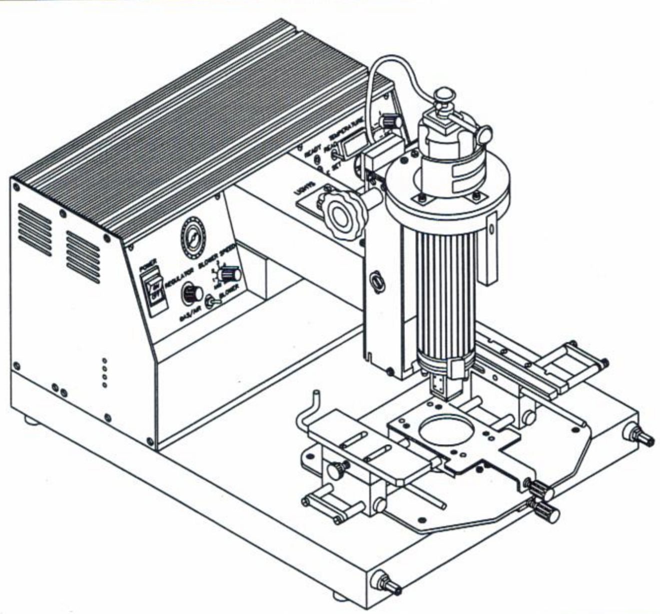
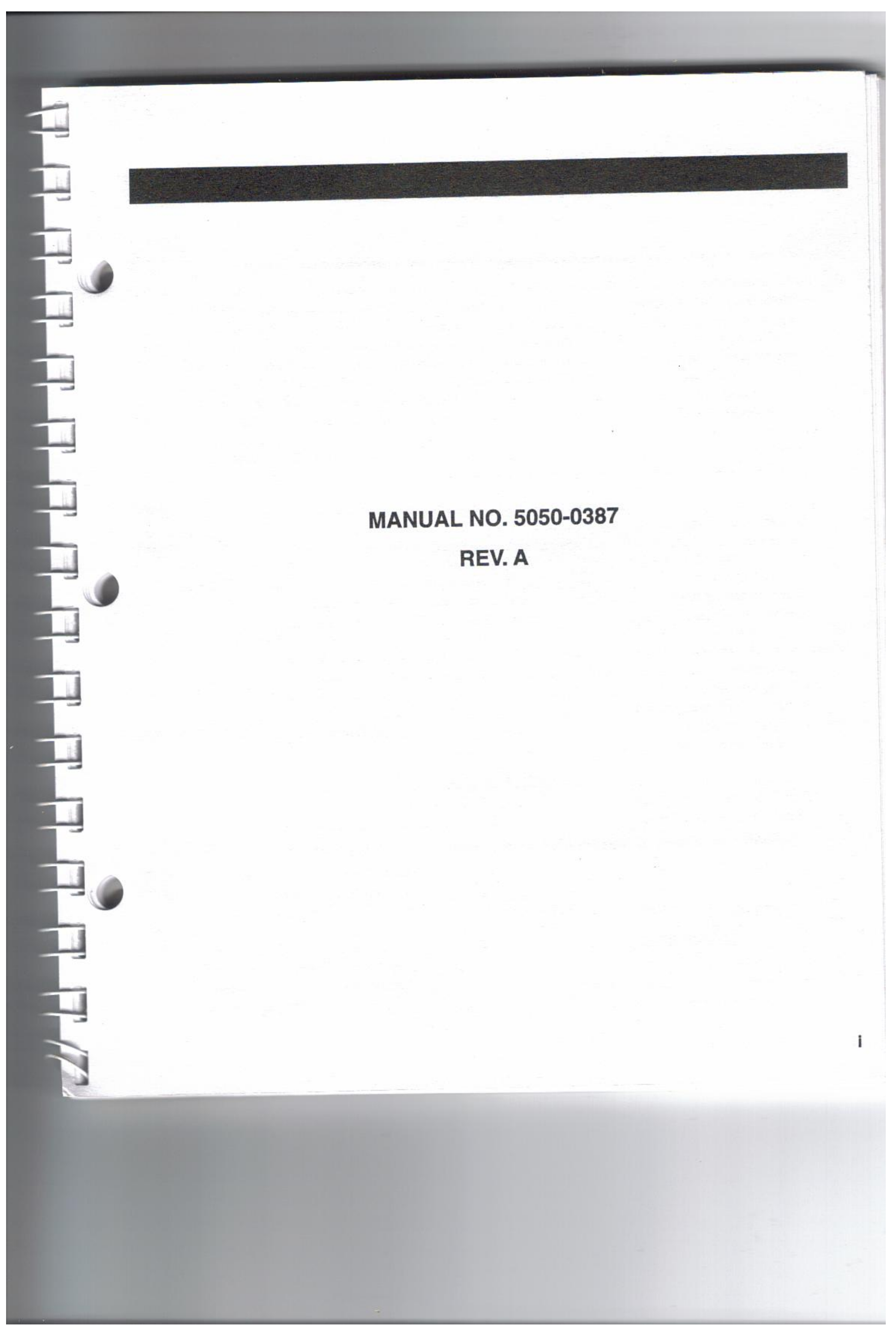
CRAFT BGA SYSTEMS



OPERATION & MAINTENANCE MANUAL



MANUAL NO. 5050-0387

REV. A

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Systems for Development, Production and Repair of Electronic Assemblies

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PACE Incorporated
Sales Administration
9893 Brewers Court
Laurel MD 20723-1990

(301) 490 - 9860
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GENERAL INFORMATION

USE OF THIS MANUAL

The information contained in this manual will provide the user with the knowledge necessary to properly operate and maintain the CRAFT BGA system. To fully utilize the features of the system, PACE strongly recommends that the user read and fully understand the "Process Development" and "Operation" portions of this manual. If you encounter any difficulty operating your system, call your local authorized PACE dealer or contact PACE Applications Engineering directly at Tel. (301) 490-9860 or FAX (301) 604-8782.

GENERAL INFORMATION

INTRODUCTION

Thank you for purchasing the CRAFT BGA system. This manual will provide you with the information necessary to properly set up, operate and maintain the CRAFT BGA system. Please read this manual thoroughly before using the system.

The CRAFT BGA is a complete system designed for the removal and installation of Ball Grid Arrays (BGAs) and many conventional SMD components. This machine contains the following key features which allows process controlled placement and reflow of BGAs and SMD components.

Utilizing either shop air, inert gas or the self-contained air blower, pressure/flow rate is easily controlled and maintained at optimum levels for the particular task at hand.

Closed-loop temperature control with digital set and read capability allows easy adjustment and repeatability of optimum reflow temperatures and (in conjunction with a selected flow rate) safe ramp-up rates.

Reflow cycle time control, adjustable in one second increments, provides consistent, repeatable results in successive reflow operations.

Workpiece handler and positioner with Memory Retention Feature allow X, Y and Theta control and precise alignment of the workpiece to the nozzle.

PACE's V-A-N (Vented Alignment Nozzle) design allows simple, repeatable component placement and alignment during the BGA installation process.

Based on extensive thermal analyses in PACE's laboratories, the CRAFT Process Development Chart has been created to aid in the development of customized reflow processes for your particular SMD tasks.

Lighting, optics and a preheating system are available options to the system.

The "SR-3" designation on the control panel is your assurance that the CRAFT BGA systems meet all applicable EOS/ESD and other government and industry specification requirements (including MIL-STD-2000 and ANSI-J-STD-001) for high performance and safety.

GENERAL INFORMATION

SPECIFICATIONS

Power Requirements

CRAFT BGA (115 VAC system)	-	Operates on 97-127 VAC, 60 Hz 1500 Watts maximum at 115 VAC, 60 Hz
CRAFT BGA (230 VAC system)	-	Operates on 197-264 VAC, 50 Hz 1500 Watts maximum at 230 VAC, 50 Hz

Gas/Air Temperature Range

260°C - 427°C (500°F - 800°F)

Timing Control

0 to 199 seconds with 1 second resolution.

Shop Air/Gas Input Requirements

4.1 Bar (60 p.s.i.) minimum
6.17 Bar (90 p.s.i.) maximum

Circuit Board Capacity (maximum size)

Standard System	- 30 cm X 46 cm (12" x 18")
With Extended Rails (optional accessory)	- 46 cm X 61 cm (18" x 24")

Component Capacity (maximum size)

4.6 cm x 4.6 cm (1.8" x 1.8")

Physical Parameters

SIZE

58.4cm H x 43.2 cm W x 56 cm D (23" H x 17" W x 22" D)

WEIGHT

22 Kg. (49 lbs.)

PRODUCT APPLICATION

The following sections of this manual will familiarize you with the parts and operation of the system. This product is very versatile and may be used to satisfy a variety of application requirements. If you require assistance in the use of this product in your particular application, contact your local authorized PACE distributor or call PACE Product Management at Tel. (301) 490-9860, FAX (301) 604-8782.

GENERAL INFORMATION

PARTS IDENTIFICATION

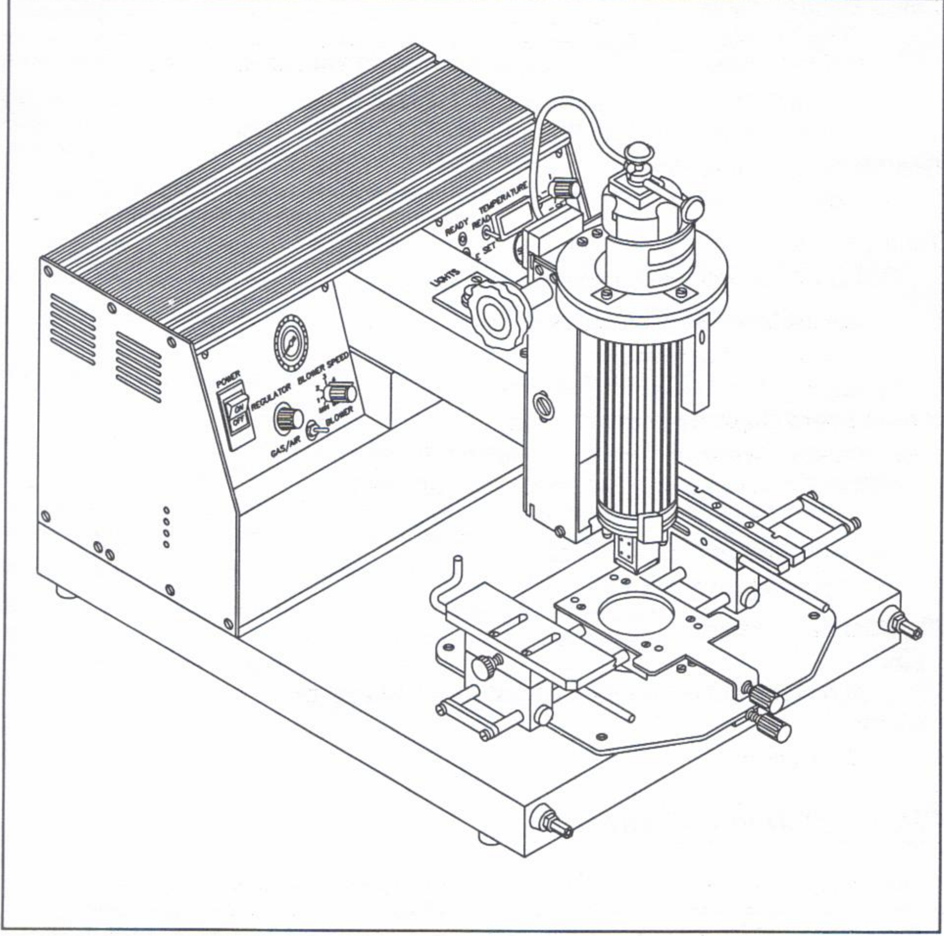


Figure 1.

CONTROL PANEL

1. **POWER** Switch - Turns system ON and OFF; controls input power to the system.
2. Gas/Air Pressure Gauge - Indicates air pressure level from compressed air or inert gas supply.
3. Gas/Air Pressure Control - Regulates compressed air or inert gas pressure flow.
4. **GAS/AIR BLOWER** Switch - Allows selection of compressed air (or inert gas) or internal blower air flow to the heater.
5. **BLOWER SPEED** Control - Controls speed of internal blower to regulate air flow to the heater in the blower mode.
6. **READY** Light - Turns on when the heater achieves operating temperature and is ready for operation.
7. **CYCLE** Light - Turns on when the heater is in the reflow cycle.
8. **TEMPERATURE** Display - Provides a three digit display of temperature readout. The temperature displayed is the air temperature at the top of the nozzle.
9. **READ/SET** Switch - Allows the **TEMPERATURE** Display to show the set temperature in the **SET** mode or the actual temperature in the **READ** mode.
10. **°F/°C** Switch - Provides either **°F** or **°C** readout on the **TEMPERATURE** Display.
11. **SET** Control - Allows the user to set the operating temperature of the heater.
12. **MAIN VACUUM PICK** Switch - Switch controls vacuum supply to the vacuum pickup assembly.
13. **CYCLE** Switch - Switch starts air flow through the heater initiating the reflow cycle. Also deactivates the air flow when pushed during a reflow cycle.
14. **CYCLE TIMER** - Manually resettable timer, controls duration of air flow through the heater.

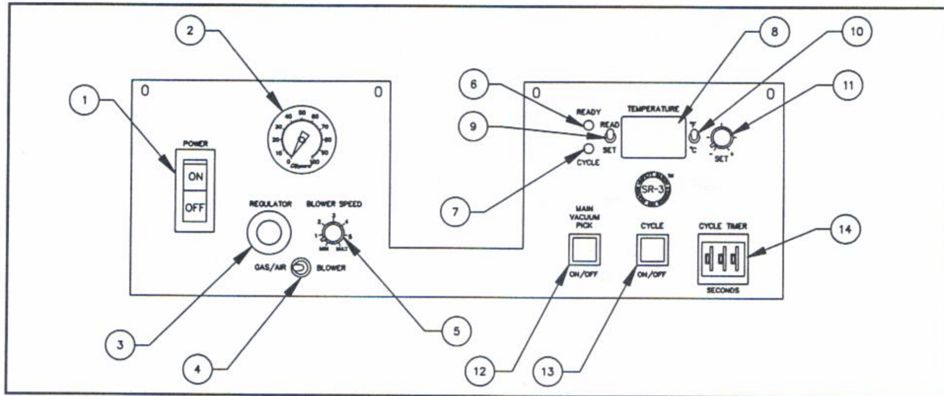


Figure 2.

WORKPIECE HANDLER

15. PCB Clamp Assembly - Holds PCB assembly on Workpiece Handler.
16. Clamp Assembly Locks - Locks PCB in place preventing X-Axis (side to side) movement along the two metal slide rods. Two locks on each PCB Clamp Assembly must be fully depressed to allow clamp movement along the slide rods.
17. Y-Axis Stop - Memory Retention Feature allows Y (front to back) directional stop reference for repeatable PCB positioning.
18. Y-Axis Stop Locks - Locks Workpiece Y-Axis Stop rods in place.
19. Theta Rotation Control Arm - Used to rotate the Workpiece Handler about its center axis. The 2 metal Stop rods may also be grasped by hand and used for this purpose (see directional arrows on illustrations in the "Operation" portion of this manual).
20. Theta Lock - Locks Theta Rotation Control Arm in position.
21. X-Axis Lock - Locks the metal slide rails in position to prevent X-Axis (side to side) movement.

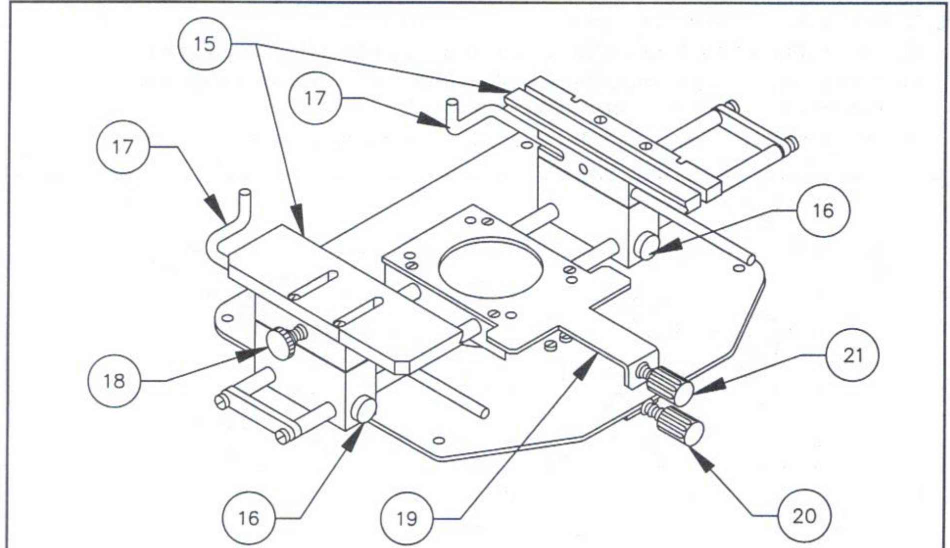


Figure 3.

REFLOW STATION

22. Heater Assembly - Supplies heated air or inert gas to the attached air nozzle to simultaneoulsy reflow all solder joints.
23. Vacuum Pickup Assembly -Provides a means to lift or place components.
24. Nozzle Assembly - Directs heated air or inert gas from the heater assembly to the solder joint areas for either soldering or desoldering of components.
25. Vacuum Cup - Provides positive holding of components for positioning during the replacement process and for lifting of the component during the removal process.
26. Vacuum Pick Locking Lever - Locks the heater assembly and vacuum pickup assembly together for simultaneous movement and unlocks to allow independent Heater Assembly movement.
27. Z-Axis Control - Controls vertical movement of the heater and vacuum pickup assemblies.
28. Nozzle Clearance Limiter - Item not shown in illustration; refer to Figure 23. Limits downward movement of heater assembly to prevent nozzle from contacting the PCB and provide a specific air gap for optimum air flow.
29. Optics Rotation Bearing - Allows attached optional optic assemblies to be rotated in a 180° arc around the heater assembly for viewing of placement and reflow processes. Features position stops at 0° and ±90°.
30. Lighting Output Receptacle - Connects power from the CRAFT BGA system to the optional Dual Halogen Lighting system.
31. Nozzle Retention Lever - Provides lock, release and theta-shear for the Nozzle assembly.

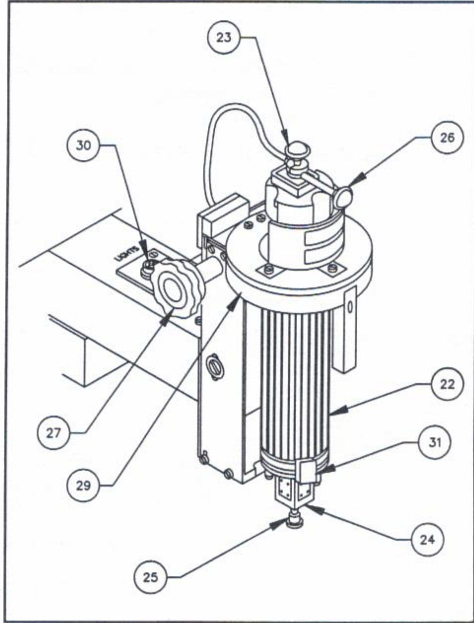


Figure 4.

GENERAL INFORMATION

REAR PANEL

32. AC Power Receptacle - Provides AC power to the system from the outlet through the power cord.

33. Lighting Power Fuse (F1) - Provides overload protection for the lighting power supply.

34. Unit Power Fuse (F2) - Provides overload protection for the CRAFT BGA unit.

35. **REMOTE OUTLET** - Input for the optional Remote Control/Countdown Timer to control activation of heat cycle and vacuum pickup.

36. **GAS/AIR INLET** - Connector for attachment of compressed air (clean, dry, filtered) or inert gas.

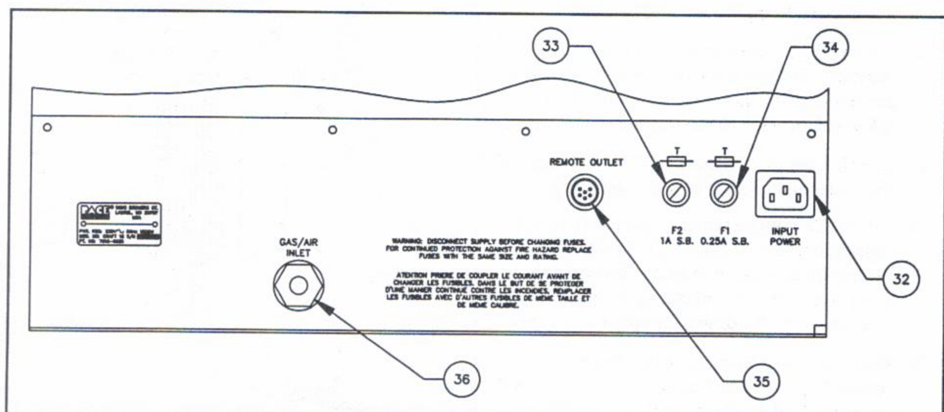


Figure 5.

OPTICS AND LIGHTING

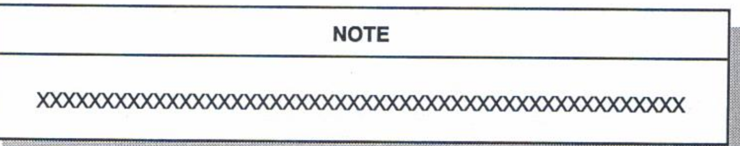
37. Optics And Lighting - Optional accessory (not shown) provides illumination and viewing of removal and placement functions.

The purpose of this "SAFETY" section is to inform users of the heading guidelines used in this manual to indicate special Notes, Cautions, Warnings or Dangers. Also included are precautions which must be observed when operating or servicing this product.

HEADING GUIDELINES

PACE adheres to the following Heading Guidelines (based on OSHA guidelines) when listing special information or precautions to be taken. Especially important are all procedures and practices which, if not strictly observed, could result in injury or loss of life.

These "NOTES", "CAUTIONS","WARNINGS" and "DANGERS" are inserted in this manual whenever deemed necessary. They appear in a blocked off form with outline and a shaded background to highlight the information as shown below.



NOTE

Used to indicate a statement of company recommendation or policy. The message may relate directly or indirectly to the safety of personnel or protection of property. NOTE is not associated directly with a hazard or hazardous situation and is not used in place of "CAUTION", "WARNING" or "DANGER".

CAUTION

Used to indicate a hazardous situation which may result in minor or moderate injury. May also be used to alert personnel to conditions, procedures and practices which, if not observed, could result in damage to or destruction of the product or other equipment.

WARNING

Used to define additional information that if not closely followed might result in serious damage to equipment and represent a potential for serious personnel injury.

DANGER

Defines additional information that if not closely followed might result in severe personnel injury or death. Danger is not used for property damage unless personal injury risk is present.

SAFETY

PRECAUTIONS

The following are general safety precautions which personnel must understand and follow when using or servicing this product. These precautions may or may not be included elsewhere in this manual.

USEAGE PRECAUTIONS

CAUTIONS

1. The CRAFT BGA heater assembly housing and any installed nozzle are hot when the system is powered on. DO NOT touch either the heater assembly housing or the nozzle. Severe burns may result!

2. Always use this system in a well-ventilated area. A fume extraction system such as those available from PACE are highly recommended to protect personnel from solder flux fumes.

3. Exercise proper precautions when using chemicals (e.g., solder paste). Refer to the Material Safety Data Sheet (MSDS) supplied with each chemical and adhere to all safety precautions recommended by the manufacturer.

SERVICING PRECAUTIONS

DANGERS

POTENTIAL SHOCK HAZARD - Repair procedures performed on this product should be performed by qualified service personnel only. Line voltage parts will be exposed when equipment is disassembled. Service personnel must avoid contact with these parts when troubleshooting the power source.

NOTES

Refer to the CRAFT Service Manual (P/N 5050-0261) whenever service is required.

To insure continued peak performance, use genuine PACE replacement parts.

SET-UP

SYSTEM REQUIREMENTS

ELECTRICAL REQUIREMENTS

The CRAFT BGA system base unit has a maximum power draw of 1500 watts. A separate, dedicated AC supply line circuit should be used to power the system. If a separate circuit is not available, arrange for a qualified, licensed electrician to install one for you.

AIR SUPPLY REQUIREMENTS

The CRAFT BGA system may be used with its internal blower assembly or may be connected to an in-house compressed air (or inert gas) supply. For proper operation, an in-house supply of compressed air (or inert gas) must be clean, dry and filtered. The input pressure must also be regulated to 4.1 Bar (60 p.s.i.) minimum, 6.17 Bar (90 p.s.i.) maximum.

SYSTEM SET-UP

Set up the CRAFT BGA base unit using the following steps and associated drawings.

1. Remove the CRAFT BGA system from its shipping container(s), including all options such as lights and video system.

> **CAUTION**
>
> Read and follow the unpacking instructions enclosed with the base unit. DO NOT use the mounting arm of the base unit to lift it out of its shipping container. Realignment of the system may be required if the base unit is removed incorrectly.

2. Store the shipping container(s) in a convenient location. Reuse of these containers will prevent damage if you ship or store the system.

3. Set the CRAFT BGA base unit on a level work surface. Insure that the power switch is in the OFF position.

4. Inspect all system components to check for shipping damage and to insure that all purchased components (standard and options) are present.

5. Install all purchased options (e.g., lights, video system) at this time. Installation instructions are enclosed with each option.

6. If the CRAFT BGA system is to be used with compressed air (or inert gas), connect the supply line to the **GAS/AIR INLET** (1/4" - 27 NPT fitting) located on the rear panel of the base unit.

NOTE
The input pressure must be clean, dry and filtered and must be regulated at 4.1-6.17 Bar (60-90 p.s.i.).

7. Place the **READ/SET** Switch in the **SET** position.

8. Adjust the **SET** Control fully counterclockwise.

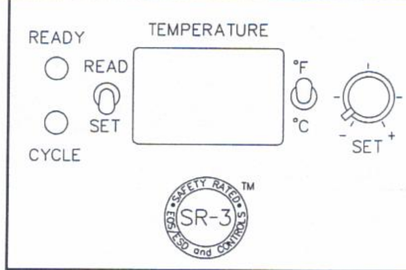


Figure 6.

9. Insert the power cord into the AC Power Receptacle located on the rear panel of the base unit.

CAUTION
To insure operator safety, the house AC supply receptacle must be checked for proper grounding before initial system operation. Also, insure that this receptacle is on a separate circuit (see "Electrical Requirements").

10. Plug the power cord into the AC supply receptacle.

11. Turn the POWER Switch to the ON position.

12. Test the system for proper operation. Refer to the "Operation" portion of this manual.

PROCESS DEVELOPMENT

INTRODUCTION

The CRAFT BGA system provides the user with the ability to perform non-destructive, repeatable, high quality, installation or removal operations on Ball Grid Array (BGA) and many other SMD component assemblies. The operator can adjust the parameters of gas/air temperature, gas/air flow rate, cycle time, nozzle configuration and pre/auxiliary heating (using the PACE HS 150 HotSpot unit) to suit the heating characteristics of the particular component and substrate mounting site. The PACE Process Development system allows the operator to determine "starting point" parameters for the particular application based upon the particular component and substrate. Using these parameters and the Process Work Sheet, initial trial runs are conducted with successive corrections made based upon observed results. Once optimum results are obtained, the corresponding final process parameters for that particular component and mounting site are entered on the Process Control Chart for future reference. A summary of the required Process Development sequence is listed below.

NOTE

When developing processes for BGA removal/replacement, PACE recommends the use of embedded thermocouples on the test board to insure optimum process results.

PROCESS DEVELOPMENT SEQUENCE

1. Use the Process Development Chart to determine base line parameters.
   a) Select the "Component Type" and "Overall Size" which matches your application.
   b) Select the "Substrate" type that matches your application. Enter the indicated Preheat and Reflow temperatures onto the "Base Line Parameters" section of the Process Work Sheet.
   c) Locate the two vertical "Air Flow" columns at their point of intersection with the horizontal row of the selected "Component". Enter the indicated "Air Pressure" or "Blower Speed" parameter onto the "Base Line Parameters" section of the Process Work Sheet.
   d) Locate the point of intersection between the "Substrate" and the "Component" rows. Enter the indicated "Reflow Time" parameter onto line number 1 of the Process Work Sheet.
2. Enter the requested "PC Assembly I.D." and "Component Location or Designation" onto the Process Work Sheet.
3. Complete the "Base Line Time Parameter" computation section of the Process Work Sheet.
4. Complete the "Process Testing" section of the Process Work Sheet.
5. Enter the "Established Process Guidelines" (as determined by the process testing) onto the Process Work Sheet.
6. Sign and date the Process Work Sheet.
7. Enter the "Established Process Guidelines" onto the Process Control Chart.

PROCESS DEVELOPMENT CHART

CRAFT BGA PROCESS DEVELOPMENT CHART					SUBSTRATE					
This chart provides a base starting point for the development of exact parameters ("Established Process Guidelines") for your surface mount rework process. Select the Component Outline and Substrate which best matches your application. Enter the indicated settings onto a CRAFT BGA Process Work Sheet.					Epoxy Glass (FR-4)		Flex	Ceramic	Polyimide	← PCB Material
					1-3 Layer	4+ Layer				
COMPONENT			AIR FLOW		None	100°C (212°F)	None	120°C (248°F)	120°C (248°F)	← Preheat Temp.
Component Outline	Component Type	Overall Size	Air Pressure	Blower Speed	371°C (700°F)	371°C (700°F)	371°C (700°F)	430°C (806°F)	371°C (700°F)	← Reflow Temp.
	BGA	ANY SIZE	30	1	The base Cycle Time for BGA components on substrates is 70 seconds. Final process parameters may vary widely and unlike standard SMT components, solder joints cannot be inspected visually. Final process parameters must be confirmed by X-ray or other specialized inspection techniques.					← CYCLE TIME in Sec.
	PLCC (J Lead)	Less Than 12 x 12mm (.5 x .5 in.)	35	Max.	18	10	14	12	10	←
	PLCC (J Lead)	Over 12 x 12mm (.5 x .5 in.)	50	Max.	28	12	20	16	12	←
	LCCC (leadless)	Less Than 12 x 12mm (.5 x .5 in.)	35	Max.	20	14	16	20	12	←
	LCCC (leadless)	Over 12 x 12mm (.5 x .5 in.)	50	Max.	35	24	26	30	18	←
	FlatPack	Less Than 12 x 12mm (.5 x .5 in.)	20	2	12	10	12	10	8	←
	FlatPack	Over 12 x 12mm (.5 x .5 in.)	30	3	20	18	18	26	14	←
	SOIC	3.8mm (.150 inch) Body	20	3	16	12	12	14	10	←
	SOIC	SOL (large outline)	25	3	12	10	10	10	8	←

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Figure 7.

PROCESS WORK SHEET

Use this sheet to develop your rework process. Duplicate this page and complete the copied form. **DO NOT** fill out the copy in this manual. Enter the Base Line parameters determined from the Process Development Chart. Follow the Process Development Sequence instructions step-by-step to insure optimum results.

CRAFT PROCESS WORK SHEET

DO NOT fill in the original copy in this manual, use duplicated copies only to develop your rework process. Enter the Base Line Parameters (including) "Cycle Time" determined from the Process Development Chart onto line #1 and the "Base Line Parameters" section of this sheet. Follow the subsequent instructions step by step to insure optimum results.

PC Assembly I.D. ____________________

Component Location or Designation. ____________

Cycle Time Computation

1. Enter Cycle Time parameter. + _____ sec
2. Add 2 seconds if fluxing is not allowed. + _____ sec
3. Add 2 seconds if high temp solder is used. + _____ sec
4. Subtract 2 seconds if low temp solder is used. - _____ sec
5. Total Cycle Time Base Line (add 1 thru 4) _____ sec

Base Line Parameters
(from 5 and Process Development Chart)

Preheat Temp.	Air Pressure	Blower Speed	Reflow Temp.	Total Cycle Time (from 5)
_____°	_____ psi	_____	_____°	_____ sec.

Notes: ____________________

Developing Final Process Specifications

Run component removal and replacement cycles using Base Line Parameters. Adjust Total Cycle Time in 2 second increments until optimum results are obtained. IMPORTANT - If components are bonded, increase the Total Cycle Time by 2 seconds for the Component Removal procedure only.

Process Testing

Date	Cycle Time (sec.)	Results	Initials

Temperatures listed are shown in °C °F (circle one)

Established Process Guidelines

Preheat Temp.	Preheat Time	Air Pressure	Blower Speed	Reflow Temp.	Total Cycle Time (from 5)
_____°	_____min.	_____psi	_____	_____°	_____ sec.

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Figure 8.

PROCESS CONTROL CHART

Duplicate this page and complete the copied form. **DO NOT** fill out the copy in this manual.

SUBSTRATE		COMPONENT		AIR FLOW		HEATING				SPECIAL PROCEDURES
Desig. #	Material	Desig. #	Type	Air Pressure	Blower Speed	Preheat Temp	Preheat Time (min.)	Reflow Temp	Cycle Time (sec.)	

PROCESS MATERIALS

FLUX: Name ____________ Solder (or paste) ____________ Other ____________

Type ____________ Bonding Material ____________ ____________

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Figure 9.

GENERAL PROCESS GUIDELINES

BOARD/COMPONENT PREPARATION

Proper preparation is the key to successful soldering. To obtain good solder joints, use the following guidelines. Although these guidelines pertain mostly to preparation for component installation, the board and component to be removed should be properly cleaned and repair area solder joints fluxed (if allowed by your company) before performing the applicable removal procedure.

1. All SMT component leads should be freshly cleaned and/or tinned to insure solderability.
2. Do not touch component leads or PCB lands after cleaning to your company specifications.
3. BGA components should have good solder ball deposition on each land. If a BGA component requires deposition of new solder, use a procedure approved by your company.
4. Leadless Ceramic Chip Carriers (LCCCs) with gold plating should be pretinned. For quality work, check for correct solder deposition on each castellation; the tinning process should not fill the castellations with solder. Each solder joint should be concave in appearance.
5. Prepare the land pattern as per your company specifications. For recommendations regarding processes which are best for your application, contact your local authorized PACE distributor. The most widely used methods are as follows:

    a) Pretinning - The PCB land pattern is pretinned using a soldering iron. Care must be taken to insure that all lands are tinned with an equal deposition of solder (provides a uniform appearance).

    b) Solder Paste - Apply an equal amount of solder paste on each land using a solder paste dispenser to control deposition. Take care to insure that the proper amount of paste is dispensed. If too much paste is applied, solder bridges will form on the lands. If an insufficient amount of paste is applied, solder joint formation will be unacceptable (open/starved joints). The PCB assembly (or rework area) should also be preheated (in accordance with your company requirements) after solder paste deposition to remove any volatiles (e.g., solvents) in the paste. The PACE HotSpot (HS-150) unit is highly recommended for this preheating application.

    c) Solder Preforms - Any preforms must be designed specifically for each component used to insure proper solder deposition.

COMPONENT PRE-POSITIONING

The CRAFT BGA system is fully capable of placing SMD components properly. In some instances (e.g., fine pitch FlatPack placement) however, the user may prefer to pre-position a component and solder tack it in place prior to final soldering. In order to position a component accurately, an optical aid (e.g., microscope) and glare free lighting should be used. Such accessories are available from PACE as either stand alone units or as options for the CRAFT BGA.

The following information and procedures will help you to obtain optimum results.

TACK SOLDERING

The following procedure is extremely useful when installing leaded components.

1. Using a PACE HandiPik (vacuum holding device) or tweezers for handling or holding, position the component leads to align with the land areas.

NOTE
A flux paste may be applied to corners of the PCB land pattern to temporarily hold the component in place.

2. Using a soldering iron with a fine pointed tip, tack two or more lead to land locations at opposite corners of the component. This will provide stability during subsequent handling throughout the soldering process.

STAKING MATERIAL

1. Apply a small amount of adhesive or suitable staking material to the underside of the component.

CAUTION
DO NOT use a cyanoacrylate based adhesive (e.g., "super glue") When these materials are heated, cyanide gases may be emitted creating a health hazard.

2. Using a vacuum holding device (e.g., PACE HandiPik) or tweezers for handling or holding, pre-position the component leads to align with the land areas.
3. Apply a slight downward pressure to the component to obtain adhesive to PCB contact which will stabilize the component.

NOTE
Solvent or water soluble material should be removed after the soldering process.

GENERAL PROCESS GUIDELINES

PREHEATING

Preheating of a printed circuit assembly is normally required in the repair process whenever any one or more of the following situations exist.

1. Epoxy glass substrate with 4 or more layers.
2. Substrate with large ground planes.
3. Substrate of ceramic, polyimide or other high heat dissipative material.
4. Printed circuit assembly with large metal heat sinks.

Preheating of assemblies such as those listed above will accomplish the following objectives.

1. Minimize thermal shock by elevating the assembly temperature to a level closer to solder melt temperature.
2. Minimize the heat cycle reflow time.
3. Overcome the heat dissipation characteristics of the assembly.
4. Avoid adjacent melts on densely populated assemblies.

The assembly undergoing repair must be heated for a length of time sufficient to saturate at the preheat temperature required. The PCB preheat temperature normally used is 100°C (212°F) for epoxy glass substrates and 120°C (248°F) for ceramics and polyimides.

Although many different methods such as ovens and preheated plates may be utilized to accomplish the required results, the user must employ a method which heats the assembly as evenly as possible and can be employed on the CRAFT BGA unit. The preheat temperature should also be maintained throughout the Removal/Replacement process. PACE recommends the use of its HotSpot (HS 150) unit for this purpose.

NOZZLE SELECTION

Selection of the proper Nozzle is essential for achieving a quality repair. Each Nozzle is designed to insure that heated air (or inert gas) is properly directed. This is especially evident when removing and/or replacing Ball Grid Arrays; the proper V-A-N (Vented Alignment Nozzle) must be used. Listed in the Replacement Parts section of this manual are the commonly used nozzles and the components for which they are normally used. Select the Nozzle (part number stamped on the Nozzle flange) configured for the component to be replaced. Call your local authorized PACE distributor or PACE Product Management (Tel. 301-490-9860, FAX 301-604-8782) for assistance.

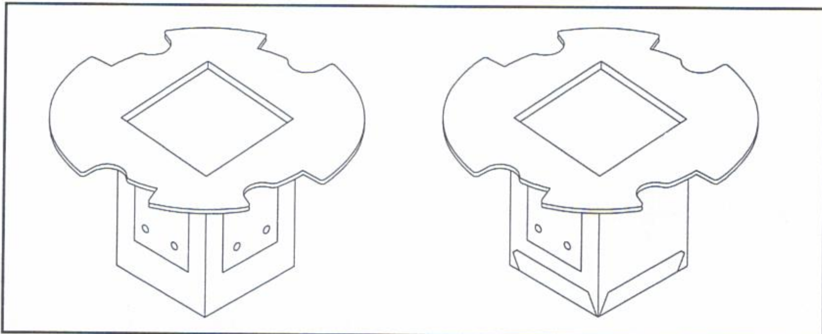


Figure 10.

TEMPLATE SELECTION

Alignment Templates are used as an aid in aligning V-A-N Nozzles to the PCB Assembly when installing Ball Grid Arrays (BGAs). The I.D. (Inside Dimension) of the template should match the O.D. (Outside Dimension) of the BGA land pattern.

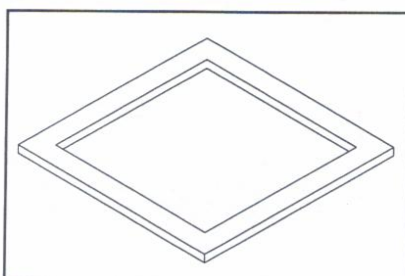


Figure 11.

VACUUM CUP SELECTION

Selection of the proper size vacuum cup is important for achieving an adequate holding force for each component. The cup selected should be as large as can be used without exceeding the body size of the component. Vacuum cups are consumable items which deteriorate over a period of time. Replacements are available in four sizes; refer to the Replacement Parts section of this manual when ordering these parts.

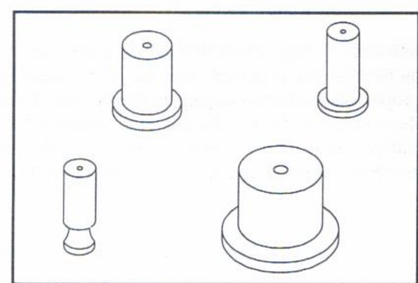


Figure 12.

NOZZLE CHANGEOUT

REMOVAL

1. With the Locking Lever in the locked position, raise the Heater Assembly to it's topmost position.
2. Using the right hand, place the Nozzle/Chip Tool under the Nozzle with the end of the Nozzle inserted into the large opening of the Nozzle/Chip Tool.

WARNING
Never remove a heated Nozzle using bare hands. Use the Nozzle/Chip Tool.

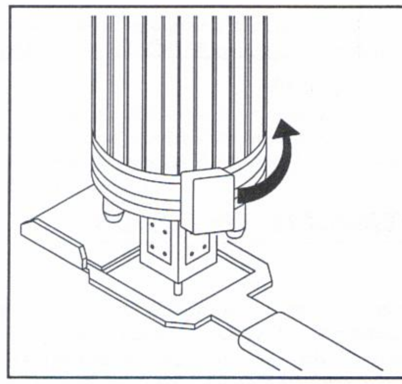


Figure 13.

3. With the left hand, move the Nozzle Retention Lever to the right. The Nozzle will be released from the Heater Assembly at this point and fall into the Nozzle/Chip Tool.

4. Move the Nozzle (still hot) to a heat resistant surface. Flip the Nozzle/Chip Tool over to release the Nozzle; allow time for the Nozzle to cool.

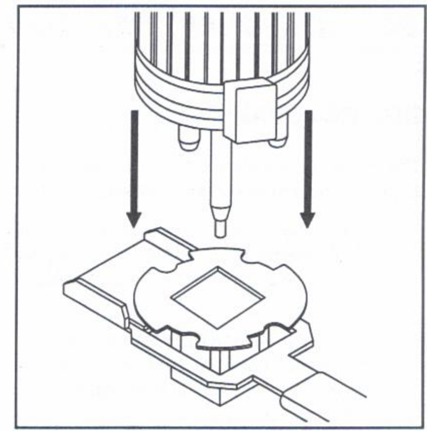


Figure 14.

INSTALLATION

1. Select the proper Nozzle for your application; see the "Replacement Parts" section of this manual.

2. If the selected Nozzle is rectangular in shape, orient the Nozzle to the component outline on the printed circuit assembly undergoing repair.

3. Holding the Nozzle in the right hand, line up the four notches on the flange of the Nozzle with the four alignment posts (brass colored) on the bottom of the Heater Assembly.

4. Lift the Nozzle up over the four alignment posts and hold in place against the bottom of the Heater Assembly.

5. With the left hand, move the Nozzle Retention Lever to the left to secure the Nozzle to the Heater Assembly. Release the Nozzle Retention Lever.

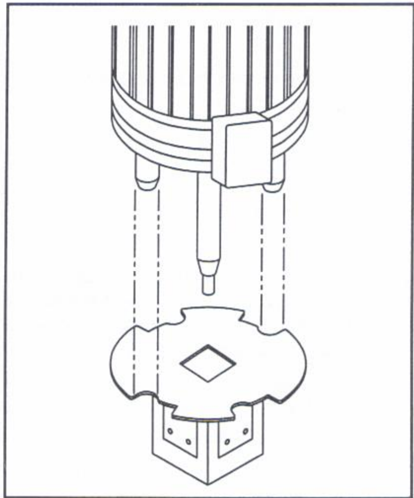


Figure 15.

BGA COMPONENT REPLACEMENT

BGA REMOVAL

The following procedure is to be used when removing BGA components only! Use the "Non-BGA Component Replacement" procedure when removing SMD components such as PLCCs, SOICs and FlatPacks.

1. Install the proper Vacuum Cup and V-A-N Nozzle Assembly onto the reflow station. Ensure that the PCB assembly to be reworked and any replacement component have been properly prepared. Refer to the "General Process Guidelines" portion of this manual.

2. Set the CRAFT BGA **POWER** Switch to the ON position and the **GAS/AIR BLOWER** Switch to the desired position. Set controls listed below to optimize performance. If a written process has been developed, set controls as specified. If a process has not been developed, refer to PACE "Process Development," page 14.

   a) Air Pressure (or Blower Speed)

   b) Reflow Temperature (°C or °F)

   c) Cycle Time

3. With the Vacuum Pick Locking Lever in the "Lock" position, raise the Heater Assembly to the topmost position.

4. Depress the Clamp Assembly Locks on one of the clamps to adjust PCB Clamp Assembly for PCB Assembly size. Adjust the second clamp if necessary. Slide PCB assembly into Workpiece Handler.

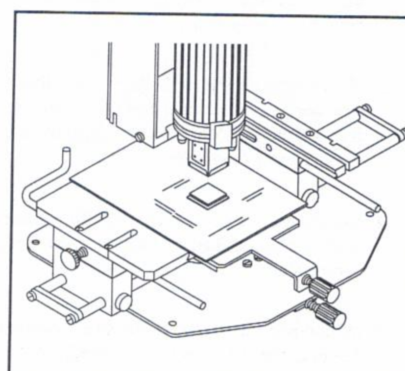


Figure 16.

5. With the X-Axis and Theta Locks in the unlocked position, adjust Workpiece Handler and PCB to align component beneath Nozzle. Use the Theta Rotation Control Arm to square the component to the Nozzle.

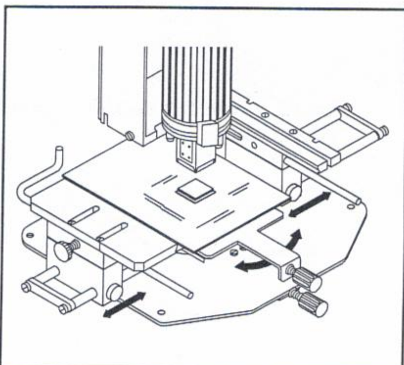


Figure 17.

6. Lower the Heater Assembly to position the Nozzle above the component.

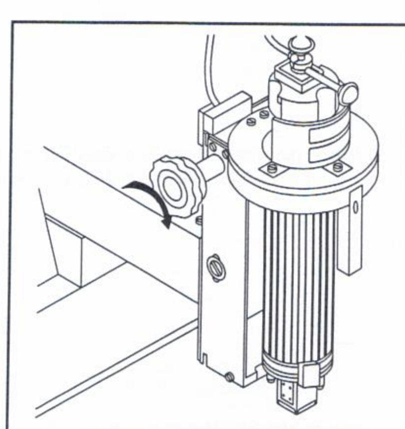


Figure 18.

BGA REMOVAL CONT'D

7. Move the Vacuum Pick Locking Lever to the "Unlock" position.

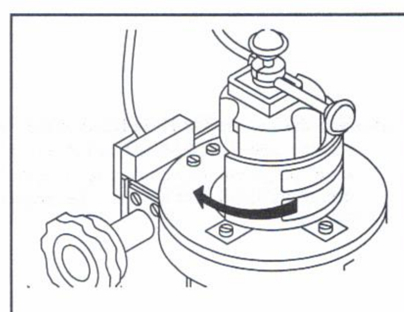


Figure 19.

8. Lower the Nozzle down over the BGA component. Adjust Workpiece Handler and PCB as necessary .

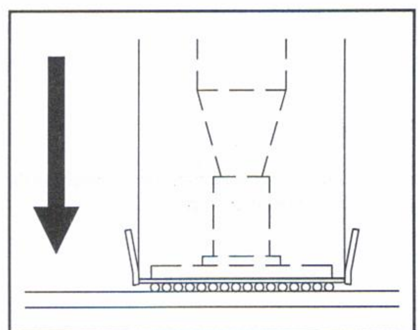


Figure 20.

9. Tighten the X-Axis and Theta Locks to lock Workpiece Handler in place. Adjust the Y-Axis Stop rods against the back of the PCB. Lock in place using the Y-Axis Stop Locks located on the sides of the PCB Clamp assemblies.

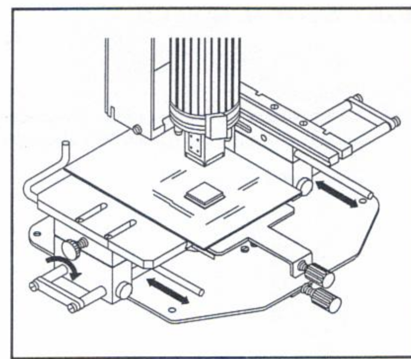
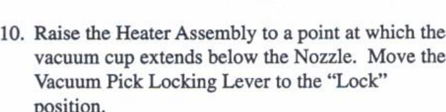


Figure 21.



10. Raise the Heater Assembly to a point at which the vacuum cup extends below the Nozzle. Move the Vacuum Pick Locking Lever to the "Lock" position.

11. Actuate **MAIN VACUUM PICK** Switch. Refer to Figure 24.

12. Slowly lower the Heater Assembly until the Vacuum Cup contacts the component.

13. Move the Vacuum Pick Locking Lever to the "Unlock" position and lower the Nozzle over the component. The bottom of the V-A-N Nozzle should rest gently against the surface of the BGA.

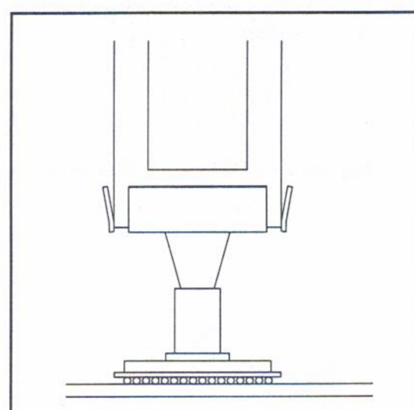


Figure 22.

BGA REMOVAL CONT'D

14. Adjust Nozzle Clearance Limiter if necessary, to provide repeatable Nozzle-to-PCB clearance.

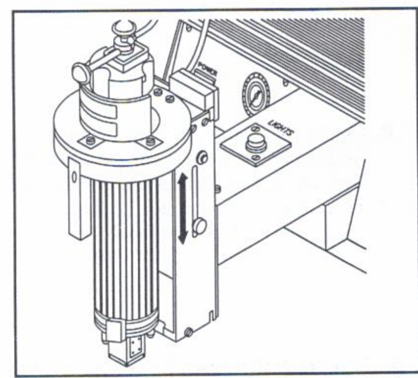


Figure 23.

15. Move the Vacuum Pick Locking Lever to the "Lock" position.

16. Push the **CYCLE** Switch to start the heat cycle.

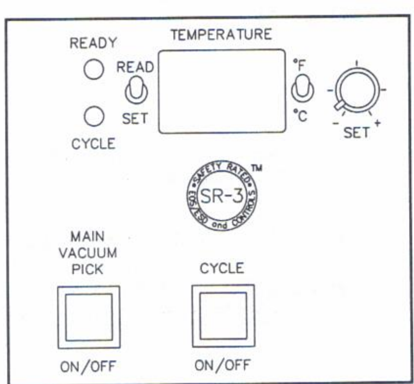


Figure 24.

NOTE

If the component being removed has been bonded to the substrate, ensure that all solder connections are molten. Move the Nozzle Retention Lever to the left and lift the Heater Assembly. This provides a shearing action to break the bond.

17. At the conclusion of the heat cycle, lift the Heater Assembly (with component) to the topmost position.

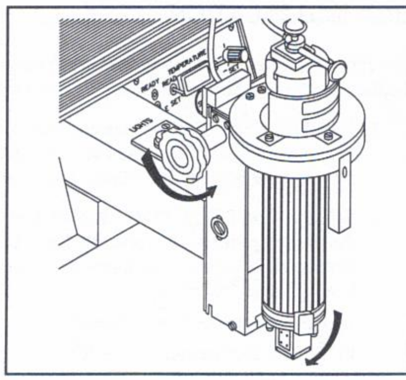


Figure 25.

18. Place Nozzle/Chip Tool under the Nozzle (refer to illustration). Turn **MAIN VACUUM PICK** Switch off to release component.

WARNING

The component is **HOT! DO NOT** remove or catch the component with bare hands. Allow the component to drop onto the Nozzle/Chip Tool. Allow sufficient time for the component and PCB to cool to room temperature before handling.

19. Move the Nozzle/Chip Tool to a heat resistant surface. Flip the Nozzle/Chip Tool over to release the component; allow time for the component to cool to room temperature.

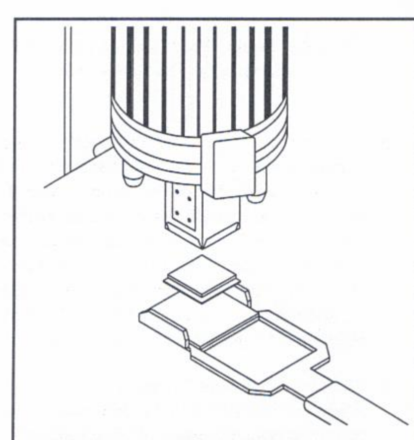


Figure 26.

BGA INSTALLATION

The following procedure is to be used when installing BGA components only! Use the "Non-BGA Component Replacement" procedure when installing SMD components such as PLCCs, SOICs and FlatPacks.

1. Install the proper Vacuum Cup and V-A-N Nozzle Assembly onto the reflow station. Ensure that the PCB assembly to be reworked and any replacement component have been properly prepared. Refer to the "General Process Guidelines" portion of this manual.
2. Set the CRAFT BGA **POWER** Switch to the ON position and the **GAS/AIR BLOWER** Switch to the desired position. Set controls listed below to optimize performance. If a written process has been developed, set controls as specified. If a process has not been developed, refer to PACE "Process Development," page 14.
   a) Air Pressure (or Blower Speed)
   b) Reflow Temperature (°C or °F)
   c) Cycle Time
3. With the Vacuum Pick Locking Lever in the "Unlock" position, lower the Heater Assembly to a point where the Nozzle extends below the Vacuum cup.
4. Move the Vacuum Pick Locking Lever to the "Lock" position and raise the Heater Assembly to its topmost position.
5. Depress the Clamp Assembly Locks on one of the clamps to adjust PCB Clamp Assembly for PCB Assembly size. Adjust the second clamp if necessary. Slide PCB assembly into Workpiece Handler. The Y-Axis Stop rods may have been previously locked in position for your rework application (during component removal process). If so, slide the PCB assembly into the Workpiece Handler until the assembly touches the stop.
6. Place the Alignment Template over the land pattern. Align the template until the perimeter of the land pattern is centered inside of the template.
7. Lower the Heater Assembly until it is slightly above the PCB assembly rework area.

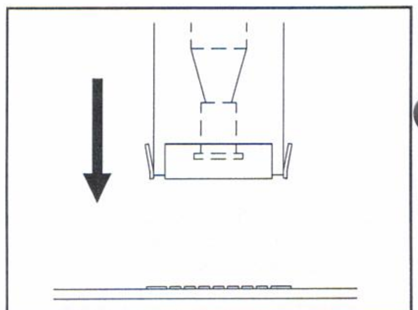


Figure 27.

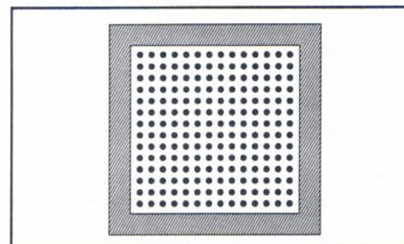


Figure 28.

8. With the X-Axis and Theta locks in the unlocked position, adjust Workpiece Handler and PCB to align nozzle to template. Center nozzle over template.

9. Raise the Heater Assembly to approximately the center of its travel limits (half way up).

10. Lock X-Axis and Theta locks on Workpiece handler and remove Alignment Template. NOTE: If you are doing repetitive installations, with all variables the same, you should adjust the Y-Axis Stop rods against the back of the PCB and lock in place using the Y-Axis locks located on the sides of the PCB Clamp assemblies.

11. Apply a flux (approved by your company) to the land pattern.

12. Move the Vacuum Pick Locking Lever to the "Unlock" position.

13. Actuate the **MAIN VACUUM PICK** Switch.

14. With the right hand and using the Nozzle/Chip Tool, insert the replacement component (properly oriented) into the Nozzle. The vacuum cup will now hold the component in position.

NOTE
You may find it necessary to raise the Heater Assembly using the left hand, in order to place the component onto the Vacuum Cup.

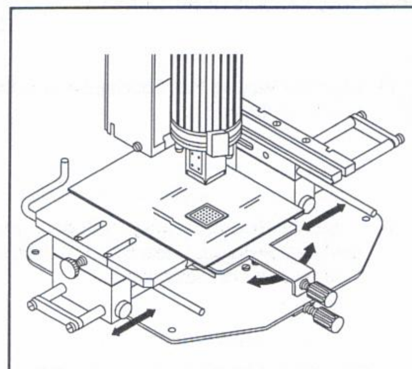


Figure 29.

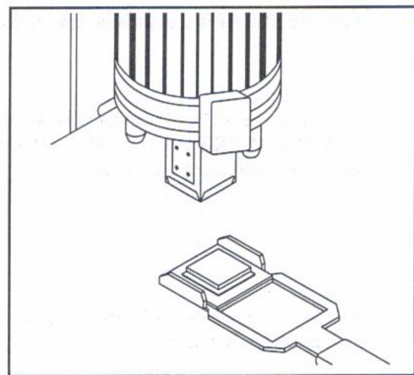


Figure 30.

BGA INSTALLATION CONT'D

13. Move the Vacuum Pick Locking Lever to the "Lock" position.

14. Lower the Heater Assembly (with component) until the component solder balls rest lightly on the PCB land area or solder paste.

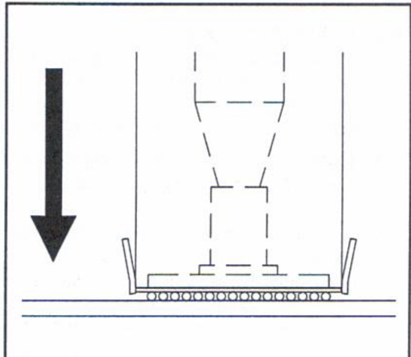


Figure 31.

15. Push **CYCLE** Switch to activate heat cycle.

16. After approximately 10 seconds, turn the **MAIN VACUUM PICK** Switch off. This will release the component and allow it to settle.

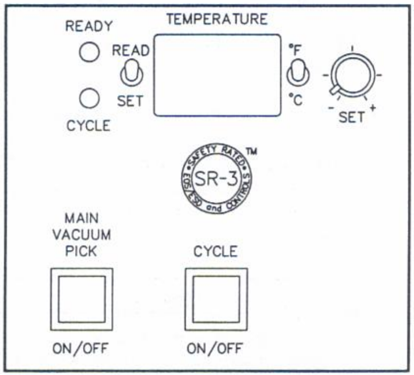


Figure 32.

17. At conclusion of heat cycle, allow the solder to cool down and solidify.

18. Raise the heater assembly to its topmost position. Allow sufficient time for cooling (solder resolidifies) and inspect rework area.

NON-BGA SMD COMPONENT REPLACEMENT

NON-BGA REMOVAL

The following procedure is to be used when removing SMD components such as PLCCs, SOICs and FlatPacks. Use the "BGA Component Replacement" procedure when removing BGA (Ball Grid Array) components.

1. Install the proper Vacuum Cup and Nozzle Assembly onto the reflow station. Ensure that the PCB assembly to be reworked and any replacement component have been properly prepared. Refer to the "General Process Guidelines" portion of this manual.

2. Set the CRAFT BGA **POWER** Switch to the ON position and the **GAS/AIR BLOWER** Switch to the desired position. Set controls listed below to optimize performance. If a written process has been developed, set controls as specified. If a process has not been developed, refer to PACE "Process Development," page 14.

   a) Air Pressure (or Blower Speed)

   b) Reflow Temperature (°C or °F)

   c) Cycle Time

3. With the Vacuum Pick Locking Lever in the "Lock" position, raise the Heater Assembly to its topmost position.

4. Depress the Clamp Assembly Locks on one of the clamps to adjust PCB Clamp Assembly for PCB Assembly size. Adjust the second clamp if necessary. Slide PCB assembly (properly oriented) into the Workpiece Handler.

5. Apply a flux (approved for use by your company) to the solder joints of the component to be removed.

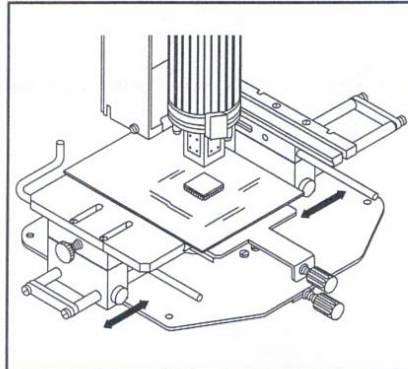


Figure 33.

NON-BGA REMOVAL CONT'D

6. With the X-Axis and Theta Locks in the unlocked position, adjust Workpiece Handler and PCB to align component beneath Nozzle. Use the Theta Rotation Control Arm to square the component to the Nozzle.

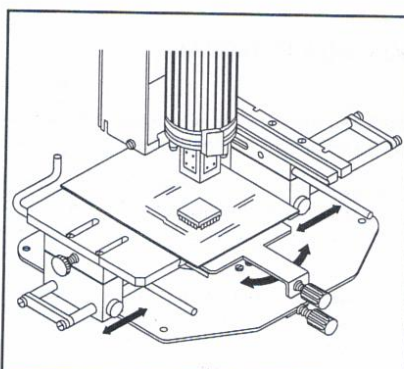


Figure 34.

7. Lower the Heater Assembly to position the Nozzle above the component.

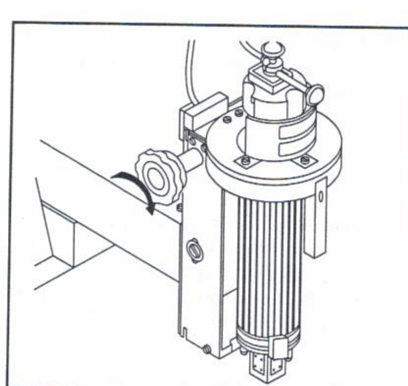


Figure 35.

8. Move the Vacuum Pick Locking Lever to the "Unlock" position.

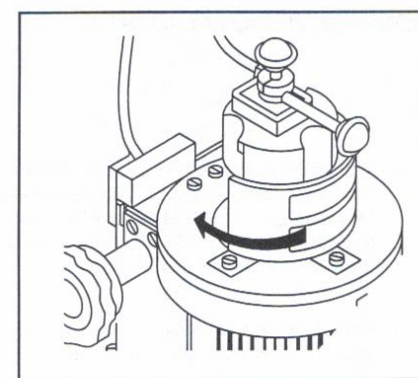
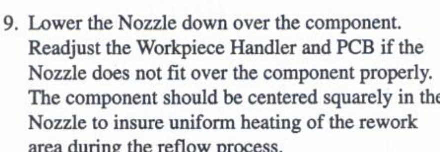


Figure 36.



9. Lower the Nozzle down over the component. Readjust the Workpiece Handler and PCB if the Nozzle does not fit over the component properly. The component should be centered squarely in the Nozzle to insure uniform heating of the rework area during the reflow process.

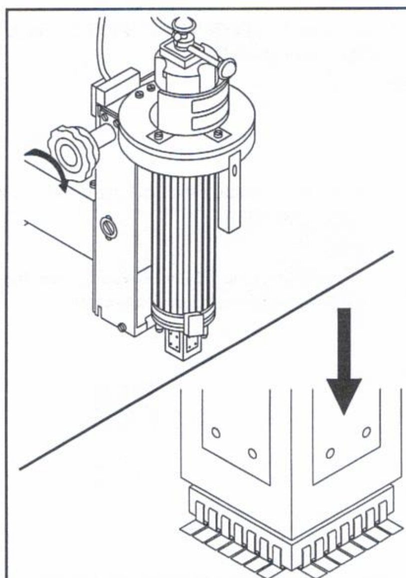


Figure 37.

NON-BGA REMOVAL CONT'D

10. Tighten the X-Axis and Theta Locks to lock Workpiece Handler in place. Adjust the Y-Axis Stop rods against the back of the PCB. Lock in place using the Y-Axis Stop Locks located on the sides of the PCB Clamp assemblies.

11. Raise the Heater Assembly to a point at which the vacuum cup extends below the Nozzle.

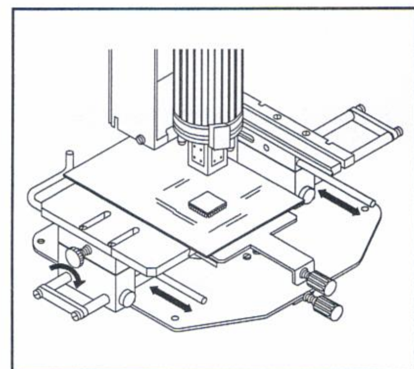


Figure 38.

12. Actuate the **MAIN VACUUM PICK** Switch. Refer to Figure 43.

13. Move the Vacuum Pick Locking Lever to the "Lock" position.

14. Slowly lower the Heater Assembly until the vacuum cup contacts the component.

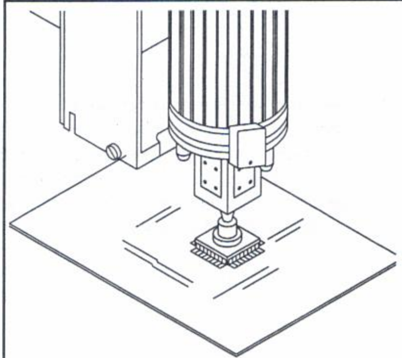


Figure 39.

15. Move the Vacuum Pick Locking Lever to the "Unlock" position. Lower the Nozzle over the component.

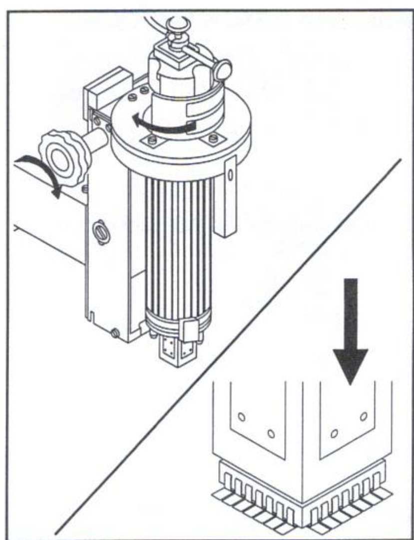


Figure 40.

16. Adjust the Nozzle Clearance Limiter if necessary, to provide repeatable Nozzle-to-PCB clearance. A clearance of .76-1.27mm (.030-.050") is recommended when using single wall nozzles. When using vented nozzles, the bottom of the nozzle should rest gently against the surface of the PCB.

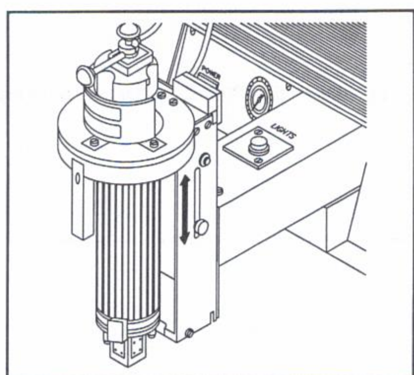


Figure 41.

NON-BGA REMOVAL CONT'D

17. Move the Vacuum Pick Locking Lever to the "Lock" position.

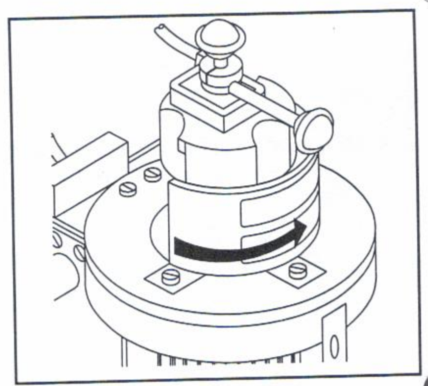


Figure 42.

18. Actuate the **CYCLE** Switch to start the heat cycle.

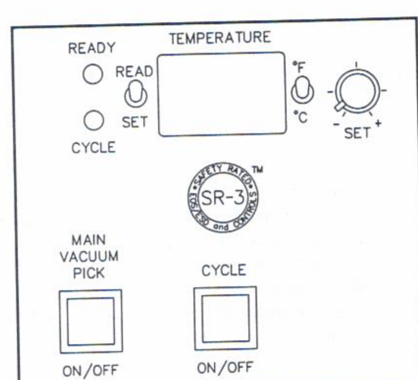


Figure 43.

NOTE

If the component being removed has been bonded to the substrate, ensure that all solder connections are molten. Move the Nozzle Retention Lever to the left and lift the Heater Assembly. This provides a shearing action to break the bond.

17. At the conclusion of the heat cycle, lift the Heater Assembly (with component) to the topmost position.

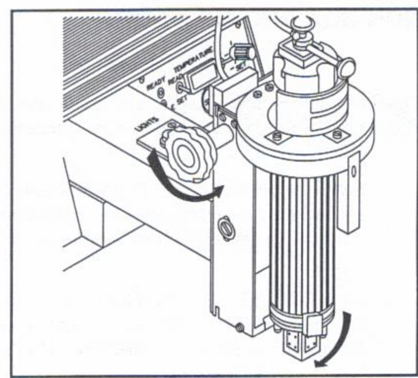


Figure 44.

20. Place the Nozzle/Chip Tool under the Nozzle as shown. Turn the **MAIN VACUUM PICK** Switch off to release the component.

WARNING

The component is **HOT! DO NOT** remove or catch the component with bare hands. Allow the component to drop onto the Nozzle/Chip Tool. Allow sufficient time for the component and PCB to cool to room temperature before handling.

21. Move the Nozzle/Chip Tool to a heat resistant surface. Flip the Nozzle/Chip Tool over to release the component. Allow time for the component to cool to room temperature.

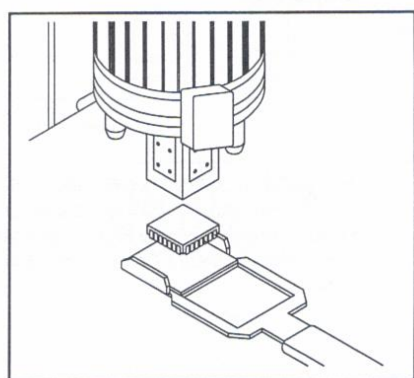


Figure 45.

NON-BGA INSTALLATION

The following procedure is to be used when installing SMD components such as PLCCs, SOICs and FlatPacks. Use the "BGA Component Replacement" procedure when installing BGA (Ball Grid Array) components.

1. Install the proper Vacuum Cup and Nozzle Assembly onto the reflow station. Ensure that the PCB assembly to be reworked and any replacement component have been properly prepared. Refer to the "General Process Guidelines" portion of this manual.

2. Set the CRAFT BGA **POWER** Switch to the ON position and the **GAS/AIR BLOWER** Switch to the desired position. Set controls listed below to optimize performance. If a written process has been developed, set controls as specified. If a process has not been developed, refer to PACE "Process Development," page 14.

   a) Air Pressure (or Blower Speed)

   b) Reflow Temperature (°C or °F)

   c) Cycle Time

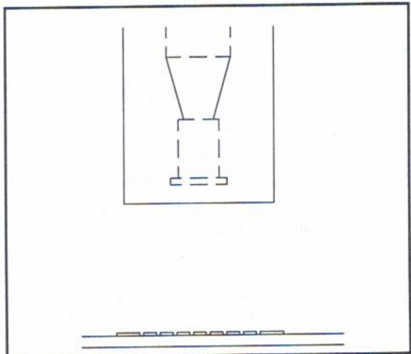


Figure 46.

3. Move the Vacuum Pick Locking Lever to the "Unlock" position and adjust the Heater Assembly to a point where the Nozzle extends approximately the thickness (height) of the component below the vacuum cup.

4. Move the Vacuum Pick Locking Lever to the "Lock" position.

5. Raise the Heater Assembly to its topmost position.

6. Depress the Clamp Assembly Locks on one of the clamps to adjust PCB Clamp Assembly for PCB Assembly size. Adjust the second clamp if necessary. Slide PCB assembly (properly oriented) into the Workpiece Handler.

7. Ensure that the X-Axis and Theta locks are in the unlocked position. Lower the Nozzle down over the land pattern. Readjust the Workpiece Handler and PCB if necessary. The Nozzle should be centered squarely over the land pattern to insure proper component placement.

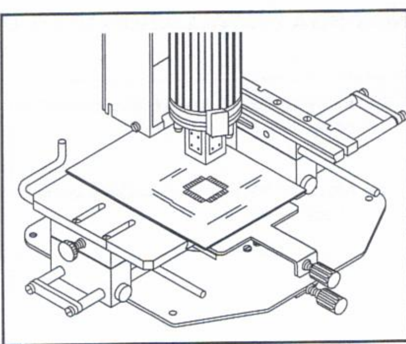


Figure 47.

8. Raise the Heater Assembly to the center of its travel (raised half way).

9. Move the Vacuum Pick Locking Lever to the "Unlock" position .

10. Actuate the **MAIN VACUUM PICK** Switch.

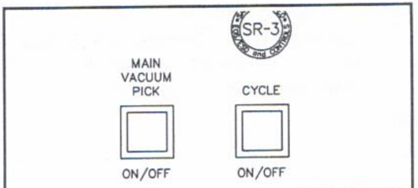
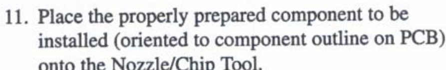
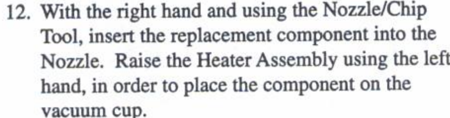


Figure 48.



11. Place the properly prepared component to be installed (oriented to component outline on PCB) onto the Nozzle/Chip Tool.



12. With the right hand and using the Nozzle/Chip Tool, insert the replacement component into the Nozzle. Raise the Heater Assembly using the left hand, in order to place the component on the vacuum cup.

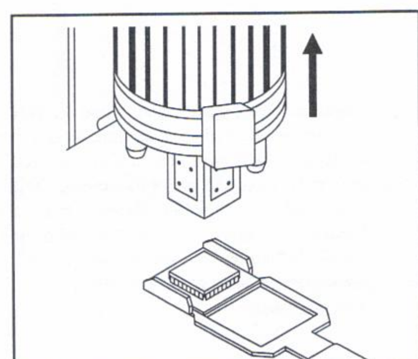


Figure 49.

NON-BGA INSTALLATION CONT'D

13. Raise the Heater Assembly to expose the component.

14. Move the Vacuum Pick Locking Lever to the "Lock" position.

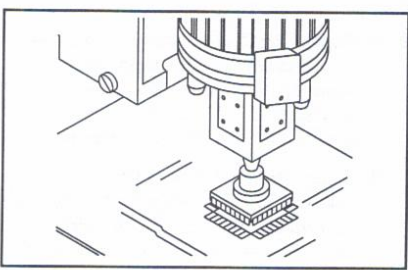
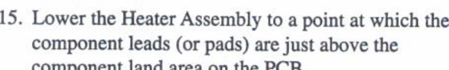


Figure 50.



15. Lower the Heater Assembly to a point at which the component leads (or pads) are just above the component land area on the PCB.

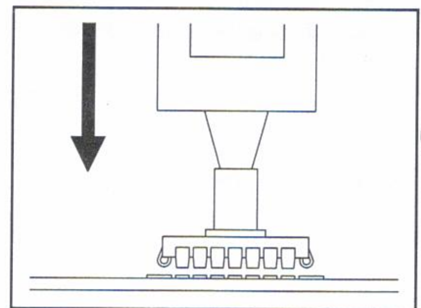
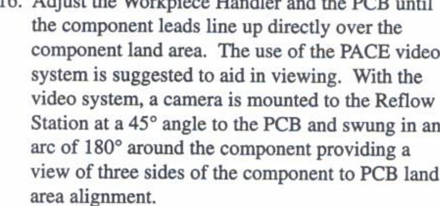


Figure 51.



16. Adjust the Workpiece Handler and the PCB until the component leads line up directly over the component land area. The use of the PACE video system is suggested to aid in viewing. With the video system, a camera is mounted to the Reflow Station at a 45° angle to the PCB and swung in an arc of 180° around the component providing a view of three sides of the component to PCB land area alignment.

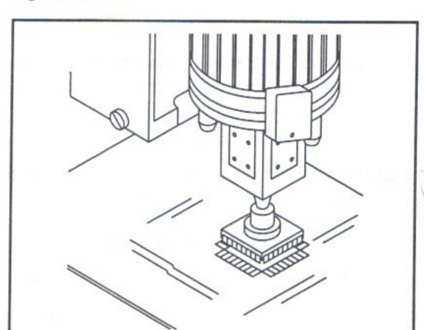


Figure 52.

17. Lock the PCB assembly in position by tightening the Theta Lock and X-Axis Locks. NOTE: If you are doing repetitive installations, with all variables the same, you should adjust the Y-Axis Stop rods against the back of the PCB and lock in place using the Y-Axis Stop Locks located on the sides of the PCB Clamp assemblies.

18. Lower the Heater Assembly (with Component) until the component leads rest lightly on the PCB land area.

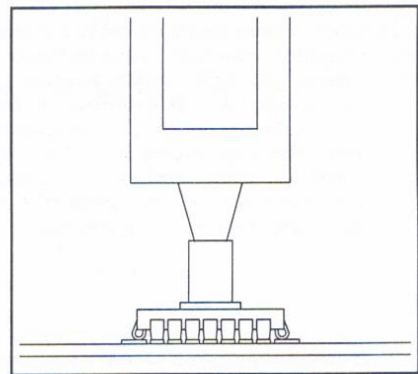


Figure 53.

19. Move the Vacuum Pick Locking Lever to the "Unlock" position.

20. Lower the Nozzle down over the component.

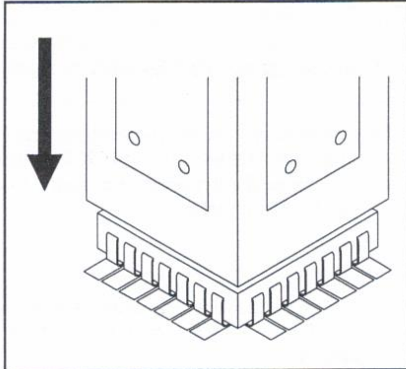


Figure 54.

NON-BGA INSTALLATION CONT'D

21. Check to insure that the desired PCB to Nozzle clearance is maintained. Adjust the Nozzle Clearance Limiter if necessary, to provide repeatable Nozzle-to-PCB clearance. A clearance of .76-1.27mm (.030-.050") is recommended when using single wall nozzles. When using vented nozzles, the bottom of the nozzle should rest gently against the surface of the PCB. Adjust the Nozzle Clearance Limiter if necessary.

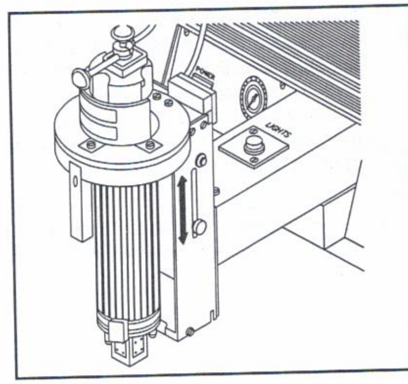


Figure 55.

22. Move the Vacuum Pick Locking Lever to the "Lock" position.

23. Actuate the **CYCLE** Switch to start the heat cycle.

24. Immediately at the conclusion of the heat cycle, turn the **MAIN VACUUM PICK** Switch off. This will release the component and allow it to settle into the molten solder.

25. Lift the Heater Assembly to the topmost position and allow time for the solder to cool down and solidify.

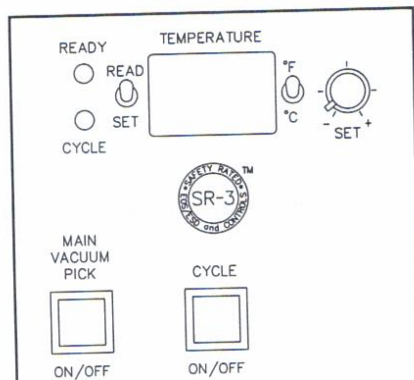


Figure 56.

Most malfunctions are simple and easy to correct. Select the "Symptom" which best describes the malfunction and follow the steps given in the "Solution" column.

Symptom	Probable Cause	Solution
No power to system.	Blown Fuse (F1).	Replace Fuse F1 located on the system rear panel.
	Line cord unplugged.	Plug line cord into AC outlet.
	AC supply circuit breaker tripped.	The CRAFT BGA should be on a separate AC supply (see "Electrical Requirements" portion of the Set-Up section of this manual). Connect system to separate AC supply.
Lighting Assembly does not light.	Blown Fuse (F2).	Replace Fuse F2 located on the system rear panel.
For all other system malfunctions, refer to the Corrective Maintenance section of the CRAFT Service Manual, part number 5050-0344. This manual is available at a nominal cost; to order, contact your local authorized PACE distributor. For further assistance, contact PACE Customer Service at Tel. (301) 490-9860 or FAX (301) 604-9215.		

Table 1. System Corrective Maintenance

REPLACEMENT PARTS

CRAFT BGA UNIT

When ordering replacement parts for the CRAFT BGA system, find the system area where the parts are located on page 47. Refer to the system area illustrations to locate the replacement part and its item number. For any additional parts, refer to the CRAFT Service Manual (P/N 5050-0261) or contact PACE Customer Service at Tel. (301) 490-9860, FAX (301) 604-9215.

Item No.	Description	Part Number
①	Power Switch	
	115 VAC System	1157-0063
	230 VAC System	1157-0059
②	AC Power Receptacle	1207-0204
③	Fuse Holder	1161-0008
④	Fuse F1	
	0.5 A Slo Blo (115 VAC System)	1159-0248
	0.25 A Time Delay (230 VAC System)	1159-0210
⑤	Fuse F2	
	2 A Slo Blo (115 VAC System)	1159-0247
	1 A Time Delay (230 VAC System)	1159-0216
⑥	Power Cord (not shown in illustration)	
	115 VAC System	1332-0134
	230 VAC System	1332-0093

Table 2. System Replacement Parts

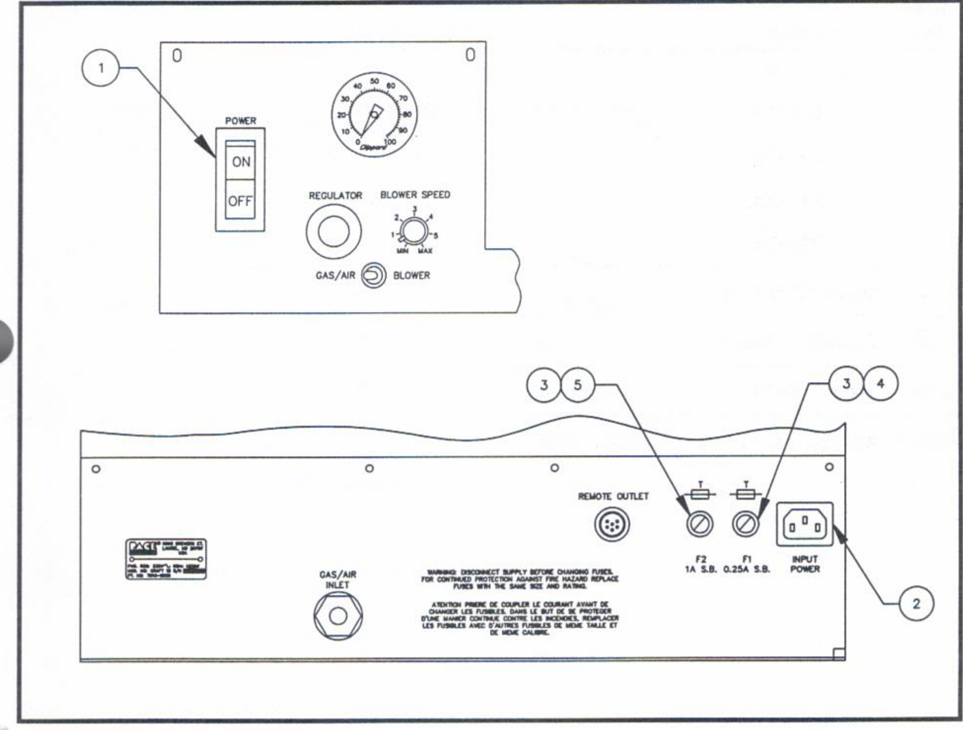


Figure 57.

REPLACEMENT PARTS

PARTS/CONSUMABLES

Item No.	Description	Part Number
①	Vacuum Cup	
	.625 Dia.	1121-0280-P2
	.400 Dia.	1121-0281-P2
	.312 Dia.	1121-0282-P2
	.200 Dia.	1121-0288-P2
②	Nozzle/Chip Tool	1100-0231
③	Operation Manual	5050-0387
④	Service Manual	5050-0261

Table 3. Additional Items, Parts/Consumables

ACCESSORIES

Listed below are the accessories which can be used with the CRAFT BGA system. Contact your local authorized PACE distributor for further information.

Item No.	Description	Part Number
①	Color Video System	
	115 VAC System	6018-0055
	230 VAC System	6018-0057
	230 VAC System Less Monitor	6018-0062
②	Reflow Station Video Mount	6018-0072
③	Monitor Mount	6018-0044
④	4X Microscope	6018-0048
⑤	20X Eyepieces	1106-0033
⑥	Reflow Station Microscope Mount	6018-0049
⑦	Dual Halogen Lighting System	7007-0011
⑧	Replacement Lamp, 12V, 20W	1165-0023
⑨	Polarizer Kit	6018-0058
⑩	Remote Control	6018-0089

Table 4. Available Accessories

REPLACEMENT PARTS

NOZZLES

Listed following are Nozzles used with standard JEDEC packages. For Nozzles other than those listed, contact PACE Applications Engineering directly at Tel. (301) 490-9860, FAX (301) 604-8782.

BGA NOZZLES

Component (# of I/Os)	BGA Size (Nominal)	Part Number
BGA-169	23mm x 23mm (0.9" x 0.9")	4018-0080-001
BGA-225	27mm x 27mm (1.1" x 1.1")	4018-0080-002
BGA-256	27mm x 27mm (1.1" x 1.1")	4018-0080-002
BGA-313	35mm x 35mm (1.4" x 1.4")	4018-0080-003

Alignment Templates	
BGA-169	3018-0057-001
BGA-225	3018-0057-002
BGA-256	3018-0057-003
BGA-313	3018-0057-004
NOTE: Alignment Templates are included with Nozzle assemblies (4018 numbers). To order replacement Alignment Templates, order the 3018 numbers listed above.	

Table 5. Available BGA Nozzles

SINGLE WALL NOZZLES

Component Type	Component Size (Max.) Inches	Nozzle Size (Nom.) Inches	Part Number
PLCC-18	.467 x .327	.475 x .336	4018-0033-001
PLCC-20	.395 x .395	.403 x .403	4018-0033-002
PLCC-28	.495 x .495	.503 x .503	4018-0033-003
PLCC-32	.595 x .495	.503 x .603	4018-0033-004
PLCC-44	.695 x .695	.703 x .703	4018-0033-005
PLCC-52	.795 x .795	.803 x .803	4018-0033-006
PLCC-68	.995 x .995	1.003 x 1.003	4018-0033-007
PLCC-84	1.195 x 1.195	1.202 x 1.202	4018-0033-008
SOIC- 8	.244 x .197	.280 x .280	4018-0034-001
SOIC-14	.344 x .244	.275 x .380	4018-0034-002
SOIC-16	.394 x .244	.424 x .280	4018-0034-003
SOL-16	.419 x .413	.446 x .446	4018-0034-004
SOL-20	.512 x .419	.542 x .449	4018-0034-005
SOL-24	.612 x .419	.642 x .449	4018-0034-006
SOL-28	.712 x .419	.742 x .449	4018-0034-007
LCCC-16	.308 x .308	.313 x .313	4018-0035-001
LCCC-18	.435 x .300	.443 x .308	4018-0035-002
LCCC-20	.358 x .358	.366 x .366	4018-0035-003
LCCC-24	.410 x .410	.424 x .418	4018-0035-004
LCCC-28	.458 x .458	.475 x .475	4018-0035-005
LCCC-44	.660 x .660	.670 x .670	4018-0035-006
LCCC-52	.761 x .761	.773 x .773	4018-0035-007
LCCC-68	.962 x .962	.970 x .970	4018-0035-008
LCCC-84	1.165 x 1.165	1.172 x 1.172	4018-0035-009
FP-80	.989 x .752	.949 x .714	4018-0036-001
- -- -	LARGEST SIZE	1.530 x 1.530	4018-0033-009
Custom-Design Single-Wall Nozzles manufactured to customer's specification and size.			

Table 6. Available Single Wall Nozzles

REPLACEMENT PARTS

HV-FIXED GAP NOZZLES

Component Type	Component Size (Max.) Inches	Nozzle Size (Nom.) Inches	PACE Part Number
PLCC-18	.467 x .327	.475 x .336	4018-0037-001
PLCC-20	.395 x .395	.403 x .403	4018-0037-002
PLCC-28	.495 x .495	.503 x .503	4018-0037-003
PLCC-32	.595 x .495	.503 x .603	4018-0037-004
PLCC-44	.695 x .695	.703 x .703	4018-0037-005
PLCC-52	.795 x .795	.803 x .803	4018-0037-006
PLCC-68	.995 x .995	1.003 x 1.003	4018-0037-007
PLCC-84	1.195 x 1.195	1.202 x 1.202	4018-0037-008
Custom-Design Fixed-Gap Nozzles manufactured to customer's specification and size.			

Table 7. Available Fixed Gap Nozzles

VENTED NOZZLES

Component Type	Component Size (Max.) Inches	Nozzle Size (Nom.) Inches	Part Number
PLCC-18	.467 x .327	.475 x .336	4018-0053-001
PLCC-20	.395 x .395	.403 x .403	4018-0053-002
PLCC-28	.495 x .495	.503 x .503	4018-0053-003
PLCC-32	.595 x .495	.503 x .603	4018-0053-004
PLCC-44	.695 x .695	.703 x .703	4018-0053-005
PLCC-52	.795 x .795	.803 x .803	4018-0053-006
PLCC-68	.995 x .995	1.003 x 1.003	4018-0053-007
PLCC-84	1.195 x 1.195	1.202 x 1.202	4018-0053-008
- -	LARGEST SIZE	1.530 x 1.530	4018-0053-009
SOIC- 8	.244 x .197	.280 x .280	4018-0054-001
SOIC-14	.344 x .244	.275 x .380	4018-0054-002
SOIC-16	.394 x .244	.424 x .280	4018-0054-003
SOL-16	.419 x .413	.446 x .446	4018-0054-004
SOL-20	.512 x .419	.542 x .449	4018-0054-005
SOL-24	.612 x .419	.642 x .449	4018-0054-006
SOL-28	.712 x .419	.742 x .449	4018-0054-007
FP-80	.989 x .752	.949 x .714	4018-0056-001
Custom-Design Vented Nozzles manufactured to customer's specification and size.			

Table 8. Available Vented Nozzles

MANUAL IMPROVEMENT & COMMENT FORM

Instructions		
1. Duplicate this form and submit comments on the copy. Keep the original to make future comments. 2. Complete all requested information. 3. Submit completed form to: PACE Incorporated, Applications Engineering, 9893 Brewers Court, Laurel MD 20723-1990 U.S.A. Fax: (301) 604 - 8782		
Document Nbr: **5050-0387**	Revision Level: **A**	Date of Submission:
Nature of Change (Identify page and paragraph and include proposed rewrite, if possible.)		
Reason for Recommendation		
Submitter:		
Name:	Company or Organization:	
Mailing Address:	Telephone (Include Area Code) Voice: Fax:	

Thank you for your comments; they are greatly appreciated!