# ELEC 6740 Electronics Manufacturing: Chapter 11 Component Placement

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# Outline

- Introduction
- Manual Placement
- Automated Placement of Parts
- Selection  Criteria for Placement Equipment
- Selection of Feeders for Placement Equipment
- Available Placement Equipment

# Introduction

- Automated placement needed for
  - Production volume
  - Finer pitch components
  - Process control

# Manual Placement

1. Care must be taken to avoid mixing parts that look identical but have different values.
2. Undue tension or compression on the components should be avoided.
3. Tweezers or other tools that may damage the part should not be used to pick up components.
4. Parts should be gripped by their bodies, not by their leads or terminations.

# Manual Placement

5. Care should be excersized to keep tweezers free of adhesive or solder paste.
6. Incorrectly placed parts should be discarded or properly cleaned.
7. Programmable devices such as programmable logic devices (PLDs) are handled manually for programming before placement. If this is not done properly, especially when the devices are pried out of the programming socket, lead damage can cause significant lead coplanarity problems. Some PLDs are now available that can be programmed after soldering by the tester.

# Manual Vacuum Pick-up

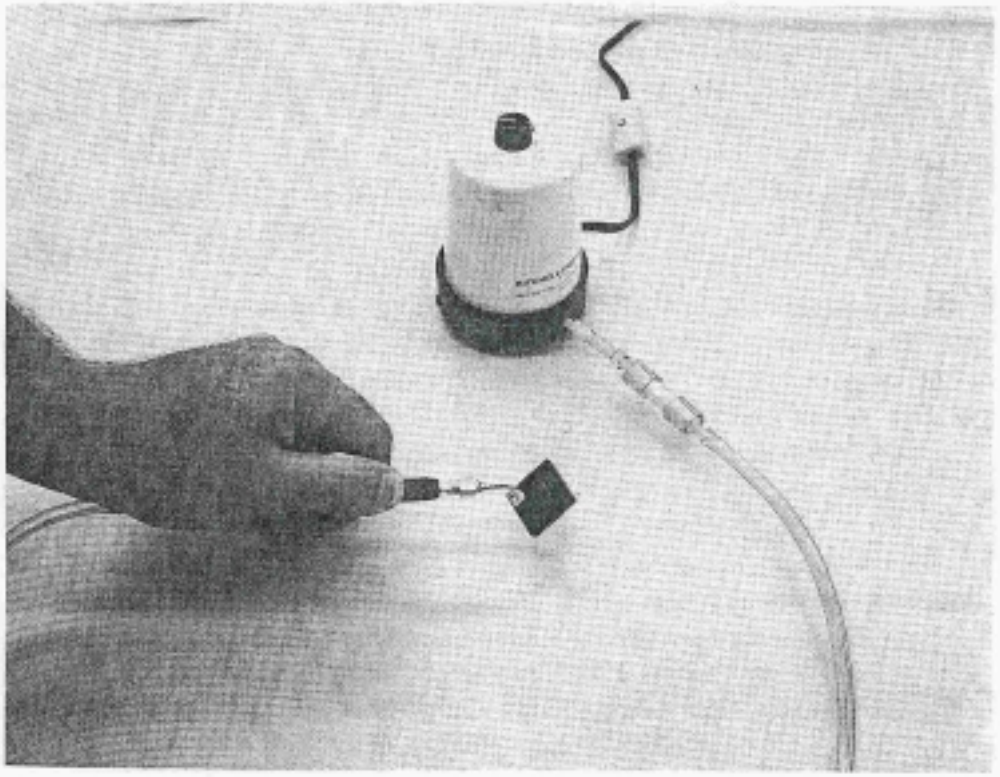

Figure 11.1 A vacuum pipette used for placement of surface mount components.

# Automated Placement of Parts

- Selection Criteria for Placement Equipment

**Table 11.1 Summary of selection criteria for pick-and-place equipment for surface mount components. (Refer to Appendix B1 for details)**

Company _____ Contact name _____
Address/Phone/FAX

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Model number _____ Base price _____
Options prices _____ Feeder prices _____
Maximum board size/placement area _____
Maximum number of 8 mm feeder slots _____
Placement rate per hour: Standard SMT ____ Fine pitch ____
Chip components _____
Placement accuracy: X-Y _____ Θ (Rotation) _____
Programming: On line _____ Off line _____ Teach mode _____
Acceptable type of feeder input: 8 mm tape _____ 12 mm tape _____
over 12 mm tape _____
7 inch reels ____ 13 inch reels ____
Tube/stick ____ Bulk ____
Maximum JEDEC standard waffle pack _____
Need waffle pack handler? _____
Adhesive application: Yes __ No __
Adhesive dot dispensing per hour _____
Smallest chip components (0402/0603/0805/1206) _____
Largest component size _____
Acceptable component types:
MELF ____ SOT ____ PLCC ____ SOJ ____ SOIC ____ BGA ____
Others _____
Fine pitch: 25 mils ____ 0.5 mm (20 mils) ____
Ultra fine pitch: 0.4 mm ____ Below 0.4 mm ____
Special features: component on-line testing _____
Component missing verifier _____
Statistical process control _____
Management information system (components left/mispicks) ____
Software for feeder placement optimization _____
CAD down load features (acceptable data format): Gerber __ ASCII __
Pin 1 orientation ____
Unique features

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Service/support/references:

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| SELECTION | CRITERION | MAX. POINTS | Machine 1 | Machine 2 | Machine 3 | Machine 4 | Machin |
|---|---|---|---|---|---|---|---|
| RISK ASSESSMENT | PARTS AVAILABILITY | 5 | 5 | 5 | 4 | 5 | 5 |
| | SERVICE/SUPPORT | 10 | 9 | 8 | 4 | 10 | 10 |
| | UPGRADE (Trade Up Machine) | 5 | 3 | 5 | 5 | 2 | 4 |
| | FEEDER (Forward Compatibility) | 10 | 8 | 10 | 8 | 10 | 8 |
| | REFERENCES | 5 | 4 | 5 | 0 | 4 | 5 |
| THROUGH-PUT | ACCURACY/ REPEATABILITY | 5 | 3 | 5 | 5 | 2 | 5 |
| | PLACEMENT RATE | 5 | 5 | 5 | 3 | 4 | 4 |
| | FEEDER CAPACITY | 10 | 7 | 9 | 10 | 9 | 8 |
| | SETUP TIME | 5 | 4 | 5 | 4 | 4 | 4 |
| | BOARD SIZE (max.) | 5 | 4 | 4 | 5 | 3 | 4 |
| SOFTWARE | EASE OF PROGRAMMING | 10 | 6 | 8 | 9 | 7 | 10 |
| | OFF LINE PROGRAMMING | 5 | 5 | 5 | 5 | 5 | 5 |
| | CPU IN THE SYSTEM | 5 | 3 | 5 | 5 | 5 | 4 |
| COST | PRICE | 10 | 6 | 5 | 8 | 6 | 10 |
| | WARRANTY | 5 | 3 | 4 | 5 | 4 | 4 |
| | **TOTAL** | 100 | 75 | 88 | 80 | 80 | 90 |

**Figure 11.2 Example of use of weighted points assigned to major selection criteria for of pick-and-place equipment.**

# Selection Issues

- Maximum Substrate Size Handling Capacity

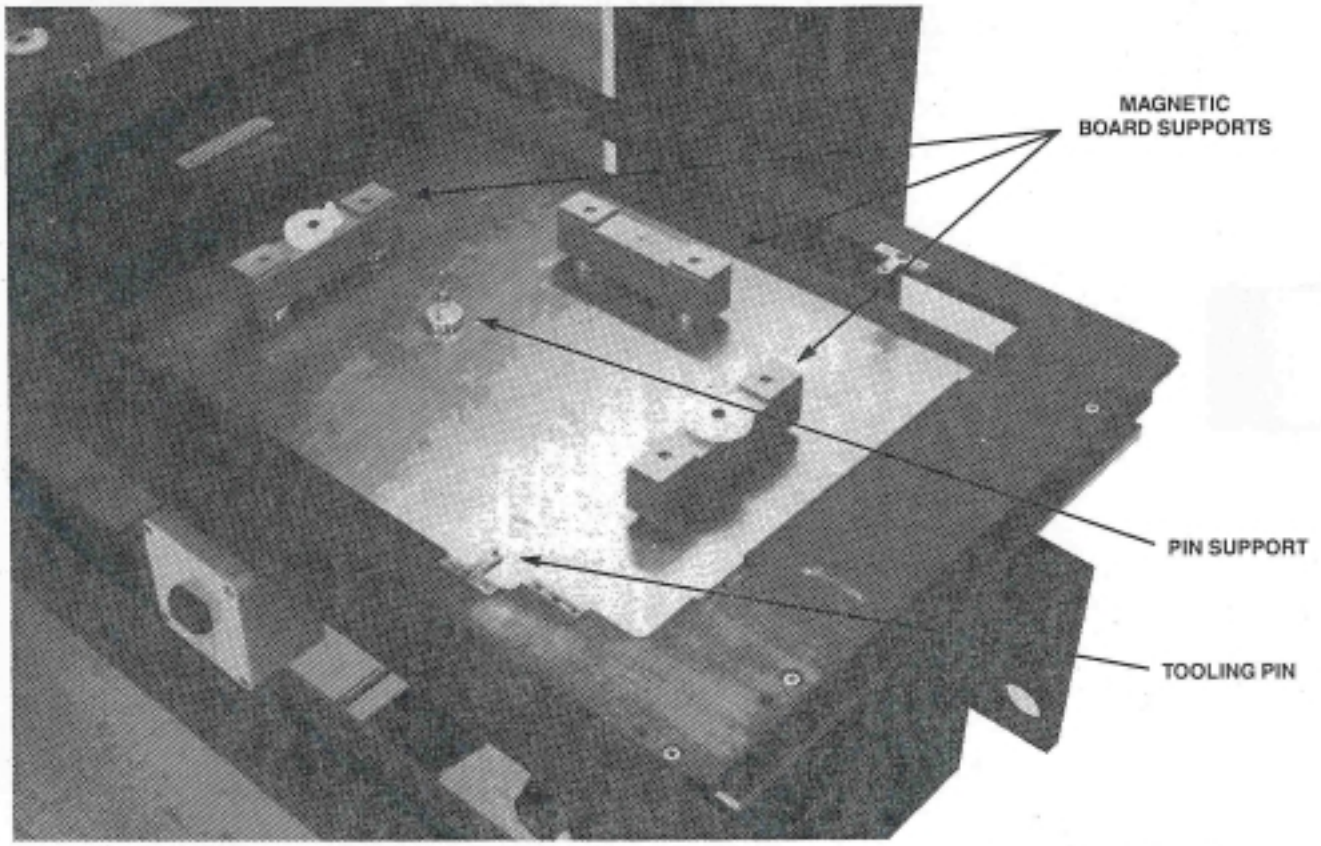



Figure 11.3 A printed circuit board holder with movable supports to accommodate different sizes of boards. (Photo courtesy of Intel Corporation.)

# Selection Issues

- Maximum Feeder Input or Slot Capacity
  - Change-over for product mix
  - Complex products
- Types and Sizes of Components
- Placement Rate and Flexibility
  - Feeder types
  - Feeder locations
  - Component testing
  - Board size
  - Change-over

# Selection Issues

- Placement Accuracy/Repeatability
  - Accuracy = the greatest tolerable deviation of the component lead from the center of its corresponding land after placement
  - Repeatability = the consistent ability of the placement head to place a part at the specified target within a limit.
  - Typically 25% shift is the maximum allowable
    - 50 mil pitch, 25 mil pad, 6mil shift
  - X, Y, $\Theta$
  - Typically specified at $3\sigma$

# Vision - Board

- Fiducials – board location
  - Board finish

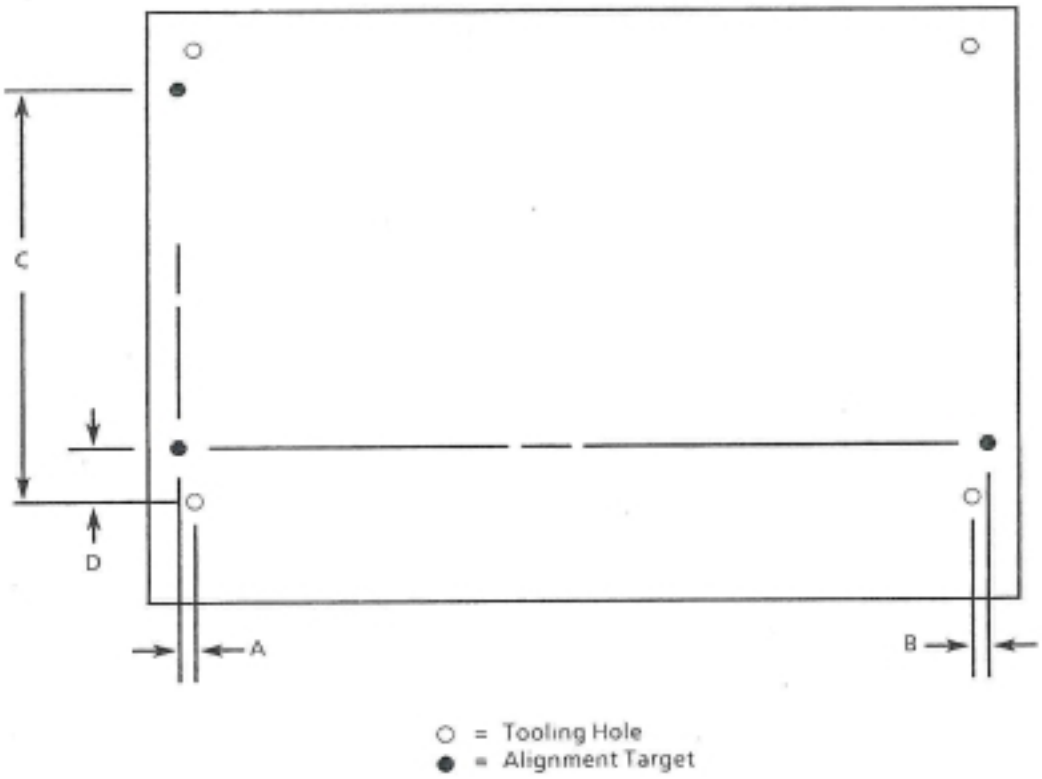



**Figure 11.4 Alignment target for the vision system in a pick-and-place machine.**

# Vision - Component

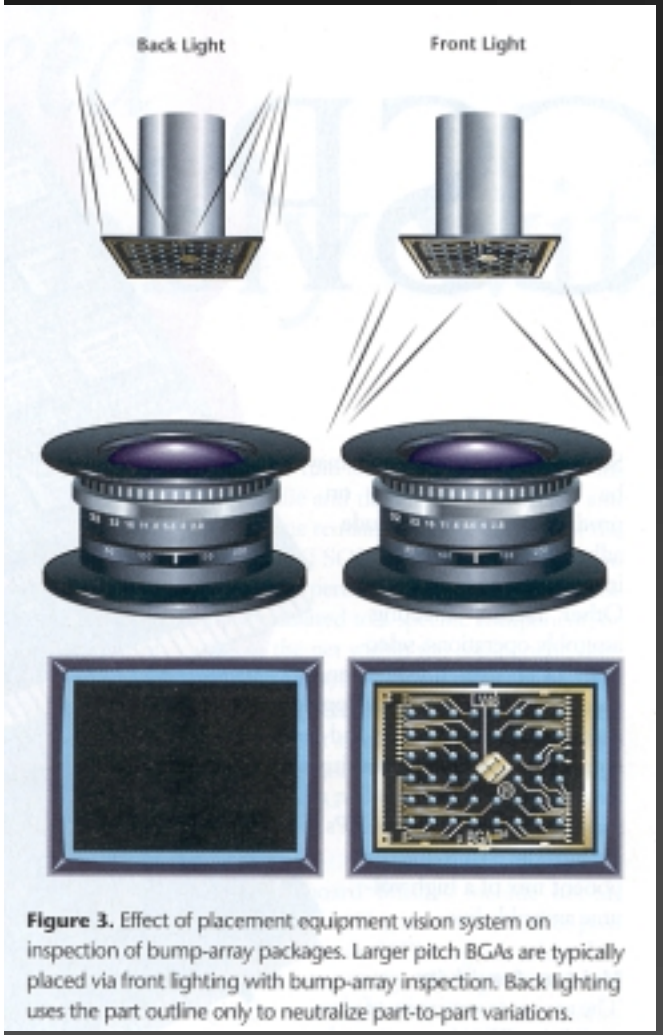



**Figure 3.** Effect of placement equipment vision system on inspection of bump-array packages. Larger pitch BGAs are typically placed via front lighting with bump-array inspection. Back lighting uses the part outline only to neutralize part-to-part variations.

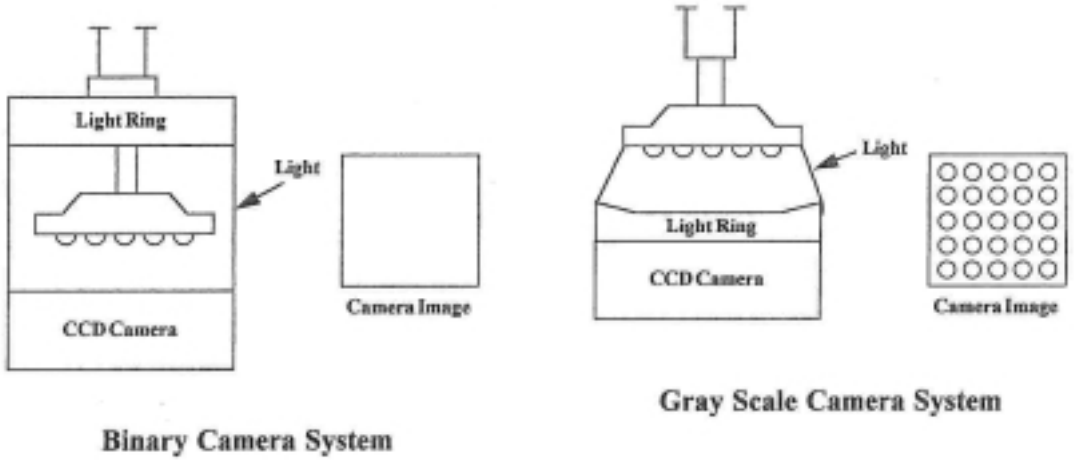



**Figure 11.5 Comparison of binary and gray scale vision imaging systems for BGA placement [3].**

# Lighting

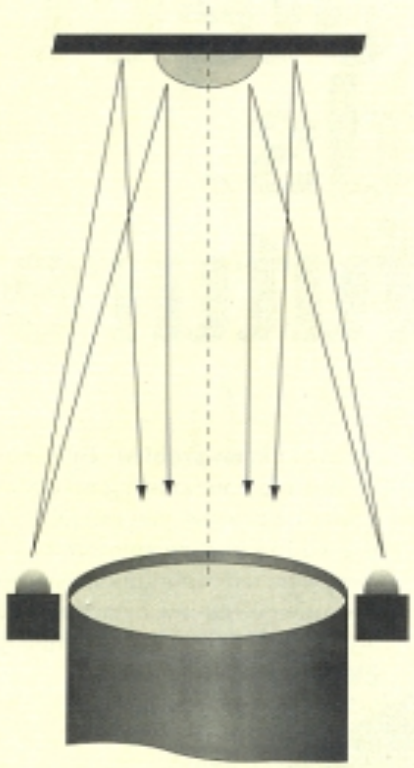


**Figure 1.** An on-axis illumination system used by some placement systems. For CSPs, a problem occurs when the system cannot recognize the component details it relies upon for accuracy.

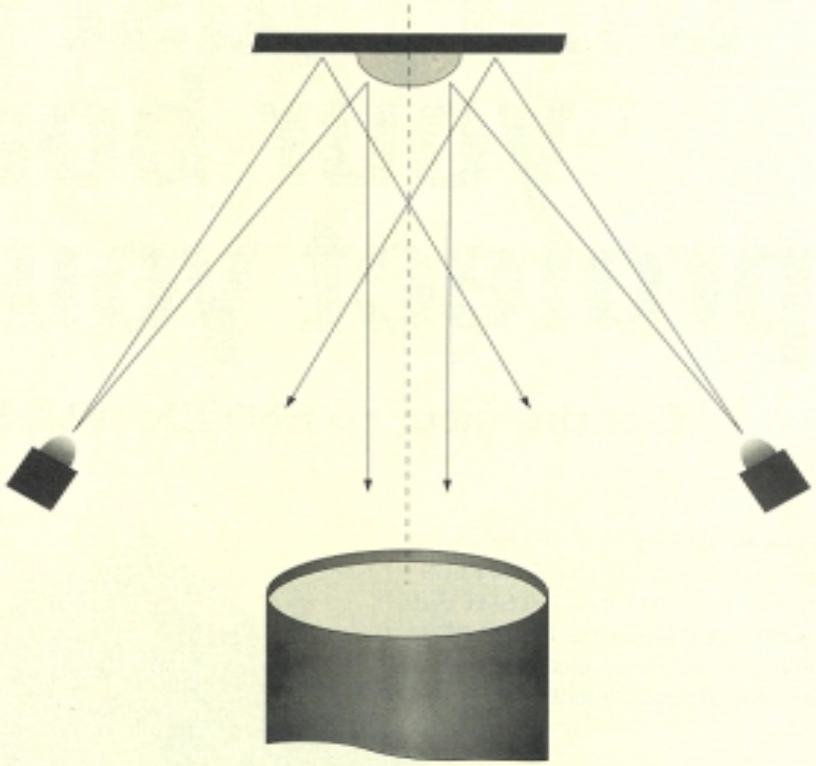
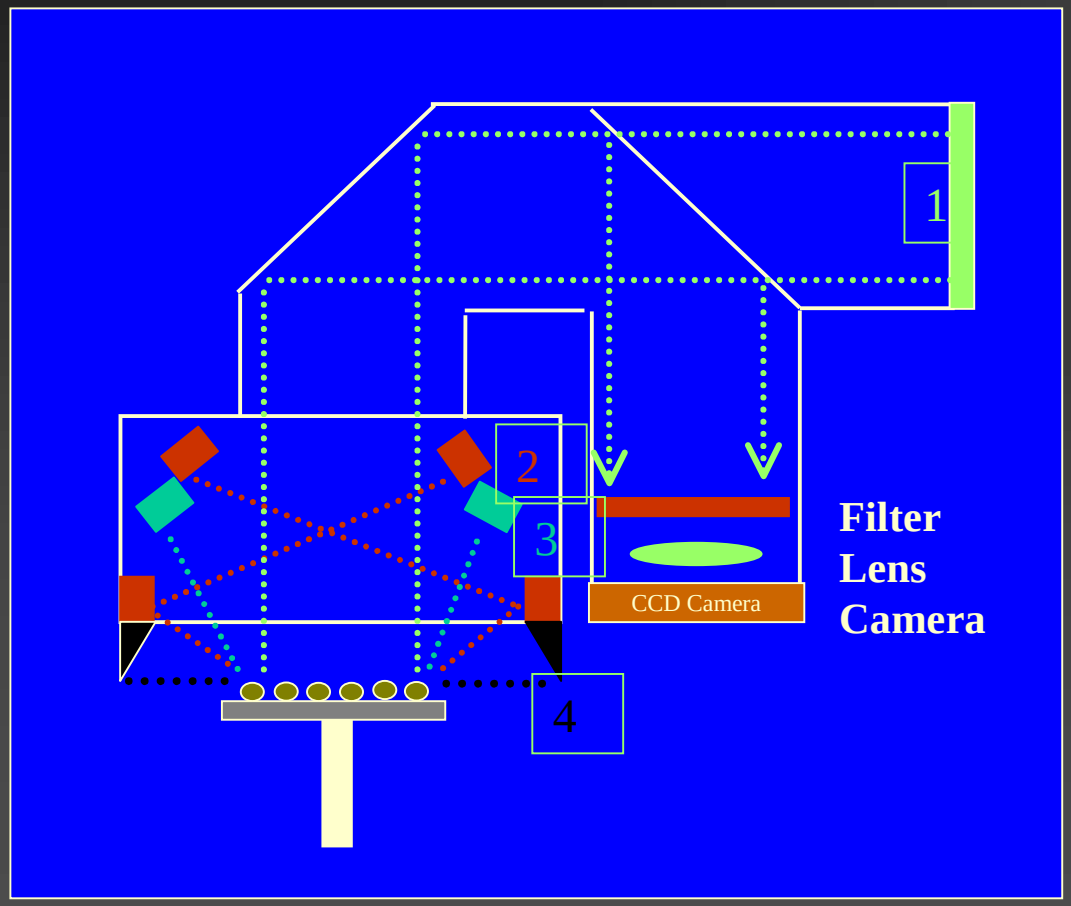


**Figure 2.** Off-axis, or "low-angle," illumination. Light rays reflecting off the CSP's solder bumps enter directly into the lens while those hitting the background go off at an angle, thus presenting good contrast for machine placement.

# Pick & Place Lighting Systems




- **High Resolution Vision Systems**

**Four separate light sources:**

1) Vertical light source
2) Plane (ring lights)
3) Middle (quadratic)
4) Super plane (ring light)

# Adhesive Dispense Capability

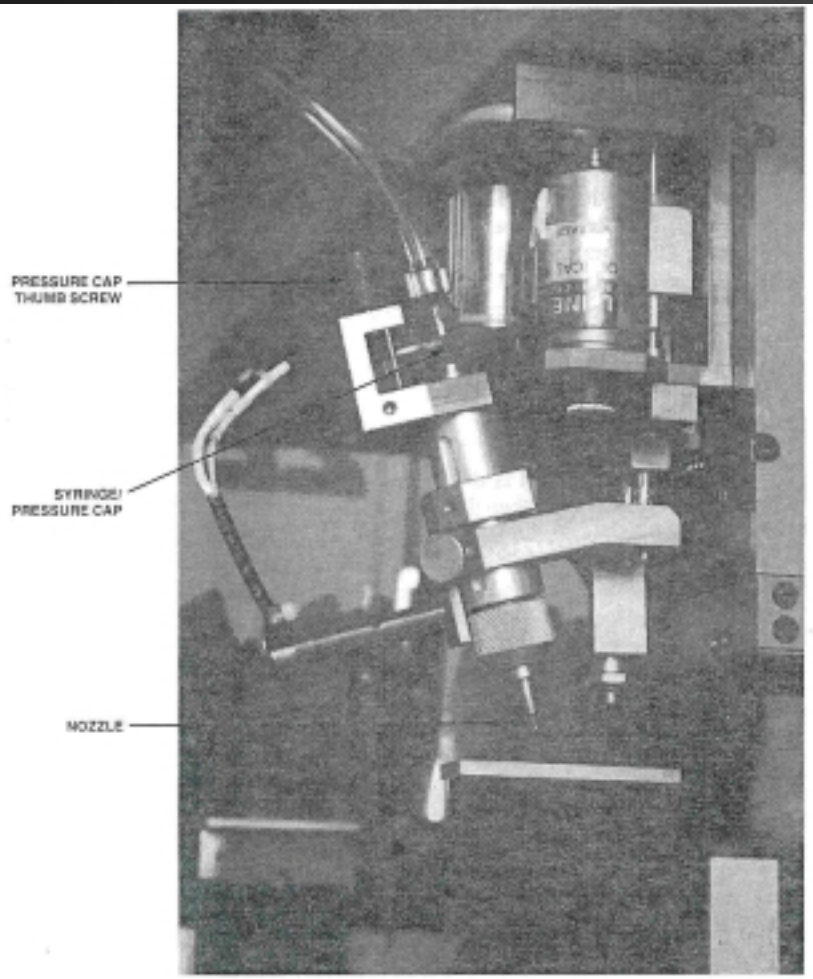



Figure 11.6 Adhesive dispenser as an integral part of a pick-and-place system. (Photograph courtesy of Intel Corporation.)

# Software Program

1. Board size and thickness
2. Global and local fiducial type and size
3. Whether the board is one up or is a panel
4. If a panel, whether the machine should identify and not build boards with rejct marks
5. X, Y coordinated of component locations on the board (Centroid)

# Software Program

6. Component names, sizes, and thickness at pick locations
7. Component orientations at pick locations
8. Location and type of feeder (tape and reel, tube, waffle pack, matrix tray, bulk, etc.) holding a given component

# Board Coordinates

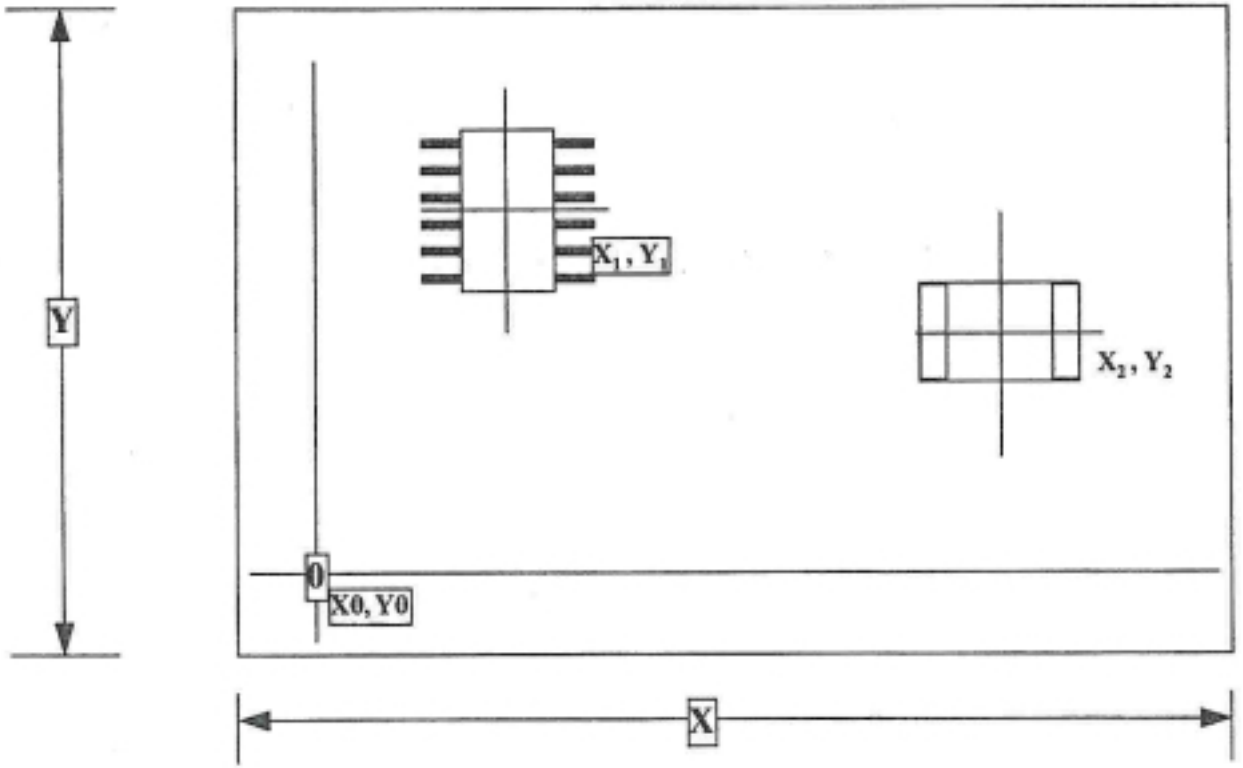



**Figure 11.7** Examples of dimensions and coordinates that need to be programmed in a pick-and-place machine.

# Programming

- Parts libraries
- Feeder libraries
- Layout (GERBER) files
  - Conversion programs

# Selection Issues

- Service, Support, Training

# Other Issues

1. The pickup mechanism can have a vacuum nozzle or mechanical jaws or both. Most machines pick up parts with a vacuum nozzle but use jaws to center components before placement
2. Movement of placement head, X,Y table (board) or both
    1. Acceleration and deceleration of table
        - Parts movement during board movement
        - Adhesive or solder paste tackiness

# Other Issues

3. Pick up head should be able to sense that a part has been picked up
4. Software should allow CAD data download, but should also allow manual editing
5. Machine should provide placement statistics
   - Number of bad picks
   - Total components placed

# Other Issues

6. The placement head should have programmable Z-axis travel and placement force
7. Component testing
   - Typically for passives and diodes
8. Flexible machines should accept a wide range of feeders

# Other Issues

9. The advance mechanism for the reels should be adjustable in 4mm increments because in a given feeder width, the feeder pitches vary in 4mm increments
   - Allows use of same feeder for multiple tape with pitches
10. Online programming capability for PLDs
11. Placement machines with intelligent feeders do not require programming of feeder locations on the machine

# Feeders

- Depends on component size, type

# Tape and Reel

- Resistors
- Capacitors
- MELFS
- SOTs
- SOICs
- PLCCs
- SOJs
- BGAs

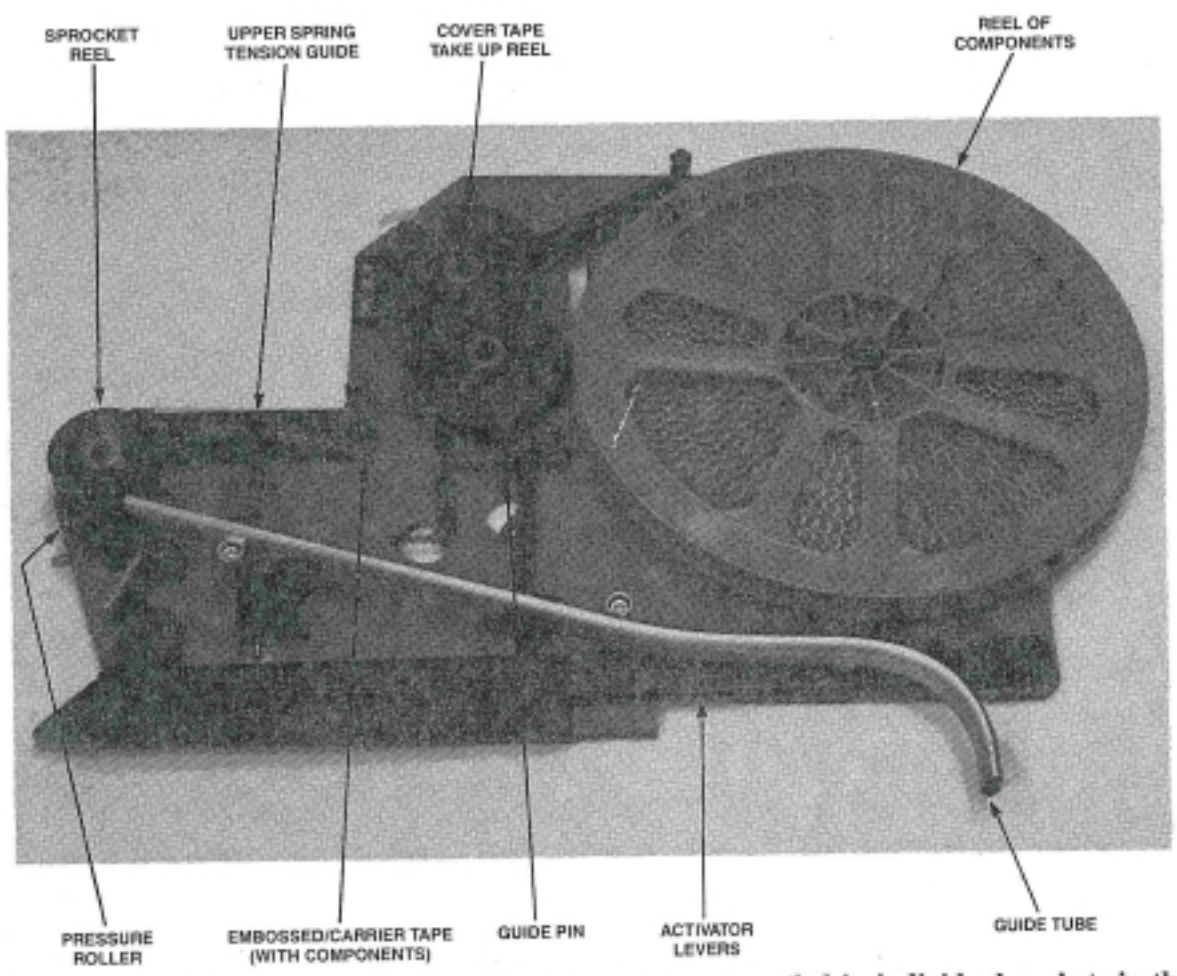



**Figure 11.8** Tape and reel feeder: the components are nestled in individual pockets in the tape and are covered with plastic. (Photograph courtesy of Intel Corporation.)

# Tape and Reel

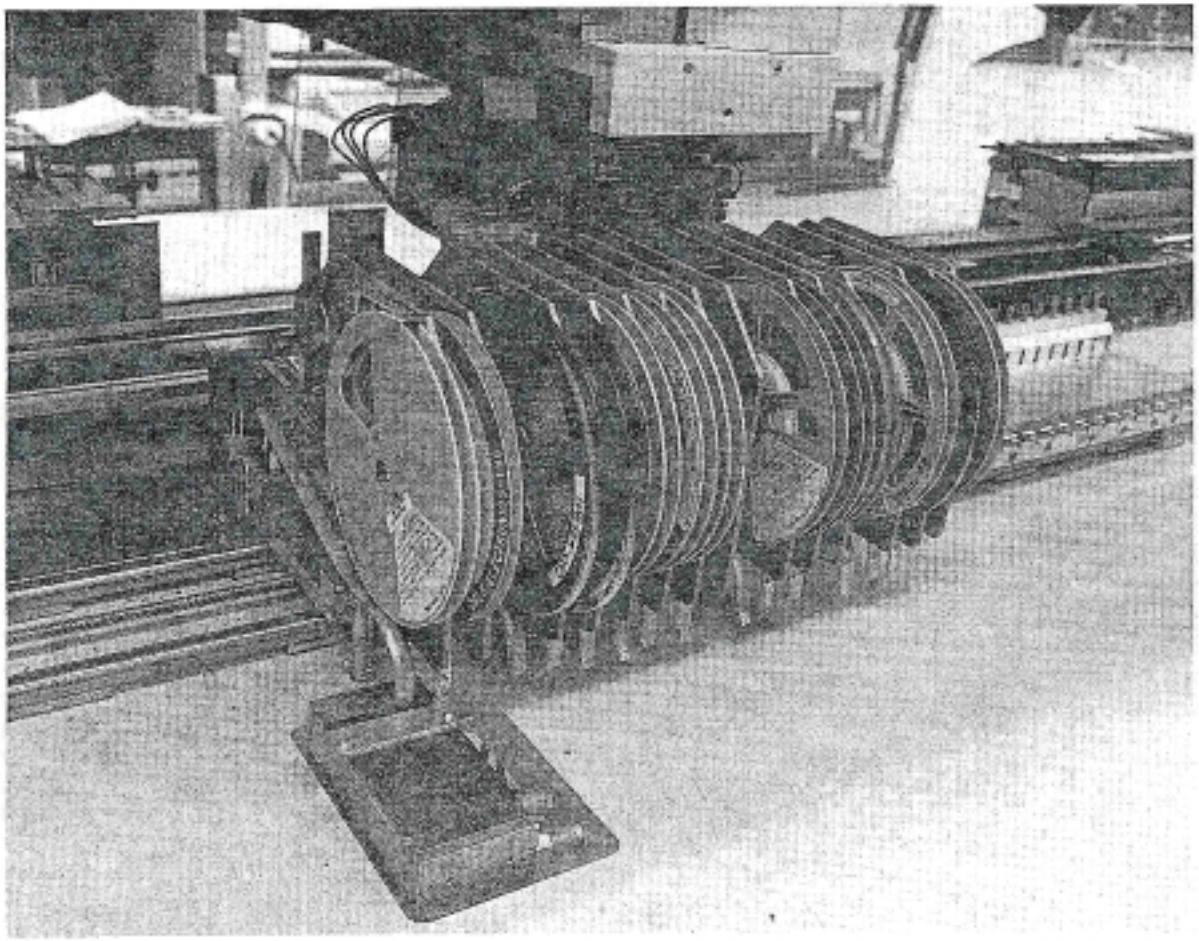


Figure 11.9 A row of tape feeders mounted on a pick-and-place machine. (Photograph courtesy of Intel Corporation.)

# Part Counts

**Table 11.2 Parts count in various sizes of reels for tape and reel feeders. (If active components become available on 7 or 10 inch reels, the number of components per reel may also be standardized)**

| TYPES OF PACKAGES | TOTAL COMPONENTS PER REEL | | |
|---|---|---|---|
| | 7 INCH[a] | 10 INCH[a] | 13 INCH |
| SOIC 8, 14, 16L | 1057 | 2323 | 4158 |
| SOIC 20, 24, 28L | 341 | 851 | 1468 |
| PLCC 18, 20L | | | |
| SOJ 20L | | | |
| PLCC 28 | 168 | 422 | 769 |
| PLCC 44, 52 | 112 | 281 | 513 |
| PLCC 68 | 52 | 140 | 259 |
| PLCC 84 | 46 | 124 | 230 |

# Tape and Reel

- Standards
  - EIA-RS-481

# Matrix Trays

- FP-QFPS
- BGAs
- CSPs

- Smaller quantities
- Dry baking
- Part protection

# Bulk Feed

- Low cost
- Resistors
- Capacitors

# Tube or Stick Feeders

- Smaller number of parts
- Good for low volume production

# Tube or Stick Feeders

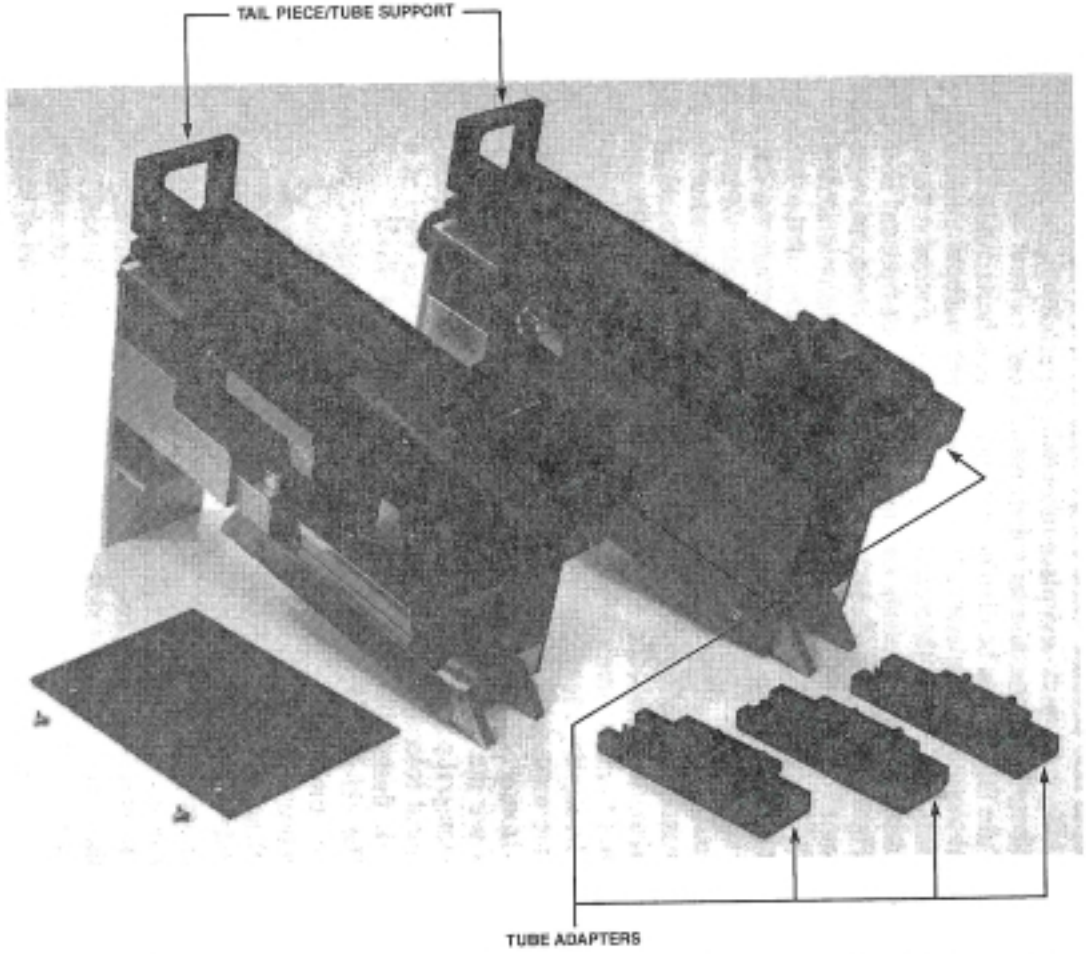



Figure 11.10 A short vibrating tube feeder. (Photograph courtesy of Intel Corporation.)

# Tube or Stick Feeders

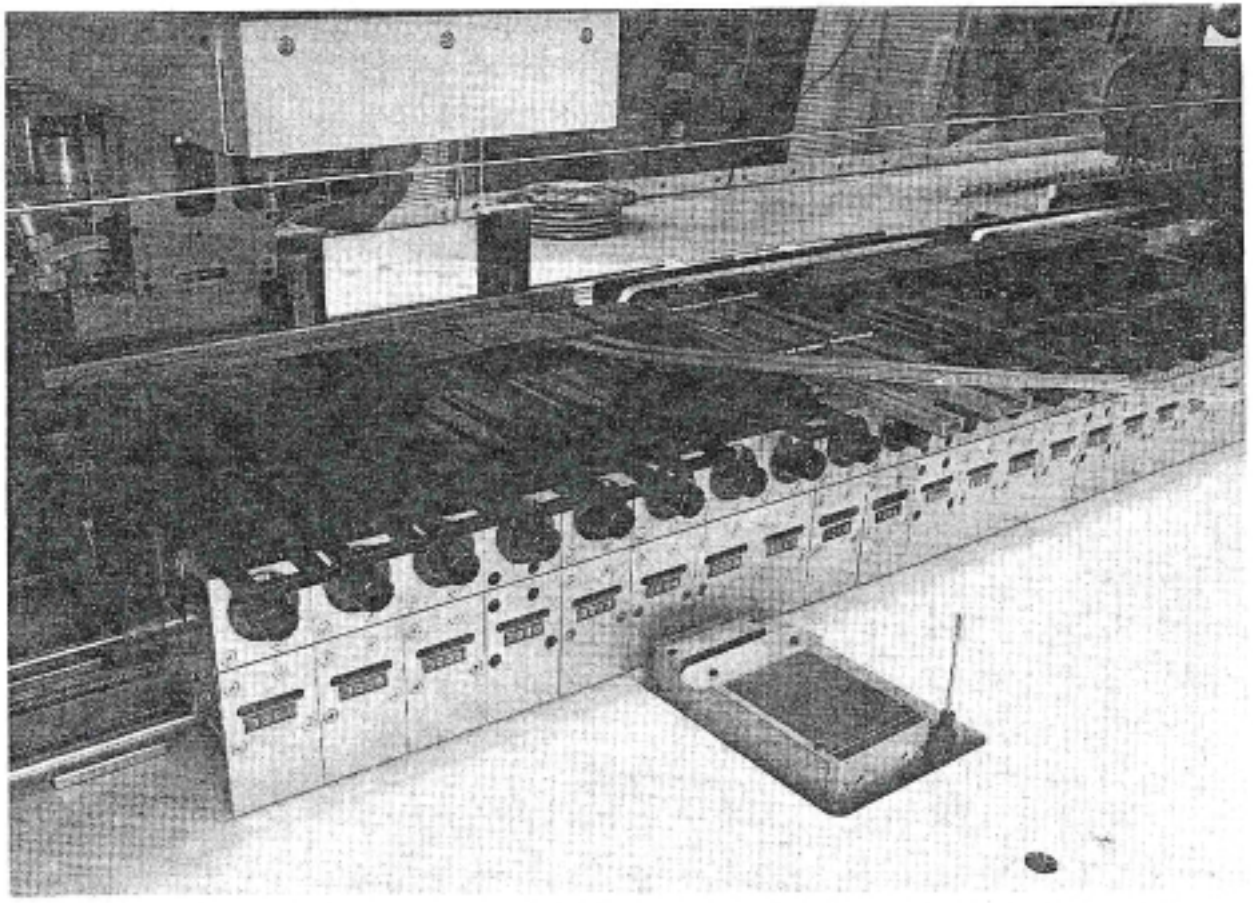


**Figure 11.11** A row of short vibrating type feeders mounted on a pick-and-place machine. (Photograph courtesy of Intel Corporation.)

# High Through Put – Many Feeders

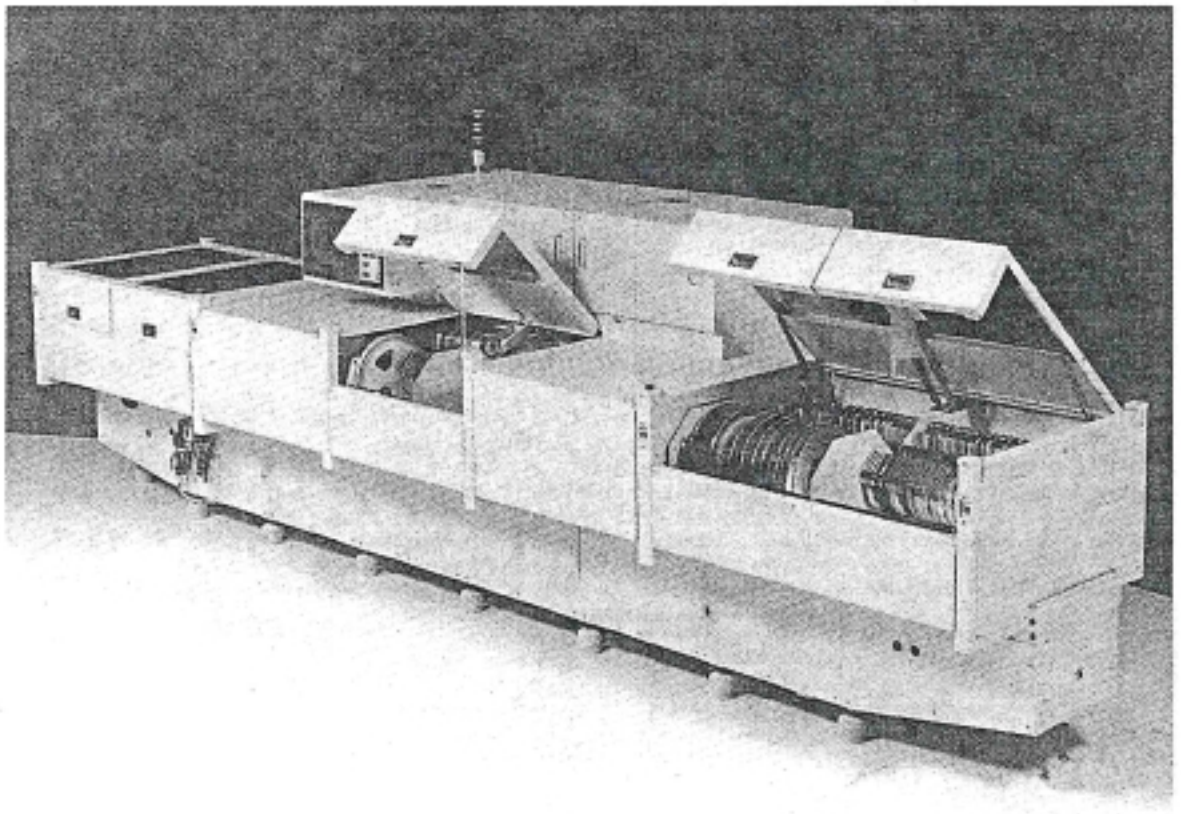


Figure 11.12 An example of a pick-and-place equipment with high throughput (Photograph courtesy of Universal Instruments.)

# High Through Put – Multiple Heads

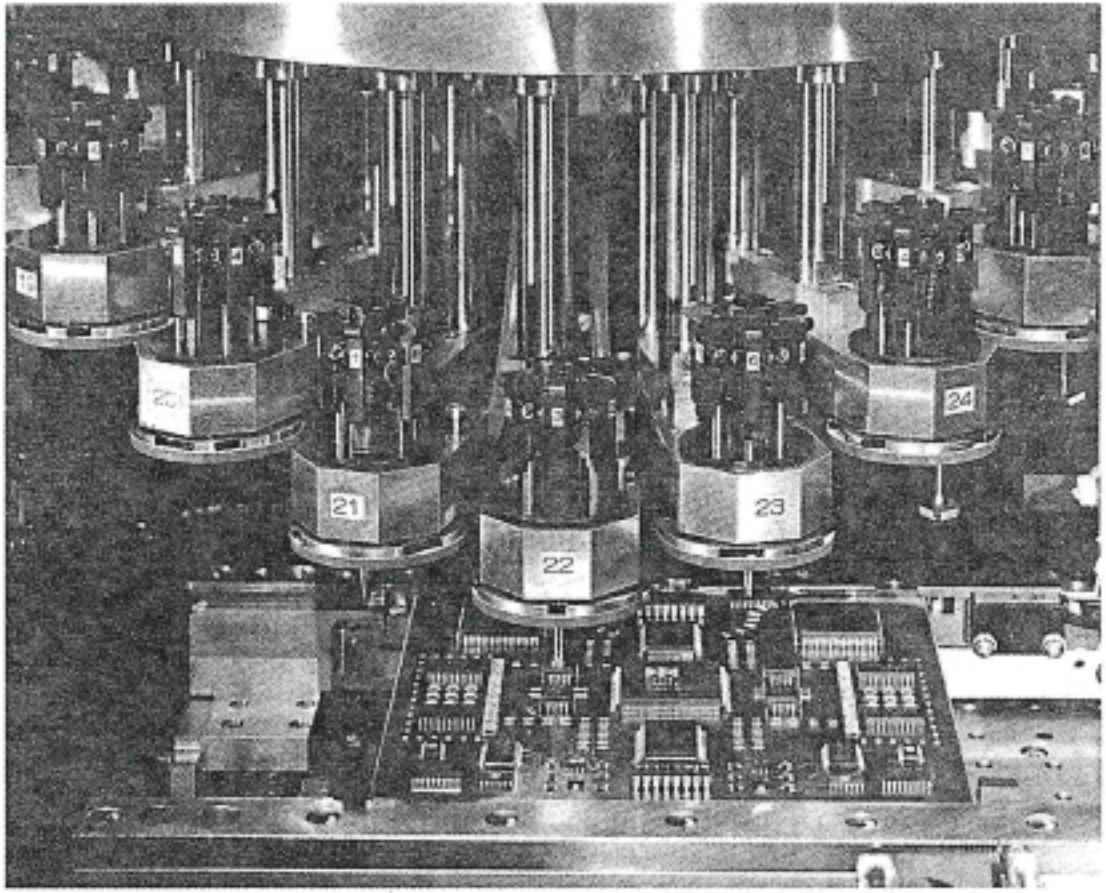



**Figure 11.13** Multiple heads commonly used in a high throughput pick-and-place machine. (Photograph courtesy of Universal Instruments.)

# High Flexibility

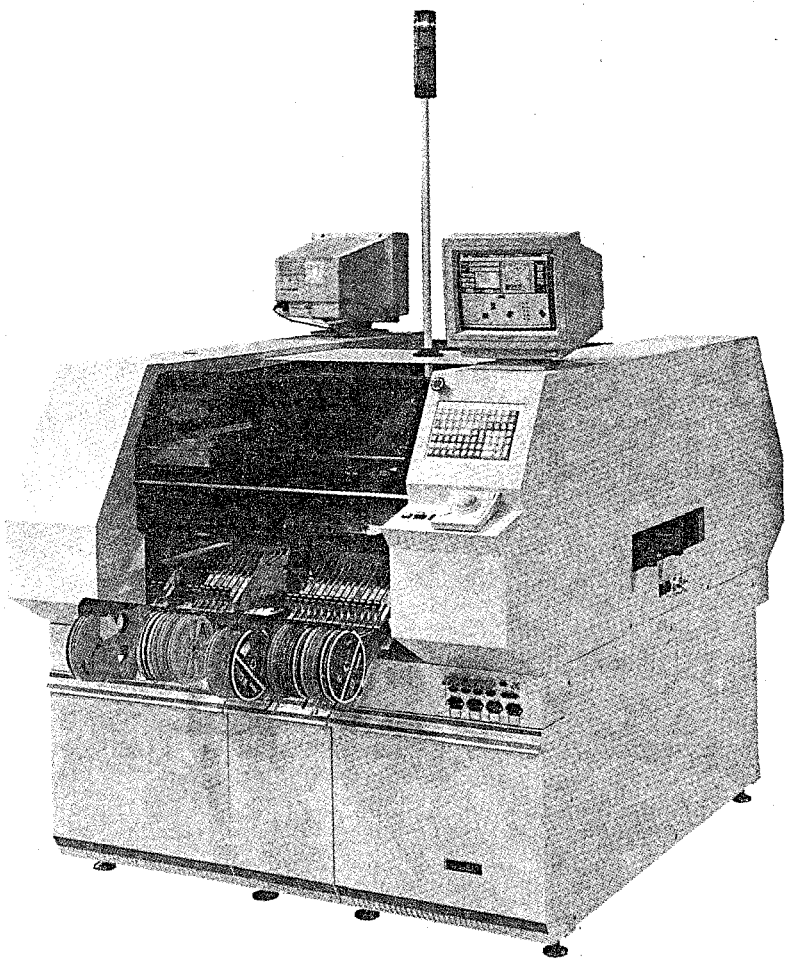


**Figure 11.14** An example of a pick-and-place equipment with high flexibility. (Photograph courtesy of Universal Instruments.)

# High Flexibility BGA Placement

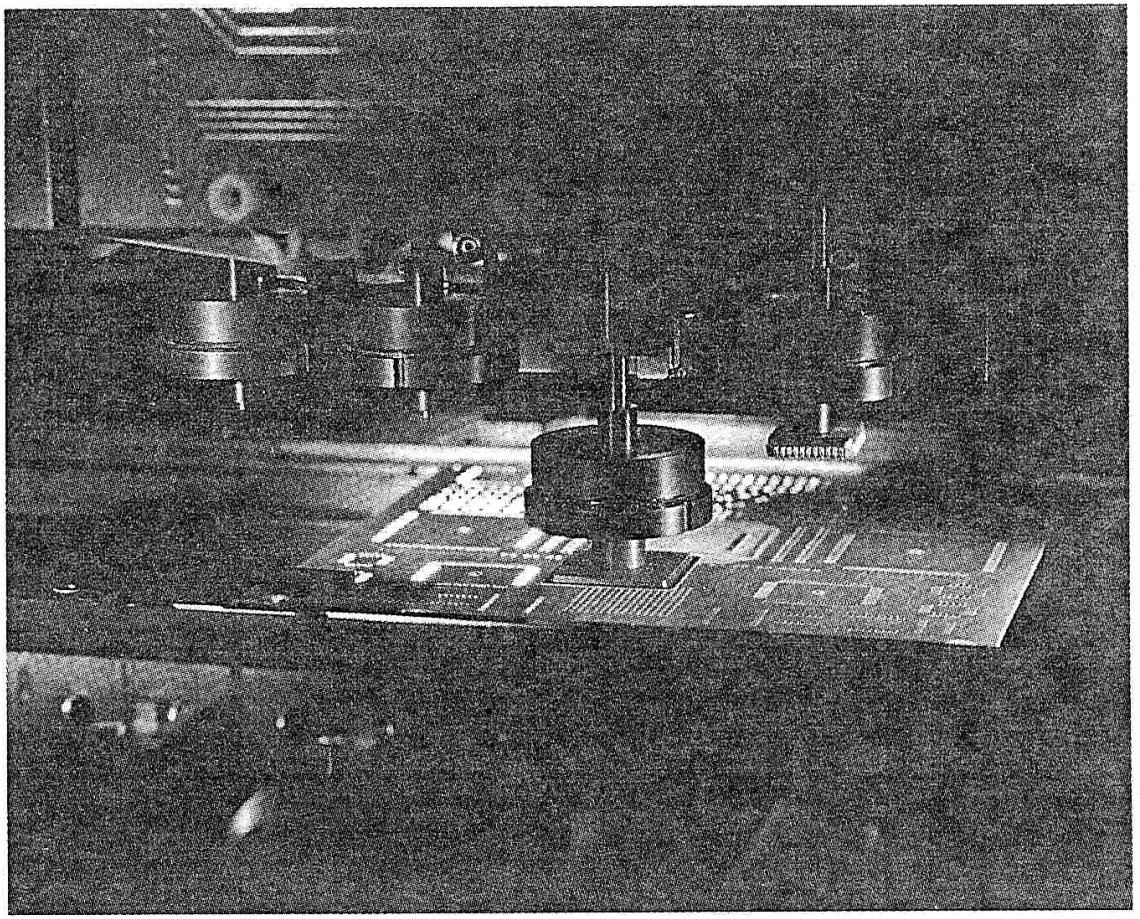


**Figure 11.15** BGA being placed by a very flexible pick-and-place equipment. (Photograph courtesy of Universal Instruments.)

# Tandem Placement

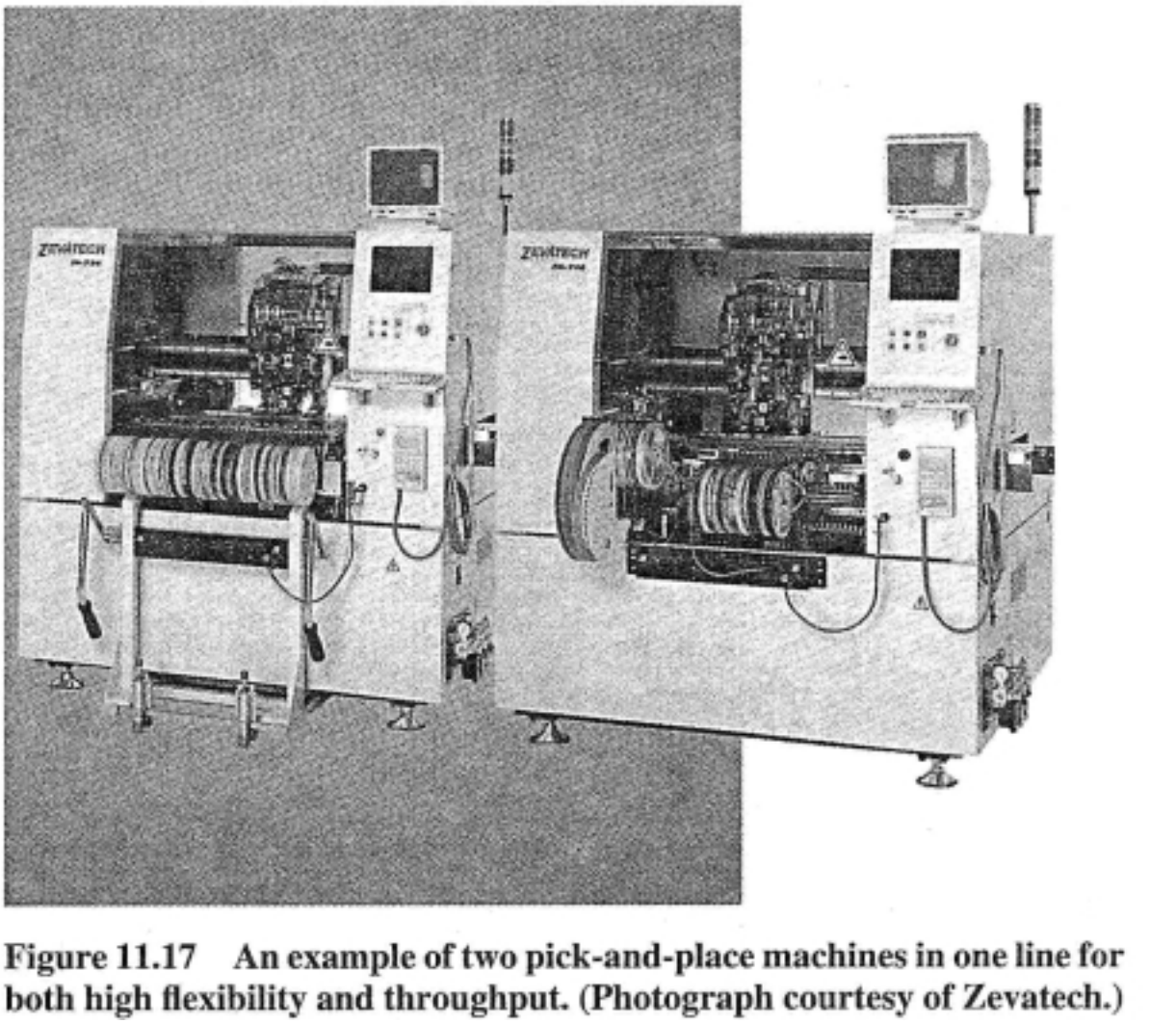


**Figure 11.17** An example of two pick-and-place machines in one line for both high flexibility and throughput. (Photograph courtesy of Zevatech.)

# Low Cost - Flexible

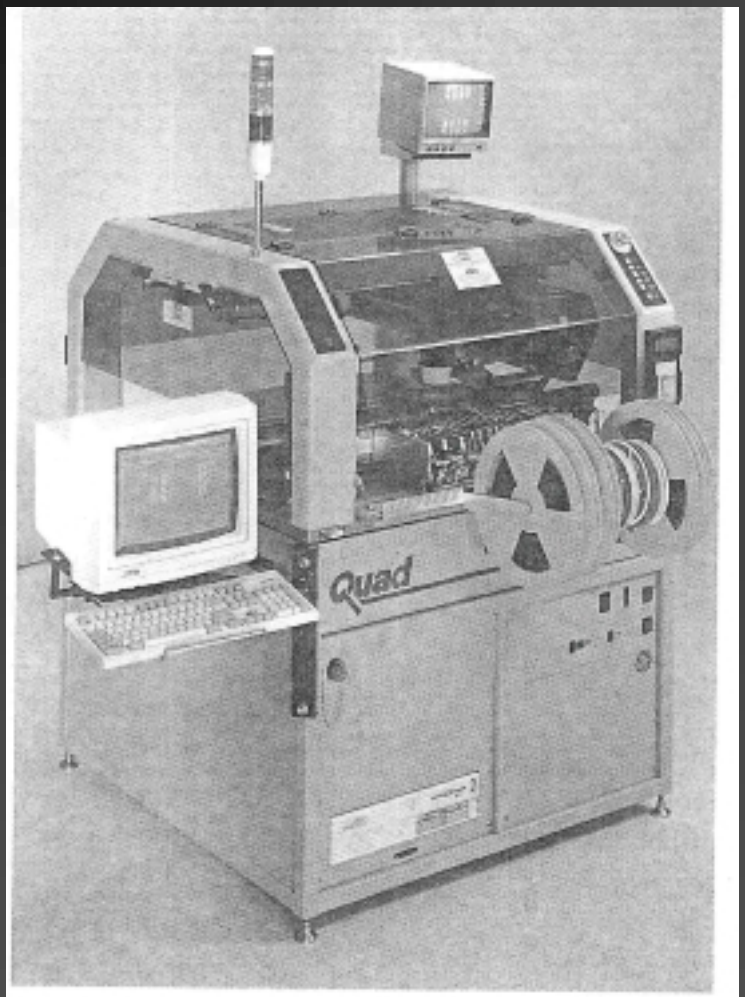



Figure 11.18 An example of a pick-and-place machine with low cost and throughput but high flexibility. (Photograph courtesy of Quad Systems.)