operating procedures and safety precautions pertinent to the hot cell operation.
CHAPTER 6
SNAP 13 GENERATOR DESCRIPTION

The SNAP 13 generator (ref. Figure II-1) is a thermionic electrical power source designed to supply 12.5 watts of electricity for 90 days at a minimum efficiency of 6 1/2%.

The required heat source is provided by 2.75 grams of curium-242 in the oxide form encapsulated in a tungsten - 2% molybdenum fuel capsule. Sufficient void volume has been allotted in the capsule to contain the helium gas generated by the alpha decay of the curium.

Approximately 40 layers of 0.0003 inch tantalum foil coated with thorium surround the lateral surface and one end of the fuel capsule for thermal insulation. To further minimize heat losses and prevent oxidation, a vacuum of $5 \times 10^{-7}$ mm Hg is maintained in a space outside the capsule. A titanium getter and stainless steel housing (1/8" minimum thickness) internally clad with copper and nickel are used to maintain this vacuum.

Since the generator will be operated in an air atmosphere, rather than a space environment, two sets of heaters are provided to compensate for heat losses due to convection. One set (two heaters, one required for operation) maintains the generator
FIGURE II-1
Cross Section of Generator 10
casing at the proper temperature; the other set (two heaters, one required for operation) is used to keep the cesium reservoir at proper temperature.

The thermal energy released by the decay of curium-242 is converted to electrical energy through a single thermionic diode. This diode uses a rhenium emitter and a molybdenum collector. The diode is mounted to one end of the fuel capsule.

The interelectrode gap is 10 mils and is filled with cesium vapor in equilibrium with liquid cesium in the heated reservoir. Emitter operating temperature under normal conditions ranges from 1725°K to 1885°K.

An external view of two of the electrical prototypes mounted on a test stand is shown in Figure II-2. Clearly shown are the heavy emitter and collector output leads, the cesium tubulation with its protective shroud, and the vacuum pinch-off shroud. The most important characteristics of this device are summarized in Table II-1.
FIGURE II-2
Generators 8A-1 and 8B-1 Mounted in a Test Stand
## SNAP 13 TECHNICAL MANUAL

### TABLE II-1

**SNAP 13 GENERATOR PARAMETERS**

<table>
<thead>
<tr>
<th>SNAP 13 Generator</th>
<th>Encapsulation Time</th>
<th>Beginning of Mission</th>
<th>End of Mission</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Design output power per generator, watts(e)</td>
<td>-</td>
<td>30</td>
<td>12.5</td>
</tr>
<tr>
<td>2. Generator design efficiency, percent</td>
<td>-</td>
<td>10%</td>
<td>6 1/2</td>
</tr>
<tr>
<td>3. Operation life, days</td>
<td>-</td>
<td>130</td>
<td>-</td>
</tr>
<tr>
<td>4. Generator weight, pounds</td>
<td></td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5. Generator output voltage, volts</td>
<td>0</td>
<td>0.50</td>
<td>0.50</td>
</tr>
<tr>
<td>6. Generator shape</td>
<td></td>
<td>Right cylindrical with appendages</td>
<td></td>
</tr>
<tr>
<td>7. Generator size, inches</td>
<td></td>
<td>2.65 diameter x 5.18 length, appendages extend 5 inches</td>
<td></td>
</tr>
<tr>
<td>8. Capsule to fuel interface temperature, °K Normal Load</td>
<td>1775</td>
<td>1935</td>
<td>1816</td>
</tr>
<tr>
<td>9. Emitter temperature, °K Normal Load</td>
<td>1725**</td>
<td>1885</td>
<td>1766</td>
</tr>
<tr>
<td></td>
<td>2370</td>
<td>2256</td>
<td>2005</td>
</tr>
<tr>
<td>10. Maximum fuel temperature, °K</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>11. Casing temperature, °K</td>
<td>700</td>
<td>700</td>
<td>650</td>
</tr>
<tr>
<td>12. Cesium temperature, °K</td>
<td>555</td>
<td>555</td>
<td>535</td>
</tr>
<tr>
<td>13. (Deleted)</td>
<td>(continued)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*To be determined by schedule test program.

**Short circuit operation.**

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<table>
<thead>
<tr>
<th>SNAP 13 Generator</th>
<th>Encapsulation Time</th>
<th>Beginning of Mission</th>
<th>End of Mission</th>
</tr>
</thead>
<tbody>
<tr>
<td>14. (Deleted)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Fuel capsule pressure, psia</td>
<td>44</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. Isotope inventory, watts (t)</td>
<td>335</td>
<td>282</td>
<td>192</td>
</tr>
</tbody>
</table>

*To be determined by scheduled test program.*
A. Introduction

In support of test operations of the SNAP 13 generator, various items of equipment are required for heating, controlling, monitoring, and igniting the unit. Some of the support equipment is located within the hot cell and other equipment is positioned immediately adjacent to the cell. The items of equipment are:

- Generator Heater Control Console (outside cell)
- Generator Monitor and Ignition Power Supply Console (outside cell)
- Transistorized Load (inside cell)
- Automatic Cesium Temperature Control (outside cell)
- Temperature Measurement Units (outside cell)
- Test Stand (inside cell)

The function, description, and operating procedures (where required) are presented in paragraphs B through G below.

B. Generator Heater Control Console

1. Function - This console provides the controls for regulating the power to the SNAP 13 test generator heaters. It also contains the voltmeters and ammeters associated with the heaters.
2. **Description** - The general configuration of the console is shown in Figure II-3 and the detailed panel layout is presented in Figure II-4. The console contains six sets of controls and six sets of instruments. Each set may be used independent of the other; thus, combinations of units can be tested simultaneously. Consult Table II-1 for heater requirements of the various generators.

a. **Diode Heater Set** consists of a pair of variac controls; one for coarse temperature and one for fine control. In the corresponding position of the instrument panel are the associated voltmeter and ammeter. The meters are activated by an off-on toggle switch located between them.

b. **Thermal Mockup Heater Set** contains one variac and the related voltmeter, ammeter, and control switch.

c. **Generator Cesium Bath Heater Sets (2)** are similar to the heater diode set excepting the voltmeter and ammeter ranges are less. This dual set permits the test operation of two fueled generators at one time.

d. **Generator Casing Heater Sets (2)** each consist of a variac and related control switch, voltmeter and ammeter. These two sets are also used in conjunction with the fueled generators.
Figure II-3 Generator Heater Control Console (Right Side);
Vacuum System Control Panel (Left Side)

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CONTROL CONSOLE

FRONT VIEW OF SNAP 13 HEATER

20 AMP CIRCUIT BREAKER

20 AMP CIRCUIT BREAKER

COARSE DIODE HEATER

DIODE HEATER

THERMAL MOCKUP HTR
e. Thermal Mockup Heater Set consists of a single variac and the related control switch, voltmeter and ammeter.

f. The console's electrical schematic is shown on Figure II-5. Power is supplied to the console through a standard 208 volt - three wire AC connector. The neutral wire and one hot lead (120 v) is applied across the primary windings of each of the six transformers. Each of the two 120 v legs of the circuit is equipped with a 20-amp circuit breaker, and each variac set is fused.

The output leads from the console to the various heaters are indicated. Power requirements for these heaters are as given in Table II-2.

<table>
<thead>
<tr>
<th>Heater</th>
<th>Volts (max)</th>
<th>Amps (max)</th>
<th>Electric Gen.</th>
<th>Fueled Gen.</th>
<th>Thermal Mockup</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diode Heater</td>
<td>40</td>
<td>15</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cesium Heaters</td>
<td>10</td>
<td>2.6</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Casing Heaters</td>
<td>110</td>
<td>4.2</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Thermal Mockup Heater</td>
<td>12</td>
<td>60</td>
<td></td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>
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All meters on this console are by Simpson with a full-scale accuracy of + 2%.

C. Generator Monitor and Ignition Power Supply Console

1. Function - This panel contains the meters for monitoring the output current and voltage from the generator and the power supply to insure operation of the generator in the ignited mode.

2. Description - Figure II-6 is a photograph of the console. Clearly shown are the 1.5-volt Weston DC voltmeters and the dual-scale (50 and 75 amps) Weston DC ammeters for use with 100 amp - 100 mv shunts which are installed in the generator output lead circuitry. One set of meters is to be used for measuring the output current and voltage from each fueled generator. Meter accuracy is + 1% of full-scale.

Also shown in Figure II-6 is a two-volt Weston DC voltmeter and a 100-amp Weston DC ammeter (in conjunction with a 100-amp - 50 mv shunt) for measuring the current and voltage from the ignition power supply.

Figure II-7 is an electrical schematic of the 1 volt - 100-amp ignition power supply. More descriptively,

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Figure II-6 Monitor and Ignition Power Supply Console for SNAP 13 Thermionic Generator

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110 VAC
20 AMPS.

IGNITION
P.S.W.

110 V
28 V
6 V

.750 KVA

THERMIONIC GENERATOR
IGNITION POWER SUPPLY

.015 OHMS

MHT1810
MHT 1810

LINI83

MHT 1810

50 Ω
5 W

50 Ω
5 W

IN-539

TEST
S.P.D.

FUELING
FIXTURE

TB-3
1 2 3

TB-3
17-18-19

IN 3260

0-100 AMPS

0-2V

100A 50MV
SHUNT

AM

VM

NOTE: CONNECTIONS TO THE FUELING FIXTURE

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device is a transistorized constant current regulator for control of currents from 5 amps to 100 amps. Essentially, it is a variable resistance inserted in series with a voltage source and its load.

3. Operation - The principle of operation of the series regulator is as follows (ref. Figure II-7):

The device is powered by a standard 110-volt AC line supply. When the power supply ignition switch is closed, the 110 v/6v transformer (0.75 kva) is energized. The AC from the secondary is rectified by the full wave bridge. The coarse control (50-ohm - 5-watt potentiometer) is used to adjust this DC voltage (current) to the driver transistor "B." This operation sets the voltage drop across transistor bank "C." The voltage drop across banks "C" and "D" is compared to the voltage developed across the reference zener diode IN702 and the difference is applied to the base of transistor "A." Because the transconductance of the circuit is high, any change in the load resistance (T/I generator) will cause an almost equal and opposite change in the regulator resistance, thus maintaining an essentially constant current output. The base current of transistor "A" and the current necessary to maintain the reference voltage on the zener flows through the 100 ohm resistor.
To operate the unit, the following procedure shall be used (ref. Figure II-7):

a. Connect the output leads of the power supply to the thermionic generator. If the generator is in the fueling fixture, make the connections to transistorized load #1 as follows: connect the positive lead of the power supply to terminal 7 and connect the negative lead to terminal 3. If the generator is in the test fixture, make the connections to transistorized load #2 as follows: connect the positive lead to terminal 6 and the negative lead to terminal 3.

b. Turn the coarse (50-ohm-5 watt) and five (6-ohm-5 watt) potentiometers to their extreme clockwise positions.

c. Close the power supply switch (P.S. ON & OFF SW.) momentarily, i.e., flip this switch up (red light will come on) and down. This will supply the full power capability of the ignition power supply to the generator.

d. Turn the coarse potentiometer clockwise until approximate desired amperage is obtained. Use the fine potentiometer, if necessary.

D. Transistorized Load

1. Function - This device is the electrical load for the SNAP 13 generator.

2. Description - Figure II-8 is a photograph of the transistorized load for a single SNAP 13 generator. The device has an

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FIGURE II-8
Transistorized Load for SNAP 13
Thermionic Generator
advantage over the standard variable resistor in its ability
to be varied remotely. Two such loads will be used in the
ONRL hot cell, one for the fixture in which the generator
is assembled (i.e., the fueling fixture) and one for the
fixture in which the generator will be tested (i.e., the
test fixture). Such an arrangement will minimize $I^2R$
losses due to lengthy output leads.

Each load consists of five transistors, cooling fins,
a 100-amp - 100 mv shunt, and a terminal strip mounted on
a chassis. Outside the hot cell in the generator monitoring
console is the control system for the transistorized load.

The control system consists of a constant current regulated
power supply which is used to vary the output of the
generator over its current-voltage characteristics. An
electrical schematic of the two systems is shown in Figure
II-9.

3. Operation - To operate the unit, the following procedure
should be used (ref. Figure II-9).

a. Move the generator load switch (GEN. LOAD SW.) to "ON"
   position.

b. Move the generator output circuit switch (GEN. D.C. SW.)
to the normal operation (N. OP.) position.

c. Increase the resistance of the load by turning the
   GENERATOR LOAD CONTROL potentiometer knob (either
   COARSE or FINE) counterclockwise. To decrease the load
   resistance, turn the potentiometer clockwise.

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ELECTRIC SCHEMATIC OF SNAP 13 TRANSISTORIZED LOADS AND GENERATOR MONITOR

FIG II-9
SNAP 13 TECHNICAL MANUAL

E. Automatic Cesium Temperature Control

1. Function - This device will maintain the cesium reservoir temperature at the desired set point during the change in the thermal environment anticipated in the assembly and subsequent life testing of the fueled generator.

2. Description - Figure II-5 contains an electrical schematic of the automatic cesium temperature control system. This system consists of a temperature sensitive bridge, differential amplifier, pulse generator, and variable AC power regulator. The control system operates on the Wheatstone Bridge principle in which an unbalance in the bridge may be achieved by either changing the setting of the potentiometer or by thermister temperature changes.

   The thermister detects changes in the cesium bath temperature and causes the control system to vary the input power to the cesium reservoir heater as required to balance the bridge. Specifically, the output signal from the temperature sensitive bridge is fed to the differential amplifier which controls the charging time of a capacitor connected between the emitter and base of a unijunction transistor. The rate that this capacitor charge builds up determines the firing rate of the unijunction transistor.

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SNAP 13 TECHNICAL MANUAL

(the unijunction pulse rate varies from 0 to 100 microseconds). The output pulse from the unijunction pulse rate varies from 0 to 100 microseconds). The output pulse from the unijunction is fed through a pulse transformer to the gate of a silicon control rectifier. The time interval between each pulse determines the "on and off" conduction time of the rectifier. This in turn governs the per-cent of available power that is furnished to the cesium reservoir heater. The variac (see Figures II-3 and II-4) is used to establish the available power to the control system.

3. Operating Procedure

a. Set the variac to 100, i.e., 100 out of a possible 140 setting.

b. Set the potentiometer to obtain the desired cesium reservoir temperature. The approximate setting for beginning-of-life generator operation is 3.59 (out of a possible 10 turns).

c. Turn on the switch for the generator cesium reservoir heater (see Figure II-4 GEN. Cs BATH HTR.)

(FIGURE II-10, DELETED)

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F. Temperature Measurement

Four Chromel-Alumel thermocouples will be used to monitor generator operation - two on the cesium reservoir and two on the casing. The output of the casing thermocouples shall be measured by a temperature compensated 12-point recorder to be supplied by ORNL. The temperature range on the recorder shall be 0 to 1200°F with a full-scale accuracy of ± 0.25%. The output of the cesium thermocouples shall be measured with a millivolt potentiometer.

G. Test Stand

The design of the SNAP 13 generator test stand is shown in engineering drawing 432-2572088, sheets 1 and 2. This test stand is designed to house one fueled thermionic generator and includes the transistorized generator load and an electrical terminal board.
CHAPTER 8
OPERATIONAL LIMITS AND PERFORMANCE
DATA FROM ELECTRICAL PROTOTYPES

To predict performance of the fueled generator and to facilitate fueled generator operation, parametric data in power input, cesium temperature, casing temperature, load voltage, and heater settings have been taken with electrical prototypes. These data are presented in this section.

Figure II-11 is a plot of capsule temperature (measured with an optical pyrometer or thermocouple at the capsule-backup plate interface) versus time (days) after encapsulation for a simulated curium-242 loading of 322 watts. Data are presented on the curve for short circuit, open circuit, and load voltages of 0.35 volts and 0.50 volts.

Figures II-12 and II-13 are plots of cesium temperature versus output voltage for input power (i.e., simulated isotope thermal power) level of 200 and 230 watts. Parametrically shown are lines of constant current and lines of constant power. Figure II-14 and II-15 are plots of output power versus output voltage for a range of cesium temperatures and for input power levels of 260 and 295 watts, respectively. Figure II-16 is a crossplot of Figures II-12 through II-15, showing optimum cesium temperature (i.e., the temperature that produces maximum output power) versus input power. Also indicated...

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on this figure are the cesium temperatures that produce 90% of the maximum power.

Figure II-17 is a plot of output power versus input power with the cesium temperature optimized and a load voltage of 0.35, 0.50, and 0.60.

Figure II-18 is a plot of minimum cesium temperature versus isotope power. These are the minimum recommended casing temperatures at various times in the life of the generator.
Test data taken on an electrically-heated generator

$T_{ca}$, optimized

FIGURE II-11
Capsule Temperature in Generator Versus Time for 322 Watt Fuel Loading
Figure II-12, Output Voltage Versus Cesium Reservoir Temperature

Changed 25 January 1965
Figure II-13 Output Voltage Versus Cesium Reservoir Temperature

Output Voltage (Volts) vs. Cesium Reservoir Temperature (°C)

Confidential

Generator No. 13
Net Power Input 230 Watts

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Casing Temperature (Greater Than) 425°C Net Power Input 295 Watts
Tcs 280 to 300°C SNAP 13 TECHNICAL MANUAL

OUTPUT VOLTAGE (VOLTS)

Figure II-15 Output Power Versus Output Voltage

CONFIDENTIAL

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Figure II-16 Optimum Cesium Temperature Versus Input Power

-100-

Confidential

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Generator No. 13

Confidential

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Figure II-17 Output Power Versus Isotope Power

Changed 25 January 1965
Figure II-18 Minimum Casing Temperature (of Optimum Range) Versus Isotope Power

Changed 25 January 1965
Figure II-19 Output Current Versus Emitter Temperature

Changed 25 January 1965
A. Introduction

Generator operation while in the fueling fixture and in the test stand shall be conducted in accordance with this procedure. Briefly, the procedure is to periodically adjust the cesium temperature, casing temperature, and load resistance of the generator as the isotope decays. Data taken on electrical prototypes will provide approximate information on adjusting these variables but will not be exact since the correction curve between gross diode heater power and net diode heater power is not 100% accurate. In addition, some variation in generator performance is anticipated. With cautious experimentation, however, optimum operating conditions should be obtainable on the fueled generator without adversity.

B. Generator Operation

The primary objective of generator operation in the test fixture is to safely operate the device for 130 days. The secondary objective is to obtain performance data at periodic intervals in the nominal 130-day life of the unit.

1. Pre-mission Operation - During the pre-mission period (40 days, nominally, if the generator were loaded with 335 watts and if the end of life generator efficiency were 6.5%), the generator shall operate on short-circuit load. This gives maximum current and thereby avoids excessively high temperatures in the device. Step 4.A.23.d shall be followed for cesium and casing heater adjustments to give optimum performance. During this period, the following parametric study should be performed at intervals of 14 days:

   a. Vary the cesium temperature around the optimum point in intervals of ± 5°C (9°F) without exceeding the limits wherein the output power is 80% of the maximum. With
FIGURE II-25
Isotope Power vs Time
the cesium temperature optimized, vary the casing
temperature in intervals of +10°C (18°F) without
exceeding the limits wherein the output power is 80% of the maximum. Record the date, time, all heater
currents and voltages, output current and voltage, all temperatures, and the calculated isotope heat input.

2. Transition from Pre-mission to Mission Operation

Refer to Figure II-19. When the isotope decays to the point where a load of 0.5 volts will produce an emitter temperature of 1885°K, the device may safely be placed under this load. As mentioned previously, this should occur approximately 40 days from the time of encapsulation. Figure II-26 does not present data as a function of input power but rather as a function of maximum output current. Since the data in Figure II-26 was taken with an electron bombardment heater on the specific diode used in the first fueled generator, the output current may be used as an indication of the input power.

This change shall be effected gradually to prevent thermal shock and to allow for the safe adjustment of the critical cesium temperature. It is recommended that this change from short circuit to 0.5 volt operation be made in maximum intervals of 50 millivolts. At each plateau, the cesium temperature shall be optimized by cautiously...
FIGURE II-26
Output Current vs Emitter Temperature

Generator #14
\[ T \text{ cesium, optimized} \]
\[ \Box, \circ, \cdot, \text{ etc.} \text{ - Symbols for constant power input (the absolute values are meaningless).} \]
adjusting the cesium variac (Ref. Figure II-4) and at each plateau steady state output (i.e., equilibrium) shall be obtained.

Once the device is placed under the 0.50 load voltage, the beginning of mission commences (by definition). This method of operation may not give exactly 12.5 watts after 90 more days of operation but it is designed to insure safe operation of the device.

3. Mission Operation

Every two days, Step 4.A.23.d of Chapter 9B.2 shall be followed for cesium and casing heater adjustments to give optimum generator performance. In addition, it will now be necessary to slightly increase the transistorized load resistance (see Chapter 7D for operating instructions) every two days in order to maintain 0.50 volts since the isotope is continually decaying. (If a dc-dc converter were in the circuit, its constant voltage regulator would automatically perform this function.)

Again, in 14-day intervals, the following parametric test shall be performed:

a. The voltage should be varied between short circuit and 0.55 volt (except for the first input power level when 0.50 volts should not be exceeded). At each load voltage point, vary the cesium temperature...
in intervals of ± 5°C (9°F) without exceeding the limits wherein the generator output power is 80% of the maximum. At 0.50 volts and optimum cesium temperature, vary the casing temperature in intervals of ± 10°C (18°F) without exceeding the limits wherein the output power is 80% of the maximum. Record the date, time, all heater currents and voltages, output current and voltage, all temperatures, and the calculated isotope heat input.
A. External Dose Rates

The penetrating radiations from curium-242 are neutrons and gamma rays. An investigation of dose rates versus time, based upon a one gram point source of pure Cm-242 shows that the radiations from the curium predominate for a period of several years. The results of the investigation are plotted in Figure II-27. Examination of this figure shows the decrease in curium dose rates and the increase and subsequent decrease in Pu-238 dose rates. Approximately 300 years decay are required before the other daughters, principally Ra-226 and subsequent daughters, begin to affect dose rates.

Dose rate estimates for the fuel capsule and assembled generator were consequently based upon the curium-242 gamma data given in Table II-3 and the neutron data in Table II-6.

The Martin generalized shielding code was used to calculate dose rates. Figure II-28 gives the dose rates around the fuel capsule while Figure II-29 presents the dose rates around a single generator.

Dose rate calculations were based upon a fuel loading of 322 watts. If other fuel loadings are used, dose rates will change linearly with the fuel loading. Dose rates at
Figure II-27: Dose rates at one meter from a one gram point source of Cm-242 & its decay products.
### TABLE II-3

**GAMMA RADIATION ASSOCIATED WITH Cm-242**

<table>
<thead>
<tr>
<th>Decay</th>
<th>Prompt Fission</th>
<th>Fission Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>E (Mev)</td>
<td>E (Mev)</td>
<td>E (Mev)</td>
</tr>
<tr>
<td></td>
<td>Gamma (Sec-Gram)</td>
<td>Gamma (Sec-Gram)</td>
</tr>
<tr>
<td>0.044</td>
<td>$3.6 \times 10^{-10}$</td>
<td>0.5</td>
</tr>
<tr>
<td>0.102</td>
<td>$5.05 \times 10^{-9}$</td>
<td>1.0</td>
</tr>
<tr>
<td>0.158</td>
<td>$2.22 \times 10^{-9}$</td>
<td>1.5</td>
</tr>
<tr>
<td>0.210</td>
<td>$1.85 \times 10^{-7}$</td>
<td>2.0</td>
</tr>
<tr>
<td>0.562</td>
<td>$2.22 \times 10^{-8}$</td>
<td>2.5</td>
</tr>
<tr>
<td>0.606</td>
<td>$1.72 \times 10^{-8}$</td>
<td>3.0 up</td>
</tr>
<tr>
<td>0.896</td>
<td>$1.06 \times 10^{-8}$</td>
<td></td>
</tr>
<tr>
<td>Description</td>
<td>Value</td>
<td></td>
</tr>
<tr>
<td>-------------------------------------------------------</td>
<td>----------------</td>
<td></td>
</tr>
<tr>
<td>Spontaneous fission half-life</td>
<td>$7.2 \times 10^6$ years</td>
<td></td>
</tr>
<tr>
<td>Average number of neutron per fission</td>
<td>2.65</td>
<td></td>
</tr>
<tr>
<td>Production rate</td>
<td>$1.65 \times 10^5 \frac{neutrons}{sec\cdot watt}$</td>
<td></td>
</tr>
<tr>
<td>Neutron Production from $(\alpha,n)$ reactions with $\text{Cm}_2\text{O}_3$</td>
<td>$7.77 \times 10^3 \frac{neutrons}{sec\cdot watt}$</td>
<td></td>
</tr>
</tbody>
</table>
Gamma = 0.0064 rem/hr  
Neutron = 0.062 rem/hr

FIGURE II-28
Dose Rates (rem/hr)  
Around SNAP 13 Fuel Capsule
FIGURE II-29
Dose Rates (rem/hr) around SNAP 13 Generator

<table>
<thead>
<tr>
<th>Distance</th>
<th>Gamma (rem/hr)</th>
<th>Neutron (rem/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 foot</td>
<td>0.068</td>
<td>0.47</td>
</tr>
<tr>
<td></td>
<td>0.0063</td>
<td>0.043</td>
</tr>
<tr>
<td>1 meter</td>
<td>0.049</td>
<td>0.22</td>
</tr>
<tr>
<td></td>
<td>0.15</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>1.12</td>
<td>7.25</td>
</tr>
<tr>
<td></td>
<td>5.25</td>
<td>41.5</td>
</tr>
<tr>
<td></td>
<td>1.45</td>
<td>12.7</td>
</tr>
<tr>
<td></td>
<td>2.9</td>
<td>20.2</td>
</tr>
<tr>
<td></td>
<td>0.98</td>
<td>6.8</td>
</tr>
<tr>
<td></td>
<td>0.06</td>
<td>0.52</td>
</tr>
<tr>
<td></td>
<td>0.0055</td>
<td>0.048</td>
</tr>
</tbody>
</table>

322 watt fuel loading
distances other than one meter may be estimated by the inverse square relation.

B. Generator Operation

The first isotopic generator will be fueled and operated solely in the ORNL hot cell. Therefore, the only safety precautions necessary for this mission are those concerning demonstration of the device in the hot cell.

The most probable accident which could occur during operation of the generator would be overheating of the fuel capsule with attendant internal outgassing. The consequence would be reduced or zero output from the unit.

An increase in hot side temperature (i.e., temperatures of the emitter, brazes, backup plate, capsule, liner, and fuel) would result from a decrease or total loss in electron cooling. Factors causing this condition would be:

1. Off-optimum cesium temperature operation or cesium heater failure. To minimize the probability for failure, redundancy has been provided in the cesium heaters and a constant cesium temperature control system has been installed, (ref. Chapter 7-E). In addition, two thermocouples are used for monitoring cesium temperature.

2. High external load resistance or, in the extreme, an open circuit. As long as the generator is operated according to schedule (i.e., near short circuit during the pre-mission
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period and at no more than 0.5 volt during the mission phase) the high temperatures that cause excessive outgassing will not be encountered, (see Figure II-11).

3. Deignition near the beginning of life; it is anticipated that the generator will initially be self-igniting. For periods later in life when the emitter is relatively cooler, deignition is more probably due to an off-optimum cesium temperature or high load voltage (order of magnitude 0.6 to 0.8 volt although this figure depends on emitter temperature). If the generator deignites, the ignition power supply must be used to restore normal operation of the generator. (See Chapter 7-C for operating instructions.)

In general, if anomalous operation of the generator occurs, the remedial action is to return to optimum cesium temperature, optimum casing temperature and the proper load voltage (short circuit or 0.5 volt depending on the time in life). If large deviations from the expected output are observed, internal damage to the generator is probable.

Since the generator is not to be handled or transported from the hot cell, once it is secured to the test fixture, a shock accident (such as a drop) has not been considered. In no case should static operation of the generator on the test fixture lead to a release of fuel. At worst, the fueled device will produce no output power.
At the time of release of the Manual, the disassembly procedures are considered to be beyond the scope of this work. Therefore, these procedures are not included herein.
A. PS-40A Packaged Pumping System

1. Description

The components used in this system are manufactured and supplied by the Consolidated Vacuum Corporation, Rochester, New York. A listing of the system primary components is as follows:

<table>
<thead>
<tr>
<th>Component</th>
<th>Model No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil Diffusion Pump</td>
<td>PNC-720</td>
</tr>
<tr>
<td>Welch Type Mechanical Pump</td>
<td>1397B</td>
</tr>
<tr>
<td>Liquid Nitrogen Level Control</td>
<td>GS-100</td>
</tr>
<tr>
<td>Multi-Coolant Baffle</td>
<td>BC 41</td>
</tr>
<tr>
<td>Ionization Vacuum Gage</td>
<td>G1C-110A</td>
</tr>
</tbody>
</table>

This system is used to lower the pressure of the bell jar interior to a level required for making the generator capsule and casing brazes. The mechanical pump lowers the pressure until it reaches the oil diffusion pump operating...
range. Once this pressure is reached, the oil diffusion pump lowers the pressure in the bell jar to the level required for making the generator capsule and casing brazes. The multi-coolant baffle and the liquid nitrogen level control are provided with the basic PS-40A pumping system in order to achieve lower pressures. The ionization vacuum gage provides a direct reading of bell jar pressure.

2. Controls

Operation of this pumping system for assembly of a fueled generator requires control switches and valves to be located both inside and outside the hot cell. The controls located outside the hot cell are mounted on the Control and Instrumentation Console (see Section 10 of basic SNAP 13 Manual) and include the Vacuum Pump Switch Control unit, Liquid Nitrogen Level Control unit, and the Ionization Vacuum Gage. A sketch of the console front face which shows the applicable controls is given in Figure A-1 and a photograph is given in Figure I-7, Snap 13 Manual.
Figure A-1

Vacuum System Control Console
Appendix A

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The controls located inside the hot cell are mounted on the right side of the PS-40A pumping system cabinet and consist of four valves: HI VAC valve, Air Inlet valve, Roughing valve, and Holding valve. These control valves must be operated remotely by manipulator during assembly of a fueled generator. A sketch of the cabinet right side panel which shows the location of all valves is given in Figure A-2.

3. Operating Instructions

Starting Procedure:

It is assumed that the required services (i.e., liquid nitrogen, water, and power) are available to the system.

a. All valves, located on the right side of the cabinet, as oriented in Figure I-1, shall be in a closed position.

b. Turn on the MASTER switch, the ROUGHING PUMP switch, and the ionization vacuum gauge power (located on the control and instrumentation console Figures A-1 and I-7).

c. With a manipulator open the ROUGHING valve.

d. When the pressure in the bell jar reaches 50 microns Hg (5 x 10^{-2} mm Hg) (TC-1) close the
FIGURE A-2

PS40 A Pumping System Valve Controls
(Right Side Panel of Pumping Cabinet)
ROUGHING valve (see Figure A-2) and open the HOLDING valve with the manipulator.

When the pressure on the holding side (TC-2) reaches 50 microns Hg (5 x 10^-2 mm Hg) open the HI-VAC VALVE (915 turns counter clockwise) with the manipulator.

Turn on the DIFFUSION PUMP switch. Approximately 12 minutes is required for warm-up.

When the bell jar pressure (TC-1) is less than 1 microm (1 x 10^-3 mm Hg) the ion gauge can be turned on.

Adjust ion tube for proper pressure readings (reference Figures A-1 and I-7) with knobs on ionization vacuum gage as follows:

1) Turn filament on (rotate EMISSION knob clockwise until it clicks).
2) Rotate mode knob to EMISSION.
3) Rotate pressure range knob to 10^-4.
4) Rotate emission knob until the meter reads (read top scale) the value supplied with ion tube.
5) Turn mode knob to DEGAS.

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6) Press button (zero adjust) under meter.
7) Rotate amplifier zero knob so meter is zeroed.
8) Release zero adjust button.
9) Allow ion tube to degas at least 10 minutes.
10) Rotate mode knob to PRESS.
11) Rotate pressure knob to $10^{-5}$, $10^{-6}$ etc., when pressure reads $1 \times 10^{-4}$, $1 \times 10^{-5}$, etc.

NOTE

If filament in ionization gage goes out, press the zero reset button. The automatic relay turns the filament off if the needle deflects off scale as when the pressure becomes too high. Turn pressure knob to a lower scale.

i. Open the valve on the liquid nitrogen Dewar flask.

j. Switch the GS-100 liquid nitrogen level control to ON.

k. While making either the generator capsule or casing braze, a pressure of $8 \times 10^{-5}$ mm Hg must not be exceeded in the bell jar. The above procedure must be completed before initiating Shut Down Procedure.

Shut Down Procedure:

For shutting down, it is assumed that the pumping system is operating normally and that all applicable valves and

---

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switches are positioned as determined by the "Starting Procedure" steps a through k.

a. Turn EMISSION knob to FIL OFF, switch MODE knob to TC-1, and then using manipulator, close the HI-VAC VALVE.

b. Turn off the DIFFUSION PUMP switch.

c. Turn off all gages, liquid nitrogen switch and amplifier zero knob.

d. Allow the boiler of the oil diffusion pump to cool to about 100°F (approximately 20 minutes required for cooling).

e. To bring the entire vacuum system to atmospheric pressure, close HI-VAC valve, open the AIR INLET valve (by manipulator), turn off the ROUGHING PUMP switch, and open the roughing and holding valves (with manipulator).

B. Continuous Use Operating Instructions

The following instructions apply while operating the system continuously. It is assumed that the pumping system is operating normally and that all applicable valves and switches are positioned as determined by the "Starting Procedure", steps a through k of this appendix.

a. To open bell jar

1. Rotate EMISSION knob counterclockwise to OFF (it will click)
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2. Rotate MODE knob to TC-1 position
3. Close HI VAC valve on right side of cabinet (about 15 turns)
4. Open AIR INLET valve on right side of cabinet
5. After 3 minutes remove bell jar

b. To pump out bell jar
   1. Close HOLDING valve
   2. Open ROUGHING valve
   3. Follow steps d through j in Section A.5 of this appendix
      (step f not applicable in this case)

C. Vac-Ion Pumping System and Leak Detector

1. Description

   The components used in this system are manufactured
   and supplied by Varian Associates, Vacuum Products Division,
Palo Alto, California. A listing of the system components
   is as follows:

<table>
<thead>
<tr>
<th>Component</th>
<th>Model No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>40 L/S Vac Ion Pump</td>
<td>911-5404</td>
</tr>
<tr>
<td>Vac Ion Pump Control Unit</td>
<td>921-0012</td>
</tr>
<tr>
<td>Vac Ion Pump Leak Detector</td>
<td>975-0000</td>
</tr>
</tbody>
</table>

- A-8a-
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The 40 L/S Vac Ion pump is used to evacuate the inside of the generator after the casing braze is made. The pump control unit provides the necessary high voltage, direct current power necessary to operate the 40 L/S Vac Ion pump. The leak detector is used to leak-check the generator after the casing braze is made; the tracer gas will be provided by back filling the bell jar with helium.

The pump and leak detector controls will be situated in a single control console which will be located outside the hot cell. A photograph showing the location of these controls in the console has been included in Figure I-7 of the SNAP 13 Technical Manual.

2. Controls

A sketch of the console front face showing applicable controls in the Vac Ion system is shown in Figure A-1. A description of these controls is given below.

a. Upper Control Panel

1) Vac Ion and Vac Ion Leak Switch - A switch-over device which allows operation of the pump by either the Vac Ion pump power supply control unit or the Vac Ion leak detector.
The normal position for this switch is the Vac Ion position; it is placed on VAC ION.

2) LEAK - This position is used only when the leak detector is to be operated.

3) He Valve - The control switch for back filling the bell jar with helium for leak checking.

4) Vac Ion Valve - The control switch for isolating the Vac Ion pumping system. With this switch closed, only the Vac Ion pump is evacuating the generator interior.

b. Vacuum Ionization Leak Detector and Pump Power Supply Panels

1) High Voltage - The power switch for the vacuum pump. (Red light on when operating.)

2) Start-Protection - In order to protect the pump from possible internal damage, which may occur as a result of arcing or overheating if the pump is accidentally operated for extended periods at pressures between 1 to 2 mm Hg, a protective circuit is provided. This protective circuit turns "off" the control unit in the event that a high pressure develops in the
SNAP 13 TECHNICAL MANUAL

During starting of the pump, the protection switch can be turned to "start" (amber light on) in order to allow the pump to draw full starting power. For operation in the fueling fixture, this switch shall be set on PROTECTION at all times.

3) Meter Range - This switch provides the setting for obtaining a direct measurement of current delivered to the pump over a large range. The LOG setting on this switch provides a direct reading of pump pressure in millimeters of mercury units.

3. Operating Procedures

CAUTION
Prior to starting Vac Ion pump after brazing operation, the PS-40A System Pump must be operated for at least 15 minutes to avoid VAC ION pump contamination.
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a. Vac Ion Pump

1) **Vac Ion** - Vac Ion Leak switch is placed in Vac Ion position.

2) **Start** - Protection switches are placed in PROTECTION position.

3) Place Vac Ion VALVE control switch in OPEN position. (Indicating lamp should light.)

4) Push High Voltage "ON" button of the pump control unit when the CVC gage reads $3 \times 10^{-5}$ mm Hg or lower. (Red indication lamp should light.)

5) Adjust METER RANGE selection switch to proper position to permit monitoring of current readings.

6) Place Vac Ion Valve control switch in CLOSED position when VAC ION reads $2 \times 10^{-5}$ mm Hg or better (106 position) (PS-40A pressure gage should read about $3 \times 10^{-5}$).

**NOTE**

Pressure on Vac-Ion meter should rise and drop again within a two minute period and continue dropping.

- A-12

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7) If pressure fails to decrease, the generator or pumping system is leaking, or outgassing is incomplete.
   a) Push VAC ION High Voltage OFF button.
   b) Place VAC ION Valve in OPEN position.
   c) Pump generator pressure down with PS-40A system for 5 minutes.
   d) Repeat steps (1) through (6).

8) Pump system down to $10^{-6}$ mm Hg.

b. Leak Detection

**NOTE**

Leak detection procedures are performed when system is at $10^{-6}$ mm Hg.

1) Push ON button of Vac Ion Pump Leak Detector Panel.
2) Place VAC ION-VAC ION LEAK switch to Vac Ion LEAK position.
3) Push OFF button of Vac Ion Pump Control Unit Supply.
4) Re-establish $10^{-6}$ mm Hg in generator interior.
   This may take as long as 2 hours.
5) Turn EMISSION knob to FIL OFF position, turn mode knob to TG-1, and close HI VAC valve using manipulators. (Isolates bell jar from PS-40A vacuum pumping system.)

6) Adjust leak detector METER RANGE selector switch to obtain current reading. Record reading.

7) Check OUTPUT SELECT or knob - should be in METER position.

8) SENSITIVITY meter should be on SHORT.

9) Switch on back of leak detector (inside console) should be on LEAK DETECT.

10) Zero LEAK INDICATOR with potentiometer (inside console).

11) Rotate SENSITIVITY knob to x 1 (full scale is 1 volt).

12) Rotate COARSE and FINE ZERO ADJUST knobs to zero LEAK INDICATOR METER.

13) If LEAK INDICATOR meter can be zeroed, rotate SENSITIVITY knob to x 10 (full scale is 0.1 volt).

14) Repeat Step 12.

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15) If LEAK INDICATOR meter can be zeroed, rotate SENSITIVITY knob to x 100 (full scale is 0.01 volt).

16) Repeat Step 12 thereby zeroing the meter.

17) Insure that the helium bottle is connected and the line to the flood valve is purged; then place He Flood Valve switch in OPEN (up) position.

18) Place He Flood Valve switch in CLOSED (down) position when bell jar pressure reaches 1000 microns.

19) Read LEAK INDICATOR meter and record deflection.

20) If the needle deflected to the right, a leak existed in the generator (or the system is out-gassing).

NOTE

Leak rate may be calculated by

\[ g = \frac{\Delta I}{7.6} \]

where

- \( g \) = leak rate, standard cc per sec of air
- \( \Delta I \) = current change, amperes.

\[ \Delta I = \text{LEAK INDICATOR DEFLECTION} \times 1 \text{ or } 0.1 \text{ or } 0.01 \]

depending on SENSITIVITY setting

\[ 10^{-4} \text{ or } 10^{-5} \text{ or } 10^{-6} \text{ or } 10^{-7} \]

depending on RANGE SELECTION SETTING

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(10^4 corresponds to a RANGE SELECTOR setting of 200 μA and 10^5 corresponds to the first 20 μA setting encountered when going in a clockwise direction, 10^6 corresponds to the second 20 μA setting, etc.)
The shaft activation control panel houses the controls which induce drive shaft movement. A sketch of the panel front face is shown in Figure B-1 and a photograph is presented in Figure I-7.

In the fueling procedure (ref. Chapter 4) and the mechanical checkout procedure (ref. Chapter 3-B), the numbers, shown on the panel front face, will be used when a specific control operation is called for; therefore, a legend defining specific control identification and their corresponding operations is as follows:

**MODE:** This switch defines the mode of operating for the fueling fixture. A key is employed with this switch which will lock the switch in either the manual (MAN) or automatic (AUTO) mode.

**MAN:** Manual Operation allows shaft controls to be operated in any sequence and makes the shaft limit switches ineffective.

**CAUTION**

When operating in "MAN" do not override the micro switch. If over-driven, damage to micro switch and/or shaft may occur.
FIGURE B-1
Front Face of Shaft Activation Control Panel
AUTO: Automatic operation—with switch in this position, no shaft, except Shaft A, may be operated unless all other shafts are in their normal rest position. The normal rest position of any shaft is defined as that position in which the green light indicator directly above the control switch is on.

NOTE

The normal rest position of a shaft occurs at one extreme of the shaft travel. At the other extreme the red light indicator above the switch will be on. When a shaft is in an intermediate position of travel, neither the red nor green light will be on.

Switch 1: panel master power switch
Shaft "A": capsule loading shaft
Shaft "B": capsule braze element
Shaft "C": generator cover loading shaft
A-V: control for vertical motion of shaft "A"
A-R: control for rotational motion of shaft "A"
B-R: control for rotational motion of shaft "B"
C-V: control for vertical motion of shaft "C"
U: Up
Capsule release controls

Switch Number

2-A and 2-B: control for opening the pickup arms to the capsule pickup position.

NOTE

Both controls must be switched to the ON position for pickup arm activation.

3: control which releases stop-wedge on back side of the pickup arms.

4: red push button control for opening the pickup arms to the capsule brasing shield pickup position.

NOTE

The capsule release switch number 3 must be activated (i.e., switched to ON) before switch number 4 will operate.

(*) The clockwise or counterclockwise rotation of any shaft is measured from a viewpoint above the fixture looking down at the fixture.
BRAZE CONTROL CONSOLE

The braze control console (Figure I-8) controls the power input to the electron bombardment (EB) filaments used in brazing the fuel capsule to the emitter plate and for making the final generator casing closure braze. A sketch of the console front face is included as Figure C-1.

On the console are two variacs which control: (1) the voltage and amperage to the braze filament (FILAMENT), and (2) the voltage and amperage of high voltage power supply (HIGH VOLTAGE). The filament power supply (AC power) heats the braze filament to electron emission temperatures while the high voltage power supply (DC) provides the driving force for the electrons.

Two AC leads and two DC leads run from the capsule to the fueling fixture. The AC leads go to the primary of the transformers. The negative DC lead joins a lead from the secondary of the transformer and is connected to one terminal of the EB filament. The positive DC lead is grounded to the fixture frame. The second wire from the transformer secondary is connected to the other terminal of the EB filament and completes the circuit.
FIGURE C-1
BRAZE CONTROL CONSOLE FRONT FACE

Changed 25 January 1965
Power is applied to the EB filament by switching the main power switch ON (switch on the right side of the console UP); by pressing the ON buttons, at the center of the console for the filament and high voltage supplies (white lights will go on), and by slowly turning up the variacs until the required power settings are obtained (see capsule and casing braze schedules at end of this section for power settings). Note that the rear door of the Braze Control Console must be closed before power can be obtained to the high voltage power supply.

Both the capsule and casing braze filaments are operated from this console. The power leads (i.e., negative DC lead from the secondary of the transformer and the second wire from the transformer) are connected to a two-way switch (see Figure C-2) which in turn is connected to: (1) two wires extending from shaft B (for operation of the capsule braze filament), and (2) two wires to the inner Alite terminals which pass through the base plate near the rear of the fixture (for operation of the casing braze filament). The control for this switch is mounted on the Braze Control Console front face; the two positions of this switch are designated CAPSULE and CASING and are set to coincide with the desired braze operation. When the braze control switch is in CAPSULE position, the emitter of the generator is short circuited to the collector of the generator through a relay which grounds the emitter.
Braze Procedures:

A. Capsule Braze Procedure for (2 mil) Vanadium Foil

1. Switch the console fan to ON (switch on right side of console as shown in Figure I-8).
2. Set the two-way braze switchover control to the CAPSULE position.
3. Press the filament power supply activation button (FILAMENT) at the "ON" position.
4. Apply 25 amps to the filament over a three minute period by gradually rotating the variac (FILAMENT) in a clockwise direction.
5. Press the high voltage power supply activation button (HI VOLTAGE) at the "ON" position.
6. Manipulate the FILAMENT and HIGH VOLTAGE control variacs in accordance with the following schedule which was developed for 250 watt capsule heat input.

Changed 25 January 1965
WARNING: Do not allow bell jar pressure to exceed $8 \times 10^{-5}$ torr during braze run.

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<th>Filament</th>
<th>Approx. Casing Heater</th>
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<td>50</td>
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<td>2</td>
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<td>500</td>
<td>0.6</td>
<td>30</td>
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<td>8</td>
<td>500</td>
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<tr>
<td>69</td>
<td>Off</td>
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<td>0</td>
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</table>

*Warning: Do not exceed 500°C generator casing temperature. Water-cool, if necessary.

B. Capsule Braze Procedure for (1 mil) Platinum Foil
(Electrically heated capsule)
Perform steps A-1 through 5 of this appendix.

WARNING: Do not allow bell jar pressure to exceed $8 \times 10^{-5}$ torr during braze run.

Changed 25 January 1965
Accumulated Time (min.) | High Voltage Settings | Filament Volts | Approx. Casing Heater* Volts | Amps
---|---|---|---|---
Start: | 200 | 0.1 Adjust the variac to attain the amperage listed under the high voltage settings |
5 | 300 | 0.2 |
7 | 400 | 0.4 |
10 | 500 | 0.5 |
18 | 500 | 0.7 |
23 | 600 | 0.8 |
28 | 600 | 1.0 |
30 | 625 | 1.2 |
32 | 650 | 1.4 |
33 | 800 | 2.0 |
35 Hold 30 sec. | 650 | 1.4 |
37.5 | 600 | 1.1 |
38 | 500 | 1.0 |
40 | 400 | 0.7 |
41 | 300 | 0.6 |
42 | 200 | 0.2 |
43 | Off |
44 |

*WARNING: Do not exceed 500°C generator casing temperature. Water cool if necessary.

C. Casing Braze Procedure for Engaloy 491 Braze Material

1. Switch the Main Power Switch ON (switch on right side console).

2. Set the two-way braze switchover control to the casing position.

3. Press the filament power supply activation button (FILAMENT) to the "ON" position.

4. Apply 25 amp to FILAMENT over a 3 minute period as previously directed.

5. Bring the generator cover to temperature (to allow thermal expansion of the cover and proper seating in the base) by

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allowing 40 minutes for thermal equilibrium after the cover is seated on the generator base.

6. Press the high voltage supply activation button (HI VOLTAGE) to the "ON" position.

7. To make the casing braze, manipulate the FILAMENT and HIGH VOLTAGE control variacs in accordance with the schedule when 250 watts are being supplied to the fuel capsule.

**WARNING:** Do not allow bell jar pressure to exceed $8 \times 10^{-5}$ torr during braze run. Do not allow casing temperature to exceed $500^\circ C$. Water cool if necessary.

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<th>Accumulated Time (min.)</th>
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<th>Filament</th>
</tr>
</thead>
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</tr>
<tr>
<td>36</td>
<td>500</td>
<td>0.9</td>
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</tbody>
</table>

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NOTE:

Height adjustment made by adjusting the wire supports and the filament support base.

Distance adjustment made by moving the wire support and the filament support base.

Filament location is at the braze joint.

There are two filament supports in each ceramic insulator.

Figure C-3 Sketch of Braze Filament Location

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1. Heat filament at 5A for 5 minutes
2. Heat filament at 10A for 5 minutes
3. Heat filament at 15A for 5 minutes
4. Heat filament at 20A for 5 minutes
5. Heat filament at 25A for 5 minutes
6. Reduce input slowly to 10A then shut off

Appendix C

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Prior to carrying out Chapter 4 A, the fueling procedure, the following steps should be completed. These items constitute the preparatory steps for a fueling operation.

Upon completion of the preparatory operation outlined in Steps 1 through 9 of this appendix, the checklist given in Table D-1 at the end of this appendix shall be executed as directed.

1. All generator components and items inside the bell jar must be handled with clean lint free white cotton gloves. The braze ring and braze disc must be abraded with 600 grit silicon carbide paper until surfaces are shiny.

2. All pre-fueling checks detailed in Part I, Chapter 3 must be completed.

3. The fuel capsule in its transfer chill block (ref. P/N 432-2572002-009) must be in a shielded container within the hot cell or immediately available for placement in the hot cell.

4. Shaft Activation Control Panel
   a. Shafts A, B, and C must be in their normal rest positions (ref. Table I-2).
Appendix D

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b. All switches and buttons should be in the positions shown in Figure D-1 (also ref. Figure E-1 and Figure I-7).

![Figure D-1](image)

SHAFIT ACTIVATION CONTROL PANEL INITIAL SETTINGS

5. Brazing Control Console
   a. All variacs on zero.
   b. All switches off, including the master switch on the right side of the console as shown in Figure C-1 and Figure I-3.

6. Generator Heater Control Console (ref. Figure II-3)
   a. Two circuit breakers at bottom of console—ON.
   b. All variacs turned to zero.
c. Toggle switches to cesium #1 meters and casing #1
meters in up position. (Switches are located
directly beneath meters.)

7. Vacuum System Control Panel

a. Vac Ion Pump Control (Varian Associates)
   All switches and buttons should be in positions
   shown in Figure D-2 (also ref. Figure A-3 and Figure
   I-7).

![Diagram of vacuum system control panel]

**Figure D-2**

**Vac Ion Initial Settings**
b. Vacuum Pumping System (Consolidated Vac.)

All switches and buttons should be in the positions shown in Figure D-3 (also ref. Figure A-1 and Figure I-7).

LIQUID NITROGEN LEVEL CONTROL

\[ \text{OFF} \]

\[ \text{TCl} \]

\[ \text{OFF} \]

\[ \text{ZERO} \]

\[ \text{OFF} \]

VAC ION

\[ \uparrow \]

MASTER

\[ \uparrow \uparrow \]

ROUGHING

\[ \uparrow \]

DIFFUSION

\[ \downarrow \]

SPARE

\[ \downarrow \]

VALVE

\[ \text{CLOSED} \]

\[ \text{CLOSED} \]

\[ \text{He} \]

FLOOD VALVE

\[ \text{VAC ION VALVE} \]

\[ \text{SELECTED} \]

\[ \text{CHANGED} \]

\[ \text{25 January 1965} \]

FIGURE D-3

VACUUM PUMPING SYSTEM INITIAL SETTINGS
8. Gas and Liquid Nitrogen Supply
   a. Argon - regulator set to 40 psi
       - regulator set to 80 psi
   b. Helium - valve on bottle on
   c. Liquid Nitrogen - valve on bottle off.

9. Generator parts described in Chapter 4 A should be placed in the hot cell.
TABLE D-1

PREFUELING CHECKLIST

1. All generator parts and fueling fixture parts properly cleaned.

2. Capsule, transfer chill block and shield positioned for use.

3. Bell jar base has vacuum seal lube applied.

4. Shaft Activation Control Console properly interconnected with fueling fixture.

5. Shaft Activation Control Console panel controls set as in Figure D-1. All shafts in their normal positions.


7. Braze Control Console panel controls set as follows:
   a. All switches in OFF position
   b. Variacs set on zero
   c. CAPSULE button depressed.

8. Generator Heater Control Console properly interconnected with fueling fixture and test fixture. Circuit breakers must be on, variacs off, toggle switches to cesium #1 meters and casing #1 meters in up position.

9. Vacuum system properly interconnected with fueling fixture.

10. Vacuum system console panels controls set as in Figures D-2 and D-3.
11. Helium bottle connected and bottle valve open to 15 Psi.
12. Two argon bottles connected and regulators set:
   one at 40 psi
   other at 80 psi
13. Liquid nitrogen bottle connected; bottle valve off.
14. Generator parts and brazing rings positioned for use in hot cell.
15. Test fixture ready to receive fueled generator.
16. Manipulating tools in working order.
17. Power available to:

   Fueling Fixture
   Shaft Activation Control Console
   Generator Heater Control Console
   Braze Control Console
   Vacuum Pumping System
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<th>Revision</th>
<th>Title</th>
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APPENDIX F

List of Standard Tools Used in the Fueling Fixture

1 3" to 4" tweezers
1 10" to 12" forceps
1 6" scale graduated in 100-ths and 64-tha
2 ea. 7/16" box - open end combination wrench
1 1/2" box - open end combination wrench
1 9/16" box - open end combination wrench
1 1/8" wide common screwdriver
1 set jeweler's screwdrivers
1 set allen wrenches
1 6" adjustable wrench
1 4" cutting pliers
1 4" needle-nose pliers
1 6" bubble level
1 set auto ignition wrenches
1 2-cell flashlight
1 small dental mirror
~6 pr. nylon gloves

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APPENDIX G

Sketch Showing Chromel-Alumel Thermocouple Lead Throughs
(Looking at lead through from right side of fueling fixture.)

Figure G-1 Chromel-Alumel Thermocouple Lead Throughs

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APPENDIX H

Electrical Connections to the Base Plate of the Fueling Fixture

The following is a top view sketch of the base plate depicting the electrical connectors:

Figure H-1

Base Plate Electrical Lead Throughs

Front of Fueling Fixture

Three types of generators will be assembled in this fixture:

1. Electron bombardment (EB) heated electrical prototype
2. Conduction heated electrical prototype
3. Radioisotope fueled generator

Table H-1 shows the connections to be made to the fueling fixture base plate connectors for each of these generators.

Also given are the electrical connections to be made to the fueling fixture when conducting brazing operations with thermal mock-up generators.

- H-1 -

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Table H-1
Base Plate Electrical Connections

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