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19. ABSTRACT (Continue on reverse if necessary and identify by block number)

Both leaded and leadless surface-mount components will be automatically placed on Printed Wiring Boards (PWBs). A pattern recognition vision system will identify circuit board positions and feed offset information to the host microprocessor. A pick and place machine will be programmed to interface with the microprocessor and individually mount prepared parts to the board surface.

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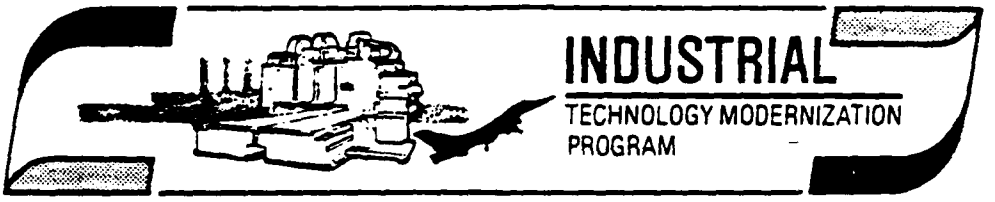
INDUSTRIAL TECHNOLOGY MODERNIZATION

Phase II Final Report
Project 1
Pick & Place Assembly Machine



Prepared for
GENERAL DYNAMICS
Fort Worth, Texas

Contract No. F33657-82-C-2034

Delco Systems Operations

DELCO ELECTRONICS CORPORATION
Goleta, California 93117

FINAL REPORT

CATAGORY I PROJECT I

PICK AND PLACE ASSEMBLY MACHINE

REPORT BASIS:

This final report is prepared following the guide lines for a catagory I type project. This project was entirely researched, designed, developed and fabricated with Delco Electronic's Div. of General Motors funding.

Being a catagory I type project without support funding from the ITM Program, the following final report is condensed as opposed to a typical catagory II type project.

OBJECTIVE:

Objective was to provide an assembly method for low volume Avionic's products utilizing a mix of leaded flatpacks, leaded quadpacks and leadless chip carrier devices. The machine was intended to be flexible, automated to require a minimum of operator intervention and provide the placement accuracies required by military electronic circuit board assemblies.

TECHNICAL APPROACH FOLLOWED:

To meet the objectives of:

1. Achieving component placement accuracies within $\pm$ .0035".
2. Parts handling flexibility.
3. Hands on labor reduction thru automation.
4. Assemble circuit boards in batch lots as small as ten units.

The following approach was employed:

1. Placement accuracy of $\pm$ .0035" is required to insure the part leads are within the solder pad geometry on the circuit boards. The variables to be considered include the part forming dimensions, basic tolerances of parts procured to Mil-Std 38510, "SWIM" and manufacturing variability within the circuit board, basic circuit board registration and the placement accuracy of the machine.

   Automatic compensation for the possible variables dictated:

   a. Vision system to inspect each part and identify true position of each lead in the foot area which must ultimately fall within the solder pad geometry.

   b. Provide a method of maintaining accountability for parts which are rejected by the vision system for part lot traceability.

c. Vision system camera to determine the board registration on the machine and also identify the "SWIM" variations within the board and compensate the placement location data accordingly for each part.

d. Robotic arm which could be driven by the vision data and place the components within the tolerance.

2. Parts handling flexibility was required to accommodate any mix of the following part types, with as many as fifty (50) different part numbers on any circuit board.

a. Flatpacks range from 10 to 28 leads in a variety of case sizes.

b. Quadpacks range from 64 to 132 leads in a variety of case sizes.

c. Ceramic leadless chip carriers range from 20 to 156 pins and case sizes from .25 to 1.00 square with rectangular shapes within the range.

Presenting each of the part types to the robot/vision camera's required the following feeders:

a. Sixty positions for flatpacks with 10 to 28 leads.

b. Twenty positions for flatpacks or quadpacks with 42 to 132 leads.

c. Sixty positions for leadless chip carriers up to .5" square.

d. Twenty positions for leadless chip carrier from .5 to 1 1/4" square.

3. "Hands on" labor reduction:

a. Machine to be automated for minimum operator intervention.

b. Operator presents the board to be assembled, enters the board part number and assembly is automatic.

c. Operator removes the assembled board. If another board of the same part number is required the part number does not have to be re-entered - only the board is presented and start command initiated.

4. Assemble small batch lots (ten) of boards:

a. Machine was to be flexible to assemble up to 300 different circuit board part numbers.

b. Board program data to be down loaded from a host and programs for each board to reside in a hard disk on the cell.

c. Operator changeover from one board part number to another to be limited to loading the parts.

d. All operation including maintenance trouble shooting to be menu driven.

EXPLANATION OF TECHNICAL APPROACH TASKS:

1. Existing methods (prior to this machine design) were manual assembly of each part on the circuit board.

2. Industry/vendor survey determined, that no available equipment would meet the objectives of this machine at the time.

   - Machines to place leadless chip carriers were available but could not provide the assembly mix of flatpacks, quadpacks and leadless chip carriers required.

   - No capability could be found for flatpack assembly.

   - No capability could be found for a 132 pin quadpack on .025 centers. In addition, in-house prototype assembly of this type of part was found to be far to labor intensive to be done manually.

   - Isolated capability for one part type could be found but no commercial vendor was receptive to develope all the capability into one machine.

   - During the vendor survey we were able to find a source capable of developing and integrating the various technologies. We ultimately used this source for development, design & fabrication of the machine.

3. Proposed technical approach:
   Detailed "statement of work" was written and presented to (see attached):

   Automation Tooling Systems, Inc.
   80 Alpine Rd.
   Kitchener, Ontario,
   Canada N2E 1A1

The highlights of the approach included:

a. Cycle times of 5 seconds per part.

b. Placement accuracy of $\pm$ .0035".

c. Pattern recognition of the parts and boards described above.

d. Totally automatic operator menu driven system.

e. Program generation off line from a CAD with down load to the cell.

f. Self diagnostics, menu driven calibration, and trouble-shooting.

g. Parts presented in Delco designed carriers and magazines.

h. Part inspection for bent leads and polarity.

i. Fifteen minute changeover for different part number assemblies.

4. Preliminary cost benefit analysis:

a. Quotation for development, design, and fabrication was provided by ATS.

b. "Hands on Labor Savings" of hand assembly verses assembly using the above approach was estimated to average .53 hours per circuit board assembly (dependant on the number of parts).

c. R.O.I. was generated on a five year volume forecast and the estimated savings per board using the quoted cost by ATS. R.O.I. was found to be within the General Motors guideline for the investment.

5. Equipment alternatives:

Due to negative results of the vendor surveys, only minor change to the proposed approach were considered. The basic design approach remained as proposed.

6. Preliminary designs/development, machine layout concept and configuration was provided by ATS. The pattern recognition capability was demonstrated to our in-house vision experts in a lab enviroment and was considered to be sound.

7. Final design:

a. Final mechanical design review was held at ATS. prior to starting fabrication.

b. Numerous contacts between ATS personnel and Delco software people were held to work out both machine internal software and CAD data programs.

8. Implementation:

a. Machine was fabricated and demonstrated at the ATS facility in Aug/Sept. of 1985.

b. Machine was delivered & installed in a lab at Delco in Oct/Dec. of 1985.

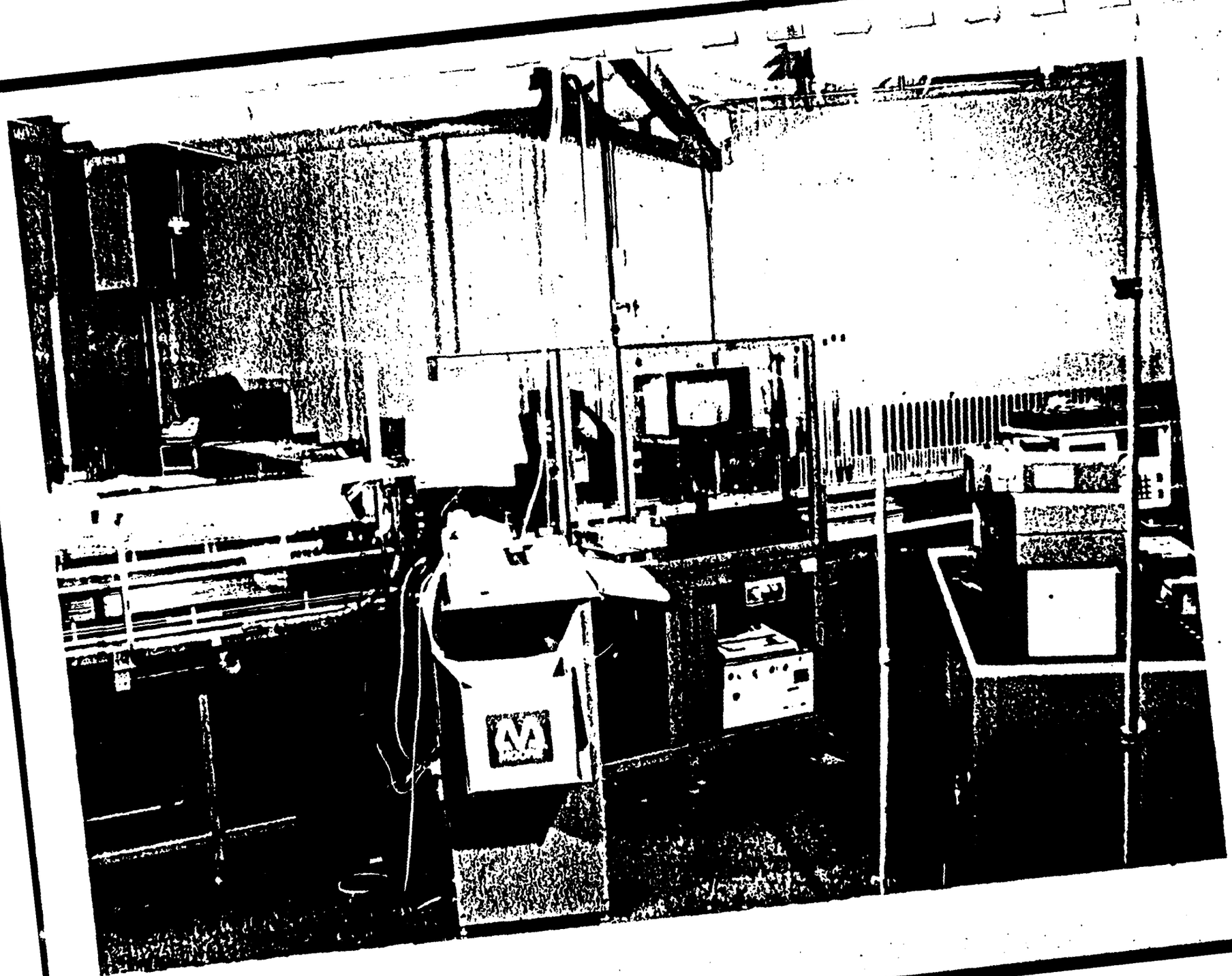
c. Limited production hardware was assembled on the machine from Jan. 86 to the present. During this period numerous minor changes in design and improvements were implemented. Machine is presently waiting completion of the final manufacturing area. Actual move and full implementation in manufacturing will be completed by June of 1987.

d. Resolution of problems:

Delco provided a direct dial-up phone line into the cell computer and into the plant host. This permitted ATS/Delco to work and revise software as each problem occured. Both the vendor and Delco could thereby monitor problems in real time.

e. Technology transfer:

The technology used in this cell is available from Automation Tooling Systems. Further detail in this report is not worthwhile as following this development, ATS has further refined software approaches, improved vision hardware is available and numerous other robotic developments have been defined. Vision guided robotics is a very dynamic technology and direct vendor contact is more advantageous.



Delco Electronics

SUBCONTRACT PROCUREMENT STATEMENT OF WORK
NO. 421-MD 1939

REV
SUPP

FOR AUTOMATION TOOLING SYSTEMS, INC.

RELEASE TO DESIGN & FABRICATE

A PICK N' PLACE ASSEMBLY MACHINE

FOR DELCO ELECTRONICS-MILWAUKEE AVIONICS PRODUCTS

PICK N' PLACE ASSEMBLY STATION

P/N FD-778841

APRIL 24, 1984

WRITTEN BY: H. D. Culver 6/28/84

H. CULVER
MANUFACTURING ENGINEERING
MILWAUKEE, WI

APPROVED BY: H. Kennedy

H. KENNEDY, ASST. SUPERINTENDENT
MANUFACTURING ENGINEERING

REVISION I 05/10/84
PARA. 8.1 REVISED
PARA. 8.1.5.4 REVISED
FIG. 7 ADDED

REVISION II 06/28/84
REVISED TO REFLECT QUOTATION #1246
& VERBAL AGREEMENTS BETWEEN A.T.S
& H. CULVER.

1.0 SCOPE

This Statement of Work and associated attachments establishes the requirements for procurement of a Pick and Place Assembly Station.

2.0 APPLICABLE DOCUMENTS

2.1 General Motors Corporation

2.1.1 GM Basic Electrical Standards for Industrial Equipment, dated April 1980.

2.1.2 GM Sound Level Specification for Machinery & Equipment dated 1 June, 1971.

2.1.3 Fluid Power Standards for Industrial Equipment Section R, dated Sept. 1970.

2.2 Delco Electronics

Delco Electronics Specifications for Industrial Equipment, dated May, 1983.

Exceptions to this document for this work statement are as follows:

Para. 17.1.1 - Shipping instructions to be obtained from Mr. M. Friebert by calling 414-768-2953.

Para. 18.1.1 - The approving authority at Delco Electronics, Milwaukee is the Work Statement originator. All approval prints, final drawings, or reproducibles, requests for deviation and questions concerning this specification shall be addressed to:

Delco Electronics Division
7929 South Howell Avenue
Oak Creek, WI 53154
Attn: Mr. H. D. Culver
Mail Station 1A02
Telephone: 414-768-2346

Para. 20.2.1 - Delete reference to requirements of Indiana Law (IC 1971, 22-8-1.1 et, seq.)

On Page 38 under "PROGRAMMABLE CONTROLLERS' delete Modicon.

2.3 Occupational Safety and Health Act dated 18 October, 1972, Part 1910, 219. Mechanical Power Transmission apparatus to be obtained by the contractor.

3.0 ARTICLES & SERVICES TO BE SUPPLIED BY THE CONTRACTOR

3.1 Equipment

a. Design

b. Fabrication

c. Delivery

3.2 Engineering Data

a. Layout Drawings

b. Final Drawings

c. Specifications

d. Manuals

e. Spare Parts List

3.3 Progress Information

3.4 Training

3.5 Quality Assurance Provisions

3.6 Warranty

4.0 DESCRIPTION OF ARTICLES & SERVICES

4.1 Equipment

4.1.1 Design. The Subcontractor shall execute all new designs and the necessary modification to existing designs to meet the requirements of the Attachments to this Statement of Work. Should the Subcontractor have an engineering standard practice on design which conflicts with this Statement of Work, he may submit this standard, provided he states in detail the variance from this Statement of Work to the Author. If no exceptions are stated, Delco Electronics will require the Subcontractor to fulfill all details of this Statement of Work.

4.1.2 Fabrication. The Subcontractor shall fabricate the Pick and Place Assy. Station per the requirements of this Statement of Work.

4.1.3 Delivery. The Subcontractor shall be responsible for the packaging and safe delivery of the Pick and Place Assy. Station to Delco Electronics.

4.1.4 The Subcontractor shall act in an advisory capacity during the installation of the equipment at Delco Electronics.

4.2 Engineering Data

4.2.1 A drawing outlining the Pick and Place Assy. Station showing approximate dimensions, weight, mounting points and requirements for accessibility, operation and maintenance.

4.2.2 One reproducible electrical and pneumatic schematic and block diagram showing selected components.

4.2.3 Final Drawings. One set of reproducible and one set of non-reproducible drawings of the Pick & Place Assy. Station shall include the following information as a minimum:

a. Parts List - Including generic part number where applicable.

b. Electrical, pneumatic and hydraulic schematics.

c. Cable and wire list.

d. Modifications made to purchased commercial equipment.

e. Assembly drawings and all mechanical detail drawings.

4.2.4 Operation and Maintenance Manuals. The Sub-Contractor shall generate and submit two copies to Delco Electronics of an OPERATION & MAINTENANCE manual which shall be suitable for use by skilled technical level personnel in the repair, maintenance and the operation of the Pick and Place Assy. Station.

The MAINTENANCE manual shall contain sufficient information to permit servicing down to the component level.

4.2.5 Spare Parts List. The Subcontractor shall submit one list of recommended spare parts. Quantities listed shall be sufficient to support one piece of equipment for one year.

4.3 Training - Two day Familiarization Courses for four people will be provided.

4.4 Quality Assurance Provisions

4.4.1 Notification of Readiness for Acceptance. The Subcontractor shall notify Delco Electronics of readiness of the Pick and Place Assembly Station for acceptance. This notification shall be given at least (3) three days before the scheduled acceptance start date. Notice of cancellation or change of an acceptance date shall be given at least one (1) day in advance of any scheduled acceptance date.

4.4.2 Preliminary Acceptance. Preliminary acceptance of the Pick & Place Assy. Station shall be accomplished at the Subcontractors facility. A functional demonstration in compliance with the requirements of this Statement of Work shall be conducted in the presence of authorized Delco Electronics Representatives.

4.4.3 Final Acceptance. Final acceptance of the Pick & Place Assy. Station shall be accomplished at Delco Electronics and shall be based on demonstration of compliance with the requirements of this Statement of Work. A final acceptance shall be conducted in the presence of authorized Delco Electronics Representatives.

4.4.4 Equipment Verification. The Subcontractor shall maintain technical liaison with Delco Electronics to correct deficiencies and/or to effect improvements in the operation and design of the equipment during the warranty period.

5.0 Mailing Instruction. The mailing address for documentation, reports and notices shall be as follows:

Delco Electronics Division
General Motors Corporation
P. O. Box 471
Milwaukee, WI 53201
Attn: J. Lukomski, Purchasing
Dept. 0417, M/S 1A09

cc: H. Culver
Dept. 421, M/S 1A02

6.0 DETAIL REQUIREMENTS FOR A PICK N' PLACE ASSEMBLY STATION:

6.1 INTROCUCTION: A.T.S. will provide a Turnkey System utilizing a Seiko RT2000(3000) Robot, A.T.S. designed parts feeders and Vision System incorporating three cameras (Solid State perferred). Two cameras being employed for component alignment and one camera mounted on the Robot arm to scan the PWB for alignment and Swim. The board will be scanned for actual part location and positioning with the offset deviation presented to the Robot. The Robot will pick up a component, present it to the Vision System, correct part positioning in X, Y & Ø while moving to the placement location.

6.1.2 Develoment of a Pick N' Place Assembly Machine with the following guidelines:

6.1.2.1 Machine is intended to be extremely flexible and capable of populating various size substrates with a variety of surface mounted components.

6.1.2.2 Machine is intended for low volume usage with easy changeover to permit small batch processing of various substrate configurations.

6.1.2.3 Substrates will be populated on both sides, one side at a time, in small batch loads of 10 substrates or less per setup.

6.1.2.4 All parts to be handled are Electro-Static Sensitive and equipment described is to be properly protected.

7.0 GENERAL MACHINE DEFINITION:

7.1 Substrate Flexibility. Machine must be designed to handle three substrate sizes (2.7 x 3.4, 4.5 x 6.5, 6.5 x 9.5) with easy tooling changeover for various configurations of these sizes. Substrates will be populated on both sides, one side at a time. Delco Electronics will provide Substrate Holding Fixtures.

7.2 Parts Handling Flexibility.

a. Machine must be capable of selecting parts in "Flatpack/Quadpack" form from 60 locations with parts housed in 1 1/4" square carrier/magazines and 20 locations with parts housed in 2" square carrier/magazine sticks. Leaded parts will be presented to the machine with parts pretinned, preformed and precut. Each part will be contained in a "Delco Designed" one piece type carrier in consistent polarity orientation. Carriers containing these parts will be presented in stick magazines. (See Fig. 4 for typical carriers and magazines for reference only.) Delco Electronics will provide carriers and magazines.

b. Machine must be capable of selecting parts in leadless chip carrier form from 60 locations with parts up to 1/2" size and 20 locations with parts in 1/2" to 1 1/4" range, all in sticks without carriers. Leadless chip carriers will be presented in sticks with the LCC's pretinned and in consistent polarity orientation. (See Fig. 4 for typical magazine - Reference Only.) Delco Electronics will provide plastic sticks.

c. Machine must be capable of selecting chip capacitors and resistors from two different parts vibratory feeders, which are interchangeable. These feeders are not part of the design, but space must be provided for later installation.

d. In summary, a fully parts stocked machine will select parts from 162 different parts feeders (80 P/N stick magazines with "Flatpacks/Quadpacks" in carriers, 80 P/N stick magazines with leadless chip carriers and two different vibratory chip feeders.)

e. All machine interface with parts magazines, parts carriers, and parts shall be conductive or provide "ESD" protection to the parts thru all processing.

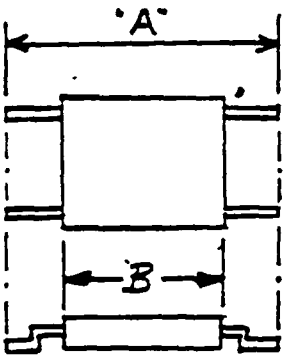
f. Each magazine feeders(Leaded and Leadless) will be provided with the standard A.T.S. designed Low Level Indicator, providing a bank of parts below the magazine/stick which permits changing magazine/sticks while the machine is in operation.

7.3 Parts Description:

a. For alignment and handling considerations, leaded devices in Flatpack or Quadpack configurations to be placed by the machine in this Statement of Work range as follows:

FIGURE 1
FLATPACK CONFIGURATIONS

"B" CASE SIZE (Mil 35810 "E" Length)	"A" TOE-TO-TOE DIMENSIONS
.240/.260--> — — — — — — .400 or	10,14,16, 20 & 24 Pin Devices
.240/.300--> — — — — — — .450 or	
.240/.300--> — — — — — —.500 or	
.245/.420--> — — — — — —.600 or	20,24 & 28 Pin Leaded Device
.245/.420--> — — — — — —.666 or	
.245/.505--> — — — — — —.700 or	
.620/.660--> — — — — — —1.100	--42 Pin Leaded Device
.620/.660--> — — — — — — 1.166	--42 Pin Leaded Device



NOTE: Flatpack device configurations will range from 10 Leads to 42 Leads with Lead Spacing at .035 "or .050".

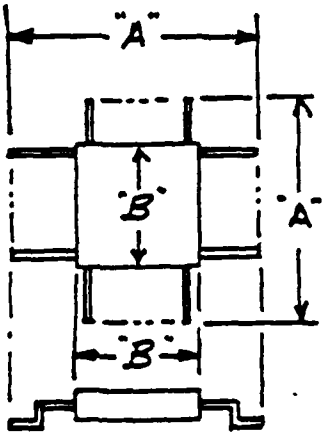


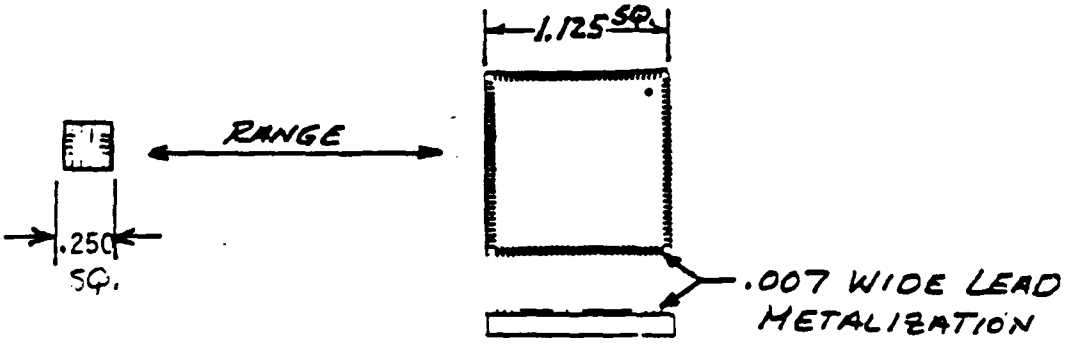
FIGURE 2
QUADPACK CONFIGURATIONS

"B" CASE SIZE	"A" DIM. TOE-TO-TOE DIMENSIONS
.900/.965 SQUARE	--1.120 - 132 Pin Leaded Device
	--1.200 - 60 & 64 Pin Leaded Device
	--1.166 - 60 & 64 Pin Leaded Device

NOTE: Quadpack device configurations will range from 60 to 132 leads with lead centers on .025" and .050" spacing.

b. Leadless chip carrier devices to be placed by the machine in this Statement of Work will be square or rectangular shaped within the ranges shown below. Tolerances between "Case to Metalized Foot Print True Position" on larger Hi-Density devices will necessitate pattern recognition for alignment. Approximately 95% of LCC's to be placed will have tolerances suitable to permit mechanical nesting or crowding for alignment.

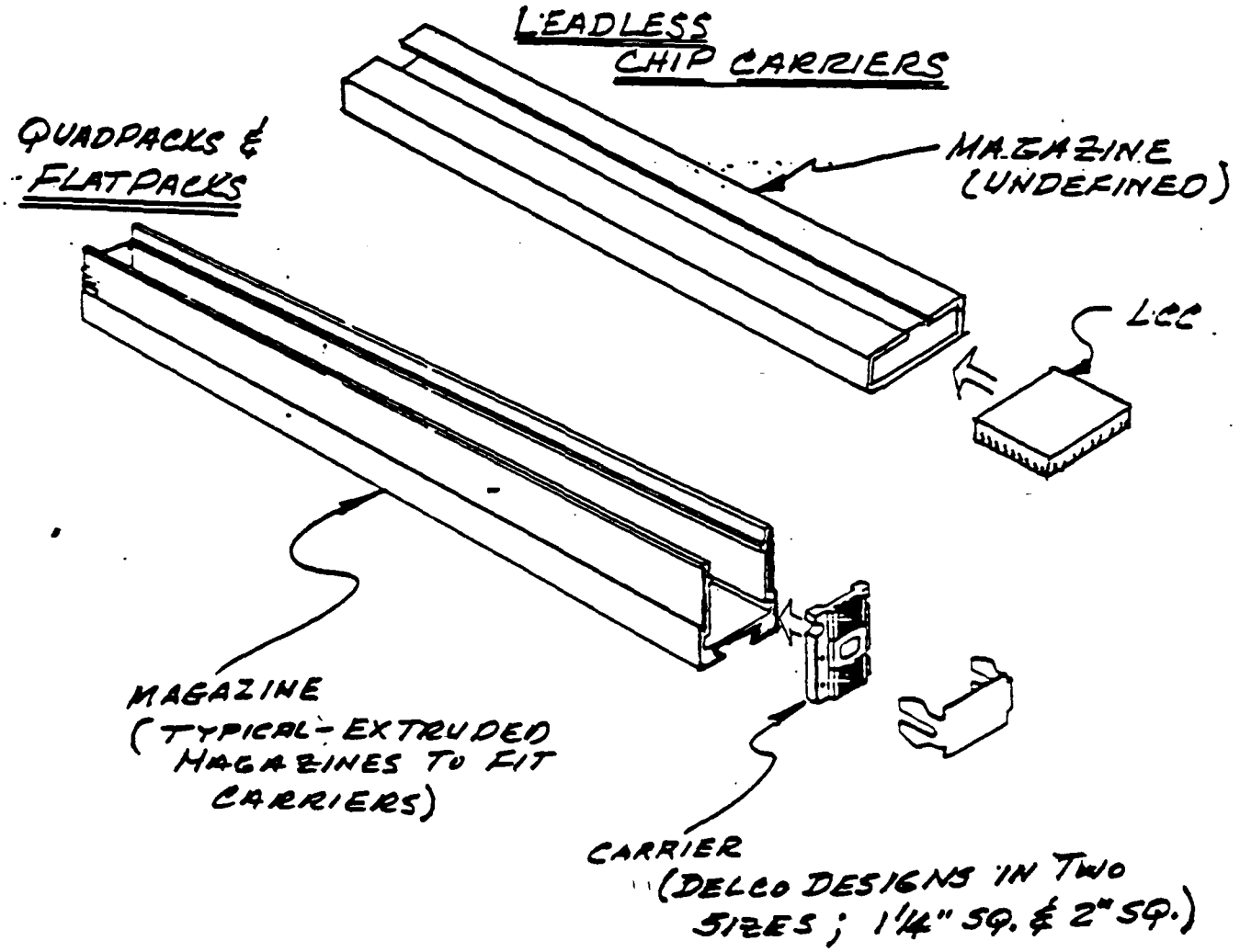
FIGURE 3
LEADLESS PARTS



Dimensions are for reference only, as actual part configurations will range from 16 pins to 156 pins in leadless carrier form.

FIGURE 4

REF. ONLY - DELCO TO PROVIDE CARRIERS & MAGAZINES.



PACKAGING METHODS FOR INTEGRATED CIRCUITS

7.4 Physical Break Down: Machine Disassembly shall permit break down into component sub-assemblies with maximum sizes of 3 1/2 feet x 8 feet to permit inter-plant relocation.

7.5 Machine Setup Time: Total machine setup time, to change magazine sticks on 60 of the 162 part tyes, and perform initial substrate alignment shall not exceed 30 minutes.

7.6 Finish: Exterior of the Pick N' Place Assembly Station shall have a "Blue" or "Green" exterior machine enamel.

7.7 Installation Instructions: Installation instructions to augment the final drawings for power drops, air lines, venting requirements or special instructions detailed to a skilled trades level are required sixty (60) days in advance of equipment delivery.

7.8 Space will be provided within the Robot working envelope to permit the addition of four "Flatpack or LCC" and one "Quadpack" standard A.T.S. Centering Stations for future "Add-On", if necessary, or this space will permit additional vibratory chip feeders to be added later. Machine control will provide I/O ports to operate these devices.

7.9 Accuracy: Total placement accuracy of the metalized footprint on Leadless Chip Carriers or Leaded Flatpack/Quadpacks to the pad Footprint pattern on the board/substrate shall be within + .0035 inches, including board/substrate "Swim" variations.

7.10 Machine Cycle Time: Total machine cycle time to obtain, center, align, place and recycle to pickup the next component shall not exceed 5 seconds on a 6" x 9" board/substrate placement area.

7.11 Programmable "Z" Axis: Vertical Z Axis movement shall be .500 inches minimum with programmable set-down pressures of 75 to 150 grams.

7.12 End Effectors: Grippers or vacuum cups shall be compatible with the parts variations described. Grippers or vacuum cups shall permit component body to body placement with .005 minimum clearance between parts in Flatpack configurations. Gripper or vacuum cup manual changes are permitted, but changeover shall not exceed 1 minute of operator time.

7.13 Positioning: Parts Positioning and Board/Substrate positioning will be accomplished using pattern recognition defined by the contractor. (Note: Flatpack devices presented at the pick-up point in Delco Electronics carriers will be on center across the part body, but may be off-center along the Leaded Axis by ± .075 worst case.)

7.14 Carriers: Carriers provided by Delco Electronics for Flatpack and Quadpacks will nest the parts without retainers, therefore, openers are not required. Carriers are color coded and can be ejected into a common bin for off-machine sorting after part removal.

8.0 OPERATING SYSTEM:

8.1 Machine Operating System will be "Menu" driven and compatible thru a RS232 link with a Digital Equipment Corp., VAX host or a Data General Host Computer.

8.2 System will permit program entry via three methods:

a. Walk thru digitizing teach process wherein the machine can be jogged thru all functions and each point stored. Each feeder can be manually operated thru a thumb wheel or toggle switch panel with "B.C.D." type input. Program will reside on disk at the machine.

b. Program entry can be keyed in on a terminal to address all feeders and board/substrate co-ordinates and stored. Program will reside on disk at the machine.

c. Programs can be down-loaded from a host. System will permit editing a program and overlaying revisions on the program in residence in the host.

8.3 Self-diagnostics, no part detection, alternate magazine selection and program editing features are required.

9.0 OPERATOR/MACHINE INTERFACE:

9.1 Ground Rules: Boards/Substrates are presented for population to the machine in "Kits" of ten or less. Parts are preformed and preloaded in magazine sticks in carriers (when applicable) by part number and lot number for the run of board/substrates contained in the kit.

9.2 Machine Operation:

9.2.1 Operator will load a disc by P/N and side "A" or "B" to be assembled, or, operator will enter P/N and side into the terminal if direct tie to the host is utilized.

9.2.2 Computer will ask the host (if applicable) for the program and the on-board microprocessor will prompt the operator acknowledging the program transfer.

9.2.3 Program will ask the operator to install a magazine in each feeder by part number and acknowledge presence. Repeat for each magazine required for the assembly. Operator will be permitted to by-pass any location.

9.2.4 Program will prompt the operator to position the first board.

9.2.5 Operator will enter "Start Assembly" command.

9.2.6 Machine will place all components and prompt operator when the assembly is complete.

9.2.7 Steps 9.2.4 thru 9.2.6 will be repeated until all boards in the "Kit" have been assembled.

9.2.8 Operator will remove the empty magazines and repeat all steps for the next assembly.

9.2.9 If a jam occurs, assembly will continue and jammed feeder locations will be stored. When assembly is complete, the operator is prompted to clear the jam and the machine will place the part or parts previously skipped.

9.2.10 Machine will stop and prompt the operator if a magazine is empty. Operator can load a magazine or bypass that location if assembly is to continue short parts.

CASH FLOW EVALUATION ($000,S OMITTED)

10-RGG-16/1IM01

03-Nov-88

PROJECT NO.: 01
PROJECT NAME: AUTOMATIC CCA SURFACE MOUNTED COMPONENTS

YEAR:	1984 (0)	1985 (1)	1986 (2)	1987 (3)	1988 (4)	1989 (5)	1990 (6)	1991 (7)	1992 (8)	1993 (9)	1994 (10)	1995 (11)
INVESTMENT DATA:												
DEVELOPMENT *		33	81	6								
FACILITIES *		72	203	16								
TOOLING *		121	15	39								
TOTAL	0	226	299	61	0	0	0	0	0	0	0	0
PROFIT AND CASH FLOW DATA:												
GROSS SAVINGS *			0	14	59	37	44	71	78	64	68	72
LESS:												
DEPRECIATION FACILITIES		0	14	64	85	65	42	19	1	0	0	0
TOOLING		0	40	59	46	21	9	0	0	0	0	0
TOTAL	0	0	54	123	132	86	51	19	1	0	0	0
PROJECT CHANGES TO OPERATIONS *	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL EXPENSES	0	0	54	123	132	86	51	19	1	0	0	0
NET SAVINGS BEFORE TAXES	0	0	(54)	(109)	(73)	(49)	(7)	52	77	64	68	72
NET SAVINGS AFTER TAXES (TAX @ .37)	0	0	(34)	(69)	(46)	(31)	(4)	33	48	40	43	45
ADD DEPRECIATION	0	0	54	123	132	86	51	19	1	0	0	0
CASH FLOW FROM OPERATIONS	0	0	20	54	86	55	46	52	50	40	43	45
INVESTMENT CREDIT		0	14	21	4	0	0	0	0	0	0	0
NET CASH FLOW	0	(226)	(264)	15	90	55	46	52	50	40	43	45
CUMULATIVE CASH FLOW	0	(226)	(490)	(476)	(386)	(331)	(284)	(233)	(183)	(143)	(100)	(55)

DEPRECIATION TABLE:
(POST 1985)
EQUIPMENT TOOLING

5 YEAR	3 YEAR	YEAR NO.
0.20	0.33	1
0.32	0.45	2
0.24	0.22	3
0.16		4
0.08		5
	TOTAL	
	291	
	75	
	466	

PAYBACK AND RETURN ON INVESTMENT:
PAYBACK 11.0 YRS.
RETURN ON INVESTMENT (DISCOUNTED CASH FLOW) -0.02158

* INPUT BY REQUESTOR