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## MATERIAL HANDLING

ROBERT J. MEINHART

APRIL 1983



US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND  
LARGE CALIBER WEAPON SYSTEMS LABORATORY  
BENET WEAPONS LABORATORY  
WATERVLIET N.Y. 12189

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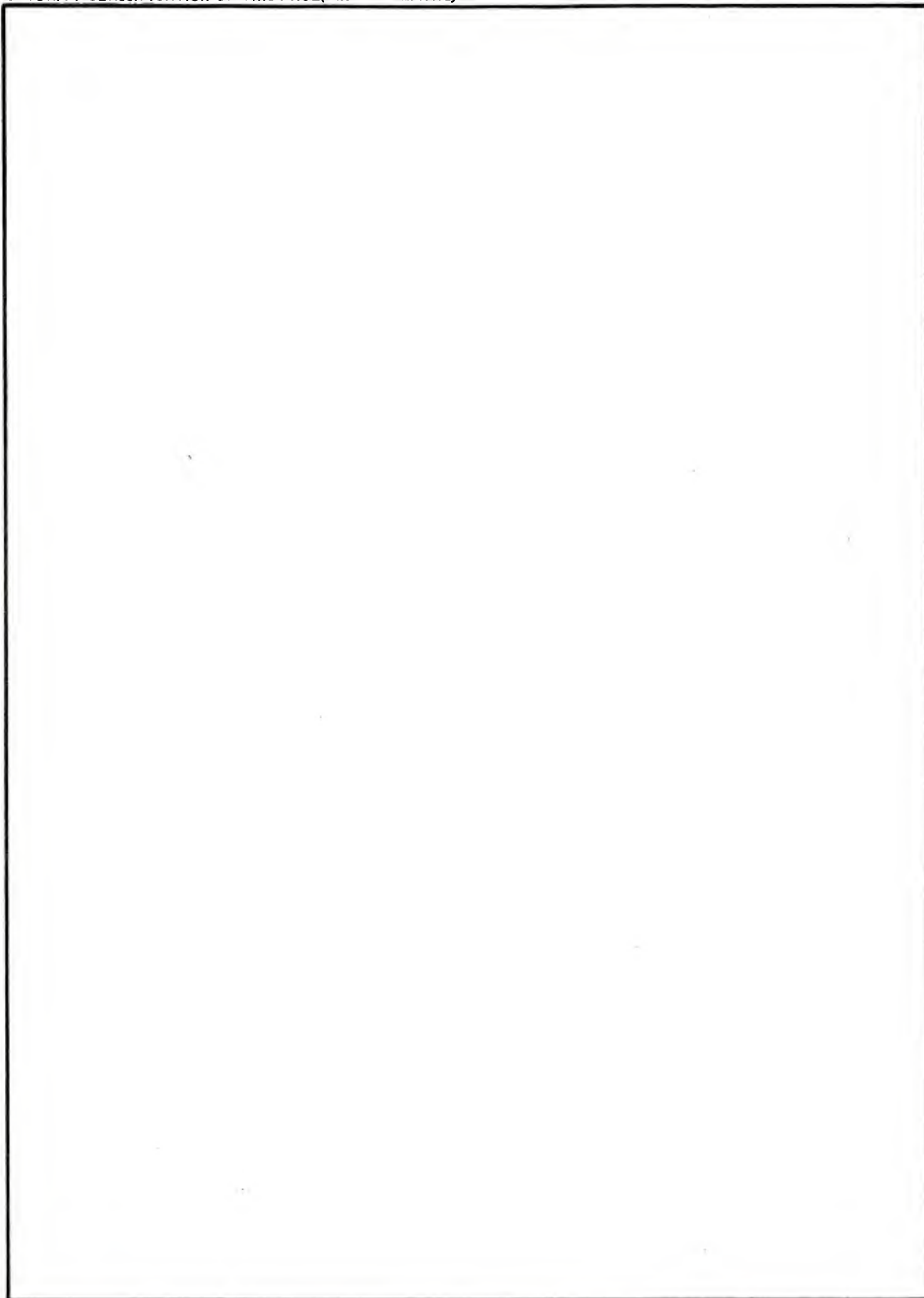
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| 1. REPORT NUMBER<br>ARLCB-MR- 83011                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER                                                                                                        |
| 4. TITLE (and Subtitle)<br><br>Material Handling                                                                                                                                                                                                                                                                                                                                                                                                                                     |                       | 5. TYPE OF REPORT & PERIOD COVERED<br><br>Final                                                                                      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                       | 6. PERFORMING ORG. REPORT NUMBER                                                                                                     |
| 7. AUTHOR(s)<br><br>Robert J. Meinhart                                                                                                                                                                                                                                                                                                                                                                                                                                               |                       | 8. CONTRACT OR GRANT NUMBER(s)                                                                                                       |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>US Army Armament Research and Development Command<br>Benet Weapons Laboratory, DRDAR-LCB-TL<br>Watervliet, N.Y. 12189                                                                                                                                                                                                                                                                                                                 |                       | 10. PROGRAM ELEMENT, PROJECT, TASK<br>AREA & WORK UNIT NUMBERS<br>AMCMS No. 3297.06.8208<br>DA Project.<br>PRON No. M1-0-P1640-M1-1A |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>US Army Armament Research and Development Command<br>Large Caliber Weapon System Laboratory<br>Dover, New Jersey 07801                                                                                                                                                                                                                                                                                                                    |                       | 12. REPORT DATE<br>April, 1983                                                                                                       |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                       | 13. NUMBER OF PAGES<br>48                                                                                                            |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)                                                                                                                                                                                                                                                                                                                                                                                                          |                       | 15. SECURITY CLASS. (of this report)<br><br>UNCLASSIFIED                                                                             |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                       | 15a. DECLASSIFICATION/DOWNGRADING<br>SCHEDULE                                                                                        |
| 16. DISTRIBUTION STATEMENT (of this Report)<br><br>Approved for public release; distribution unlimited                                                                                                                                                                                                                                                                                                                                                                               |                       |                                                                                                                                      |
| 17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)                                                                                                                                                                                                                                                                                                                                                                                           |                       |                                                                                                                                      |
| 18. SUPPLEMENTARY NOTES<br>Originally prepared as an MM&T project report in May 1981, and submitted to<br>U.S. Army Armament Materiel Readiness Command.                                                                                                                                                                                                                                                                                                                             |                       |                                                                                                                                      |
| 19. KEY WORDS (Continue on reverse side if necessary and identify by block number)<br>Material Handling<br>Overhead cranes<br>Sideloaded lift trucks<br>Automatic guided vehicle                                                                                                                                                                                                                                                                                                     |                       |                                                                                                                                      |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br>Current material handling problems encountered during the manufacturing of gun<br>tubes are discussed. Solutions recommended by a private contractor are pre-<br>sented. These solutions are (1) use mast cranes, (2) use sideloading lift<br>trucks, and (3) use an automatic guided vehicle system with sideloading lift<br>trucks. Installation costs and return-on-investment are detailed. |                       |                                                                                                                                      |

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DEPARTMENT OF THE ARMY  
U.S. ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND  
BENET WEAPONS LABORATORY, LCWSL  
WATERVLIET ARSENAL, WATERVLIET, N.Y. 12189

DRDAR-LCB-SE

SUBJECT: Final Technical Report

Project No: 6808208

Project Title: MM&T: Material Handling

Project Officer: Robert J. Meinhart

Statement of the Problem: The movement of gun tubes which are large (12" dia.), long (20 feet), and heavy (up to 4 tons), through the shops as well as positioning the pieces in machines for metal removal presents an unusual and difficult material handling problem.

Background & Introduction: The material handling of gun tubes in the bays of manufacturing buildings is done exclusively with large, rail-mounted, overhead cranes. Each crane requires an operator riding in a cab on the crane bridge. Gun tubes are attached to the crane hook by means of a wire rope sling (Fig. 1). Each time a gun tube is moved a person is required on the floor to attach the slings at the pick-up location and detach the slings at the place location. This person working the slings can be a "follower", or helper, whose job it is to assist in the movement of tubes, or this person could be the operator of the machine tool from which or to which the gun tube is being moved. Movement of gun tubes by overhead cranes is effective only within a bay of a manufacturing building. To move a tube between bays in a building it is necessary to place the tube on a gun cart, attach a battery-powered "mule" to the cart, and move the cart between bays (Fig. 2). This operation can happen only in a single section of a bay. Occasionally tube transfers between bays will occur by the bay crane placing a tube in a high bay overlap area. The high bay crane then picks up the tube and drops it in the overlap area of the new bay. The crane in the new bay will then pick up the tube and place it where it is required.

In 1975, the Watervliet Arsenal MM&T project 6717042 "End Item Manufacturing Guide" included a report prepared by RCC Inc. This report indicated that the move time for gun tubes was determined to be 12% of the total time spent in manufacturing a gun tube. It was felt that this percentage of time could be

This project was accomplished as part of the US Army Manufacturing Technology program. The primary objective of this program is to develop, on a timely basis, manufacturing processes, techniques and equipment for use in production of Army materiel.



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cut in half by using properly selected material handling systems and equipment. With the "REARM" program occurring this was the ideal time for modernizing the material handling procedures.

Approach to the Problem: Discussions were held with the Chief, Plant Layout Section concerning the overall plan for REARM with regard to gun tube manufacturing. These discussions included relocation of manufacturing lines and proposed changes in the handling of the gun tubes in those lines. At the time of these preliminary discussions there were no commitments made to change the material handling procedures.

A second Watervliet Arsenal material handling related project, 6808060, "MM&T: Improved Manufacturing Processes Related to Final Inspection of Cannon Tubes" was looked at for similar or duplicating efforts. The inspection project is intended to provide a "mechanized" inspection area. It was determined that there is no duplicating effort between the two projects.

Another Watervliet Arsenal material handling type project, 6798104, "MM&T: Improved Breech Block Manufacturing", was also looked at to determine the type of information available on material handling equipment. This block project is investigating "FANSIMS", Flexible Automated Non-Synchronous Industrial Manufacturing Systems, and Flexible Machining. Neither of these systems showed any applicability to tube handling.

Due to time and knowledge constraints, the decision was made to secure the services of an outside concern which would have the expertise to perform an assessment of our current material handling difficulties and make recommendations for easing these difficulties. After attending material handling clinics and talking to experts from various material handling manufacturers and consultants, it was decided to place a sole source contract with SysteCon, Inc., of Norcross, Georgia. The reason for the sole source contract is that SysteCon, unlike other "consultants", is not a representative of any material handling equipment manufacturers. Action to place the contract was initiated in April 1980. The contract was signed in October, 1980. The contractor made visits to Watervliet Arsenal gathering data and information, performing rough tube counts, and timing various production operations from the moment an operator signaled for a crane lift to remove a finished workpiece until a new workpiece was released into the machine. The contractor submitted his report in January, 1981, and the report was accepted in February, 1981. The report is titled "Tube Material Handling Assessment and Recommendation", Watervliet Arsenal, Watervliet, New York, January 5, 1981, DAAA22-81-M-0006. A copy of the report is inclosed as Attachment 1.

Discussion: The manufacture of gun tubes presents unique materials handling problems. The size of the workpiece and the variety of machine tools used to produce a finish machined gun tube cause the major problem with designing a materials handling system. The various machine tools require different loading techniques. One common aspect of these techniques, however, is that

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machine loading occurs from above the machine tool. To load the machines from the side would require large and cumbersome equipment. This implies a second problem which directs the design and selection of materials handling equipment, the arrangement of the manufacturing facility. Floor space is at a premium. The large number of machine tools required to maintain our production requirements necessitates narrow aisles and limited in-process storage space.

The SysteCon evaluation and subsequent report, produced three alternatives. The first and simplest is to use masthead cranes in place of the current cranes and use a central storage area in each manufacturing bay for in-process storage. The second is to use side loading lift trucks and multiple tube fixtures and move the tubes in small batches from operation to operation. However, current cranes would still be required to load the machines. The third alternative is to use the side load trucks in conjunction with an automatic guided vehicle system. Again the current cranes would actually load the machines.

The first two recommendations had been considered earlier in conjunction with the rotary forge integrated production line, MOD 67X7238 "Modern Integrated Production Line for Cannon - Rotary Forge", and MM&T 67X7588 "Rotary Forge Technology". The masthead crane and side loading lift trucks were evaluated for handling preforms. However, the cost of the equipment was not budgeted and return on the investment would have been marginal. These options are constantly being reconsidered as solutions to materials handling problems. The third option, the guided vehicle system, has been considered in the general material handling scheme at Watervliet Arsenal but has been found to be unacceptable in the current production philosophy.

The side loading lift trucks and the guided vehicle system would require large amounts of floor space for tube storage. Currently tubes are stacked four or five wide and up to four high using wooden sweeps (Fig. 3). These tube stacks are located in various places in a machining bay. The alternatives suggested by SysteCon would require a storage area for each machine tool and have only single layer storage, two wide on a fixture with space available for a third tube but not being used except when transferring a completed tube to the fixture. This proposal would require more floor space than that which is currently allocated to in-process storage. In addition to the increased storage area, these vehicle-oriented handling systems would require wider aisles than currently allocated, again causing a space problem.

A review of the SysteCon report by the Chief, Plant Layout Section revealed certain "inadequacies" with the report: 1) the sampling performed occurred during a period of relatively low production; 2) rework and defective work report materials were not considered and can produce interference; 3) interference between vehicles and the cranes was



SUBJECT: Final Technical Report

not discussed. These inadequacies are most likely due to the low contract cost (\$10,000) rather than inexperience of SysteCon. SysteCon's personnel time was charged at the rate of \$600 per day. When travel and living expenses are considered, there are not many days in a \$10,000 contract. As a result, the evaluation and subsequent recommendations made by SysteCon do not have the "depth" or details which would produce a totally adequate report.

As stated previously, the alternatives recommended by SysteCon had received prior consideration as solutions to materials handling problems here at the Arsenal. Therefore, the benefits of the recommendations could be considered to be non-existent. However, to have an expert recommend the same equipment as a non-expert, has to boost the confidence level of the non-expert and lend appreciable credibility to his work. The recommendations given by SysteCon will be considered on a continuing basis as solutions to Watervliet's materials handling problems. To utilize these recommendations will require decreasing the amount of floor space dedicated to manufacturing and inspection equipment and increasing the space dedicated to in-process storage and aisles. As more and more machine tools become numerically controlled, performing multiple operations in a single setup in less time, the change from equipment space to storage and aisle space could occur, removing the current space constraints. As that time approaches, the recommendations of SysteCon, or even more sophisticated materials handling equipment, will be implemented into the gun tube production lines.

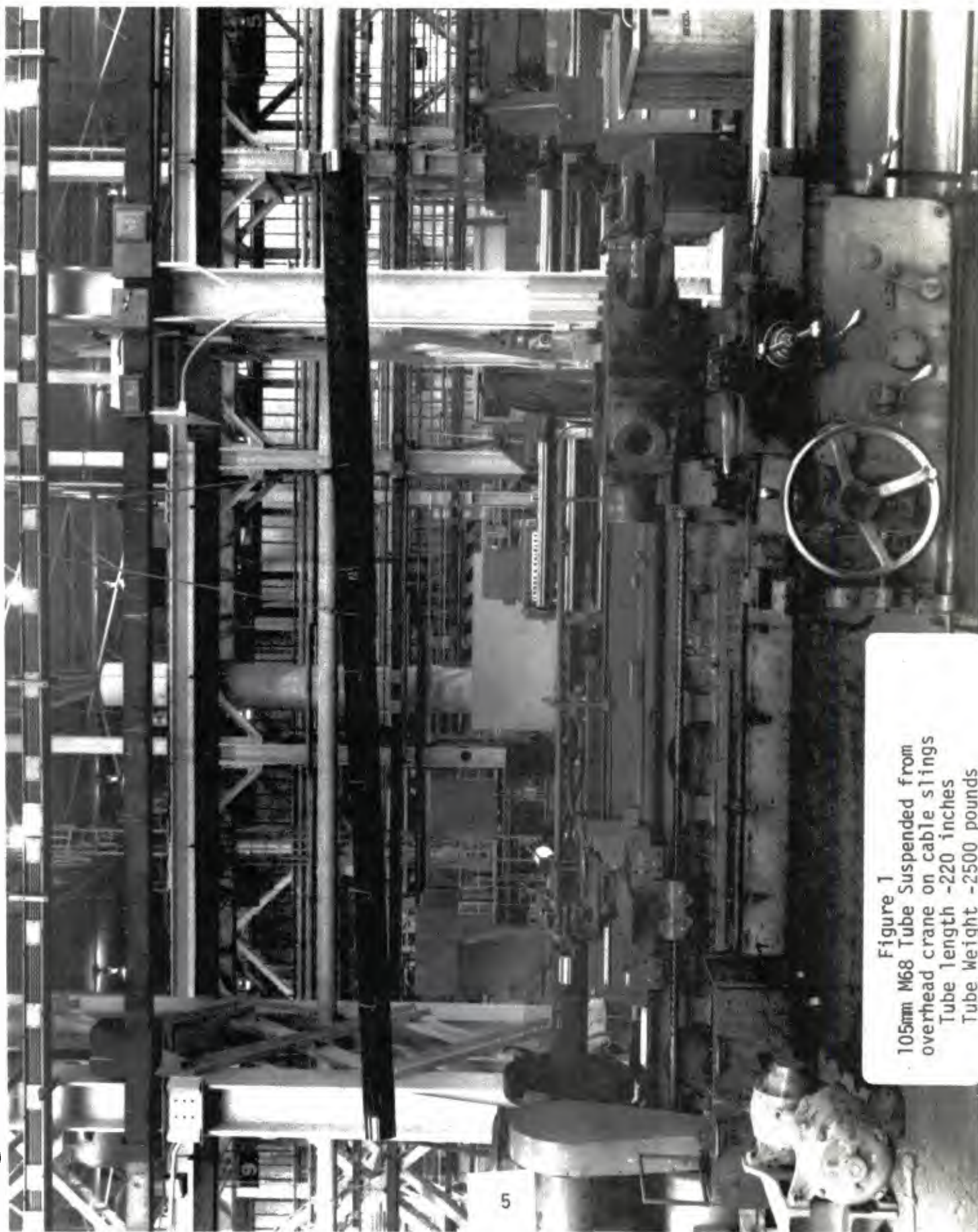


Figure 1  
105mm M68 Tube Suspended from  
overhead crane on cable slings  
Tube length -220 inches  
Tube Weight -2500 pounds





Figure 2  
Gun Cart with Battery powered "mule"



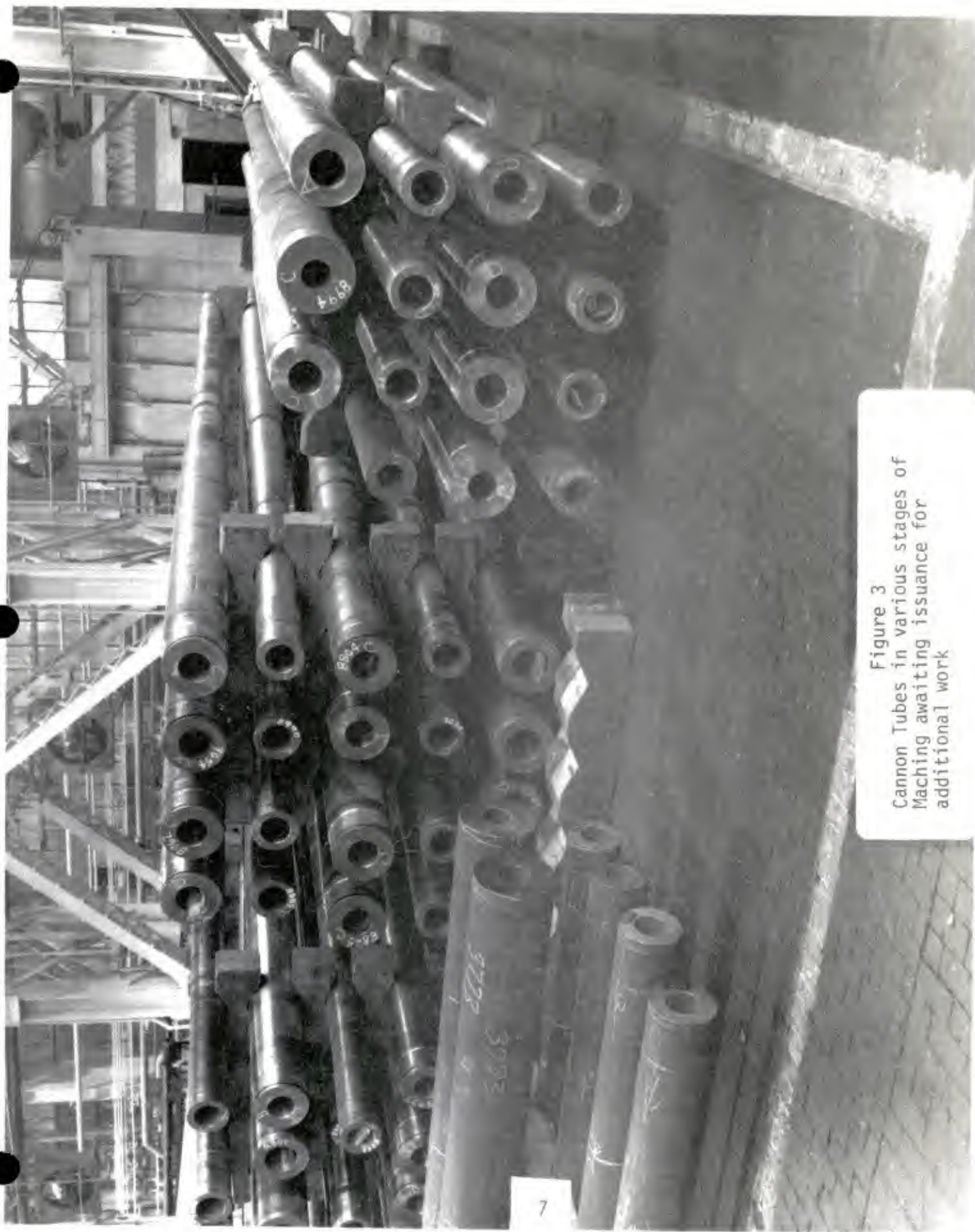


Figure 3  
Cannon Tubes in various stages of  
Machining awaiting issuance for  
additional work

APPENDIX

TUBE MATERIAL HANDLING  
ASSESSMENT AND RECOMMENDATIONS

WATERVLIET ARSENAL  
WATERVLIET, NEW YORK

DAAA22-81-M-0006

SYSTECON, INC.  
7000 PEACHTREE IND. BLVD.  
NORCROSS, GA 30092  
404-448-9292

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## INTRODUCTION

WATERVLIET ARSENAL IS CURRENTLY UNDERGOING A MAJOR MODERNIZATION AND EXPANSION EFFORT UNDER THE TITLE OF PROJECT REARM. AS A PART OF THE OVERALL PLAN SYSTECON, INC. WAS CONTRACTED TO IDENTIFY AND EVALUATE ALTERNATIVE MATERIAL HANDLING SYSTEMS FOR THE TRANSFER AND POSITIONING OF TUBES DURING THE MANUFACTURING PROCESS.

PREVIOUS STUDIES CONDUCTED BY AND FOR THE ARSENAL, AS WELL AS THIS STUDY, INDICATE THAT THE TRANSFER AND POSITIONING TIME IS EQUAL FROM 10% TO 15% OF THE DIRECT LABOR USED TO PRODUCE TUBES. THE CURRENT MATERIAL HANDLING METHODS, FOR THE MOST PART, HAVE REMAINED THE SAME FOR SEVERAL DECADES.

WITH THE AID OF BENET WEAPONS LAB PERSONNEL, SYSTECON HAS BEEN ABLE TO DEVELOP AN UNDERSTANDING OF CURRENT TUBE HANDLING REQUIREMENTS, PROCESS FLOWS, AND THROUGHPUT REQUIREMENTS. USING THIS DATA BASE SEVERAL ALTERNATIVES FOR REDUCING HANDLING COSTS AND INCREASING MANUFACTURING CAPABILITY HAVE BEEN DEVELOPED. THE ALTERNATIVES PRESENTED INCLUDE BOTH LOW AND HIGH TECHNOLOGIES.

## BACKGROUND

CURRENTLY TUBE MANUFACTURING, "CHIP" OPERATIONS, CONSISTS OF 2 MAJOR CATEGORIES CLASSIFIED BY THE SIZE OF THE TUBE PRODUCED. MID SIZE TUBES OF 105MM AND 155MM BEGIN THE MANUFACTURING PROCESS IN BUILDING 135 AND ARE TRANSFERRED TO BUILDING 35 WHEN APPROXIMATELY ONE-THIRD COMPLETE. LARGE TUBES OF 8" ARE MANUFACTURED WITHIN BUILDING 110 EXCEPT FOR TWO SEPARATE TRANSFERS TO BUILDING 35 FOR CHROME PLATING AND HEAT TREATING.

THERE ARE THREE TYPES OF MOVEMENTS IN THE MANUFACTURING PROCESS OF TUBES:

- MOVEMENT WITHIN A BAY
- MOVEMENT BETWEEN BAYS
- MOVEMENT BETWEEN BUILDINGS

MOVEMENTS WITHIN A BAY ARE BY USE OF CAB OPERATED OVERHEAD CRANES USING WIRE ROPE SLINGS AS THE HOLDING DEVICE FOR THE TUBE. EACH MOVEMENT OF THE TUBE REQUIRES A PERSON ON THE FLOOR TO ATTACH OR REMOVE THE SLING AT EACH PICK UP OR DEPOSIT POINT. THEREFORE, EACH MOVEMENT REQUIRES TWO PEOPLE, THE CRANE OPERATOR AND A "FOLLOWER", USUALLY A MACHINIST OR INSPECTOR. BECAUSE OF THE IMBALANCE OF OPERATION TIMES A TUBE IS SELDOM MOVED DIRECTLY FROM ONE OPERATION TO ANOTHER, BUT PLACED IN A WORK-IN-PROCESS STORAGE AREA SOMEWHERE BETWEEN THE OPERATIONS. THEREFORE, ONE PROCESSING STEP REQUIRES TWO MOVEMENTS

OF THE TUBE. THE TYPICAL SEQUENCE OF EVENTS FOR A MOVE IS FOR THE MACHINIST TO:

- TURN A RED LIGHT ON TO CALL FOR THE CRANE
- WAIT 5 TO 10 MINUTES FOR THE CRANE TO ARRIVE
- ATTACH THE SLINGS TO THE COMPLETED TUBE IN HIS MACHINE
- FOLLOW THE CRANE WITH TUBE TO THE WORK-IN-PROCESS STORAGE AREA
- REMOVE THE SLING FROM THE TUBE
- FOLLOW THE EMPTY CRANE TO THE WORK-IN-PROCESS STORAGE AREA OF THE NEXT TUBE TO BE PROCESSED
- ATTACH THE SLING TO THE TUBE
- FOLLOW THE CRANE WITH TUBE TO HIS MACHINE
- REMOVE THE SLINGS.

MOVEMENTS BETWEEN THE BAYS ARE BY GUN CARTS PULLED BY BATTERY POWERED MULES. EACH TUBE MOVED BETWEEN BAYS UNDERGOES 3 SEPARATE HANDLINGS INVOLVING A MACHINIST, A CRANE FOLLOWER, AND TWO CRANE OPERATORS. FROM THE MACHINISTS' STANDPOINT THE SEQUENCE OF EVENTS IS THE SAME EXCEPT FOR DEPOSITING THE COMPLETED TUBE ON A GUN CART RATHER THAN IN A STORAGE AREA. THE ADDITIONAL STEPS ARE:

- ATTACH MULE TO GUN CART
- MOVE THE GUN CART BETWEEN BAYS

- WAIT FOR CRANE
- ATTACH SLINGS TO TUBE
- FOLLOW THE CRANE WITH TUBE TO THE WORK-IN-PROCESS STORAGE AREA
- REMOVE SLINGS FROM TUBE
- RETURN TO GUN CART
- REMOVE MULE FROM GUN CART

MOVEMENTS BETWEEN BUILDINGS ARE VERY SIMILAR TO MOVEMENTS BETWEEN BAYS. ALL STEPS ARE THE SAME EXCEPT A FLAT BED RAILROAD CAR IS USED RATHER THAN A GUN CART. ALSO MULTIPLE TUBES AT A TIME ARE MOVED ON THE RAIL CAR AS COMPARED TO ONE TUBE PER TRIP OF A GUN CART.

WITH CURRENT MATERIAL HANDLING METHODS IT IS VERY ADVANTAGEOUS TO KEEP PROCESSING STEPS AS CLOSE TOGETHER AS POSSIBLE AND SPECIFICALLY TO AVOID MOVEMENTS BETWEEN BAYS. WHERE POSSIBLE THE MACHINES ARE LOCATED TO ACCOMPLISH THIS. FROM TIME TO TIME AS PRODUCTS PRODUCED CHANGE OR MANUFACTURING STEPS ARE MODIFIED, THE MACHINES ARE RELOCATED TO ALLOW A MORE OPTIMUM MATERIAL HANDLING FLOW. HOWEVER, THIS TECHNIQUE IS LIMITED BY A NUMBER OF MACHINES WITH UNIQUE REQUIREMENTS, SUCH AS PITS, THAT WOULD BE IMPRACTICAL TO RELOCATE DUE TO BUILDING MODIFICATION COSTS.

IN THE PRODUCTION OF 155MM TUBES THERE ARE 73 STEPS. FIFTY-EIGHT STEPS REQUIRE MOUNTING ON A MACHINE OR PLACEMENT IN A SPECIALLY DESIGNED CABINET OR PIT, 8 STEPS ARE PERFORMED ON WORK HORSES WITH HAND TOOLS, AND 14 STEPS ARE INSPECTIONS. OF THE 73 STEPS,



SIXTY-EIGHT REQUIRE MOVEMENT OF THE TUBE. SIX OF THESE STEPS REQUIRE MOVEMENT BETWEEN BAYS VIA GUN CARTS. THE NUMBER OF STEPS AND MOVES REQUIRED ARE TYPICAL OF MIDSIZE TUBE PRODUCTION. WITH AN AVERAGE SCHEDULED PRODUCTION OF 195 MIDSIZED TUBES PER MONTH OF SEVERAL DIFFERENT TYPE THERE WILL BE APPROXIMATELY 27,690 CRANE MOVEMENTS AND 1,170 GUN CART MOVEMENTS PER MONTH. WITH THE PRESENT MATERIAL HANDLING SYSTEM IT REQUIRES 14 CRANE OPERATORS AND 2 GROUNDSMEN, AS WELL AS THE TIME OF THE MACHINE OPERATOR AND INSPECTORS. PRODUCTION OF LARGE TUBES CONSISTS OF A SIMILAR NUMBER OF STEPS WITH SCHEDULED PRODUCTION AVERAGING 30 TUBES PER MONTH.

BECAUSE OF THE LARGE NUMBER OF PROCESSING STEPS, THE MANUFACTURE OF SEVERAL DIFFERENT TUBES, AND THE SIGNIFICANT VARIANCE IN PROCESSING TIMES BETWEEN STEPS, A LARGE INVENTORY OF WORK-IN-PROCESS TUBES IS REQUIRED. A SURVEY CONDUCTED NOVEMBER 13, 1980 TALLIED 1,065 MIDSIZE TUBES AND 157 LARGE TUBES IN WORK-IN-PROCESS STORAGE. THE CURRENT METHOD OF STORING TUBES IS ON WOOD CRADLES ON THE FLOOR, EACH CRADLE HOLDING 4 TUBES. THESE CRADLES CAN BE STACKED ON TOP OF EACH OTHER TO GAIN STORAGE EFFICIENCIES. CRADLES CONTAINING TUBES OF DIFFERENT TYPES OR AT DIFFERENT PRODUCTION STAGES ARE OFTEN STACKED ON EACH OTHER DUE TO FLOOR SPACE LIMITATIONS. THIS STORAGE METHOD SOMETIMES REQUIRES THE UNDESIRABLE DOUBLE HANDLING BY THE CRANE OPERATOR AND MACHINIST OF TUBES ON TOP OF THE STACK TO RETRIEVE THE DESIRED TUBE.

THE CHARTS AND TABLES ON THE FOLLOWING PAGES PROVIDE ADDITIONAL INFORMATION RELEVANT TO THE CURRENT OPERATIONS.

TUBE MOVEMENT SUMMARY

|                                                  | <u>MID SIZE<br/>TUBE</u> | <u>LARGE SIZE<br/>TUBE</u> |
|--------------------------------------------------|--------------------------|----------------------------|
| PROCESSING STEPS                                 |                          |                            |
| USING MACHINES & SPECIAL FACILITIES              | 51                       | 41                         |
| USING HAND TOOLS W/ TUBE ON HORSES               | 8                        | 12                         |
| INSPECTIONS                                      | <u>14</u>                | <u>16</u>                  |
| TOTAL STEPS                                      | 73                       | 69                         |
| PROCESSING STEPS NOT REQUIRING MOVEMENT OF TUBE  | <u>(5)</u>               | <u>(4)</u>                 |
| MOVEMENTS WITHIN BAYS                            | 68                       | 65                         |
| MOVEMENTS BETWEEN BAYS (NOT INCL. BETWEEN BLDGS) | 6                        | 0                          |
| MOVEMENTS BETWEEN BLDGS                          | 1                        | 4                          |

SURVEY OF TUBES IN PROCESS

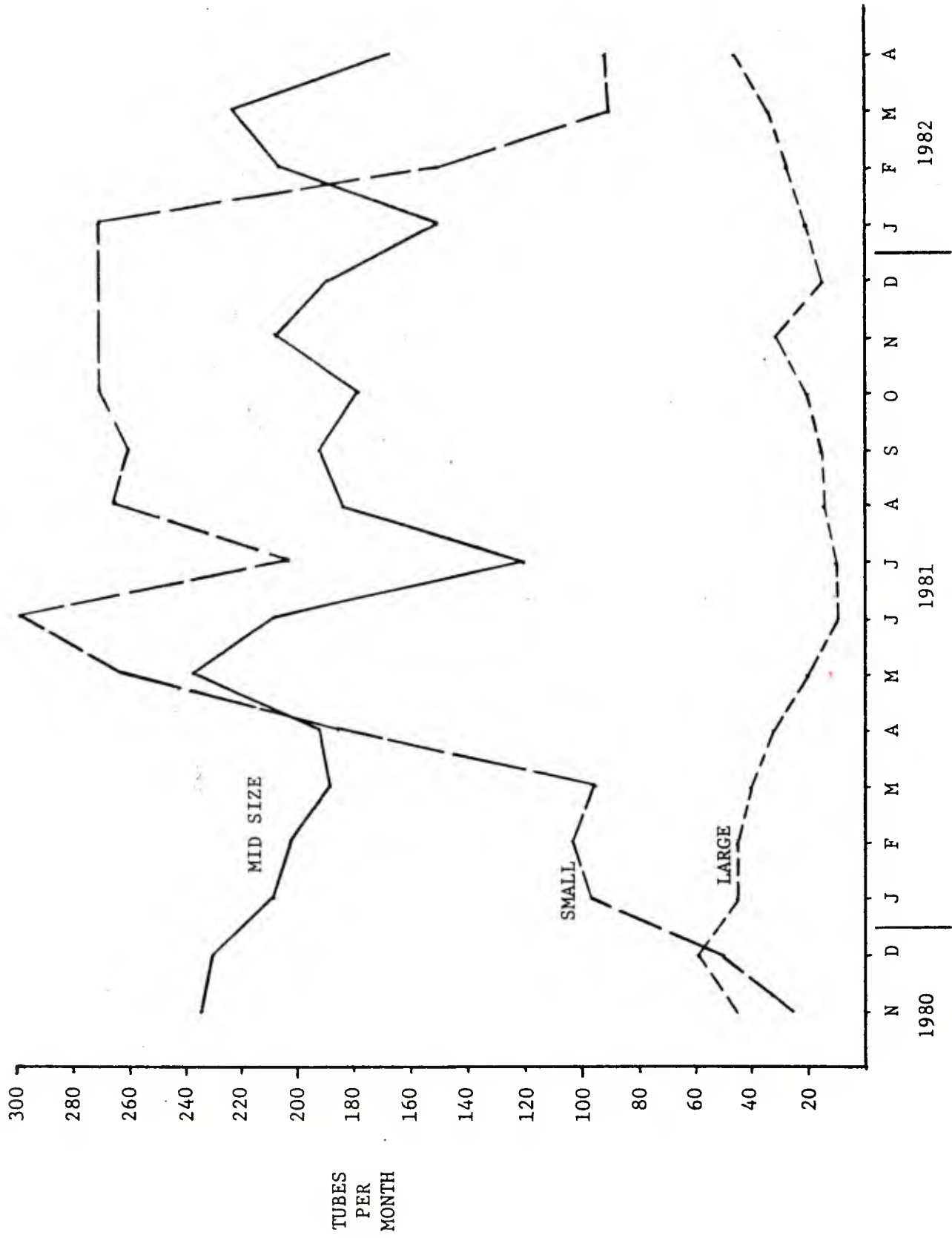
|                                 | <u>TUBES IN WORK-IN-<br/>PROCESS STORAGE</u> | <u>TUBES ON MACHINES<br/>OR OTHERWISE ACTIVE</u> | <u>TOTAL</u> |
|---------------------------------|----------------------------------------------|--------------------------------------------------|--------------|
| MID SIZE TUBES:                 |                                              |                                                  |              |
| BUILDING 135                    |                                              |                                                  |              |
| BAY B                           | 107                                          | 12                                               | 119          |
| BAY C                           | 114                                          | 13                                               | 127          |
| BAY D                           | 452                                          | 1                                                | 453          |
| BAY E                           | 69                                           | 0                                                | 69           |
| HIGH BAY                        | <u>21</u>                                    | <u>1</u>                                         | <u>22</u>    |
| TOTAL BUILDING 135              | 763                                          | 27                                               | 790          |
| BUILDING 35                     |                                              |                                                  |              |
| BAY A                           | 13                                           | 7                                                | 20           |
| BAY B                           | 87                                           | 13                                               | 100          |
| BAY C                           | 55                                           | 10                                               | 65           |
| BAY D                           | 106                                          | 8                                                | 114          |
| BAY E                           | 38                                           | 20                                               | 58           |
| END BAY                         | <u>3</u>                                     | <u>0</u>                                         | <u>3</u>     |
| TOTAL BUILDING 35               | 302                                          | 58                                               | 360          |
| TOTAL MID SIZE TUBES            | 1065                                         | 85                                               | 1150         |
| TOTAL LARGE SIZE TUBES-BLDG 110 | <u>157</u>                                   | <u>43</u>                                        | <u>200</u>   |
| ALL TUBES                       | <u>1222</u>                                  | <u>128</u>                                       | <u>1350</u>  |

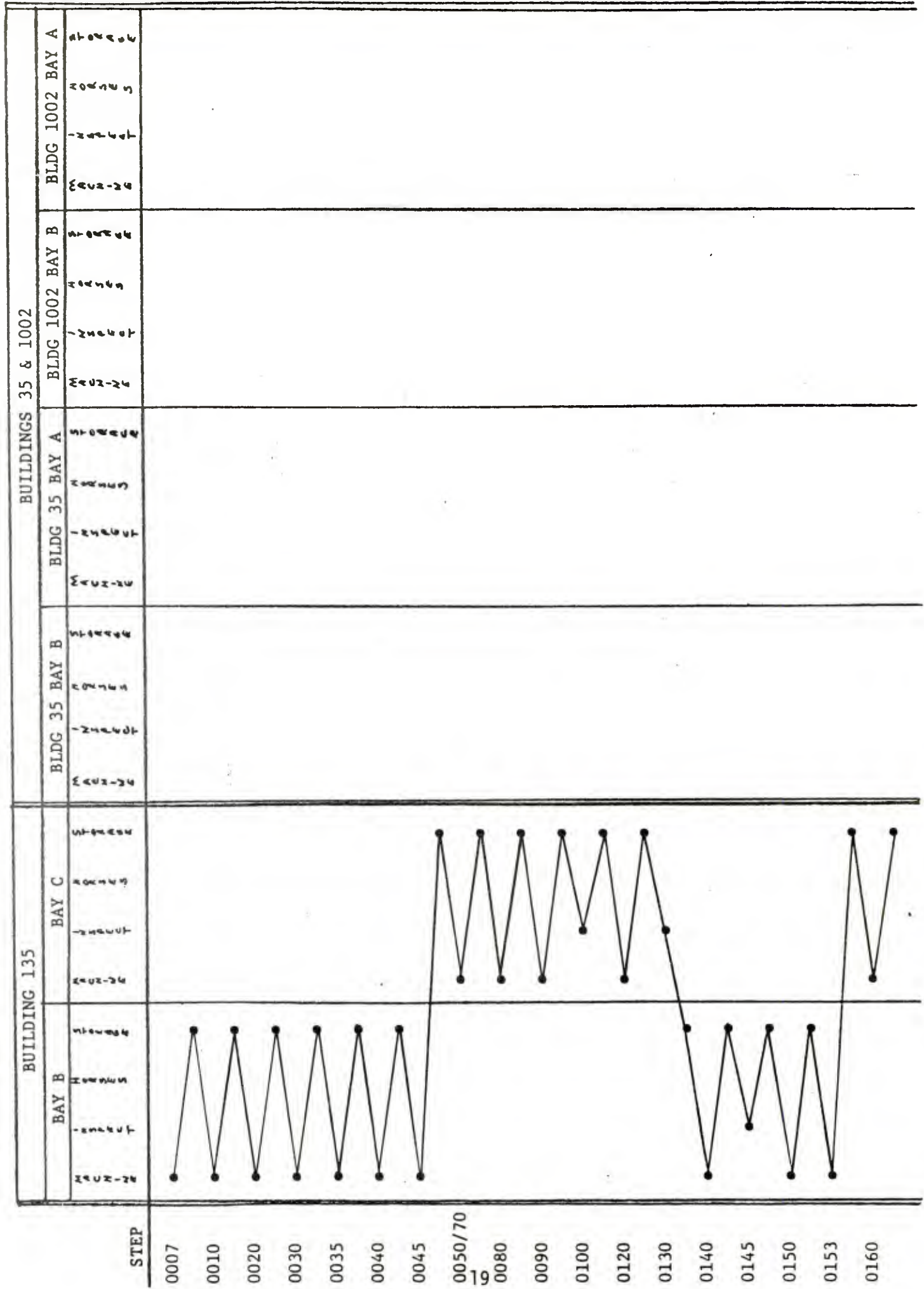
TUBE PRODUCTION SCHEDULE NOVEMBER 1980 TO APRIL 1982

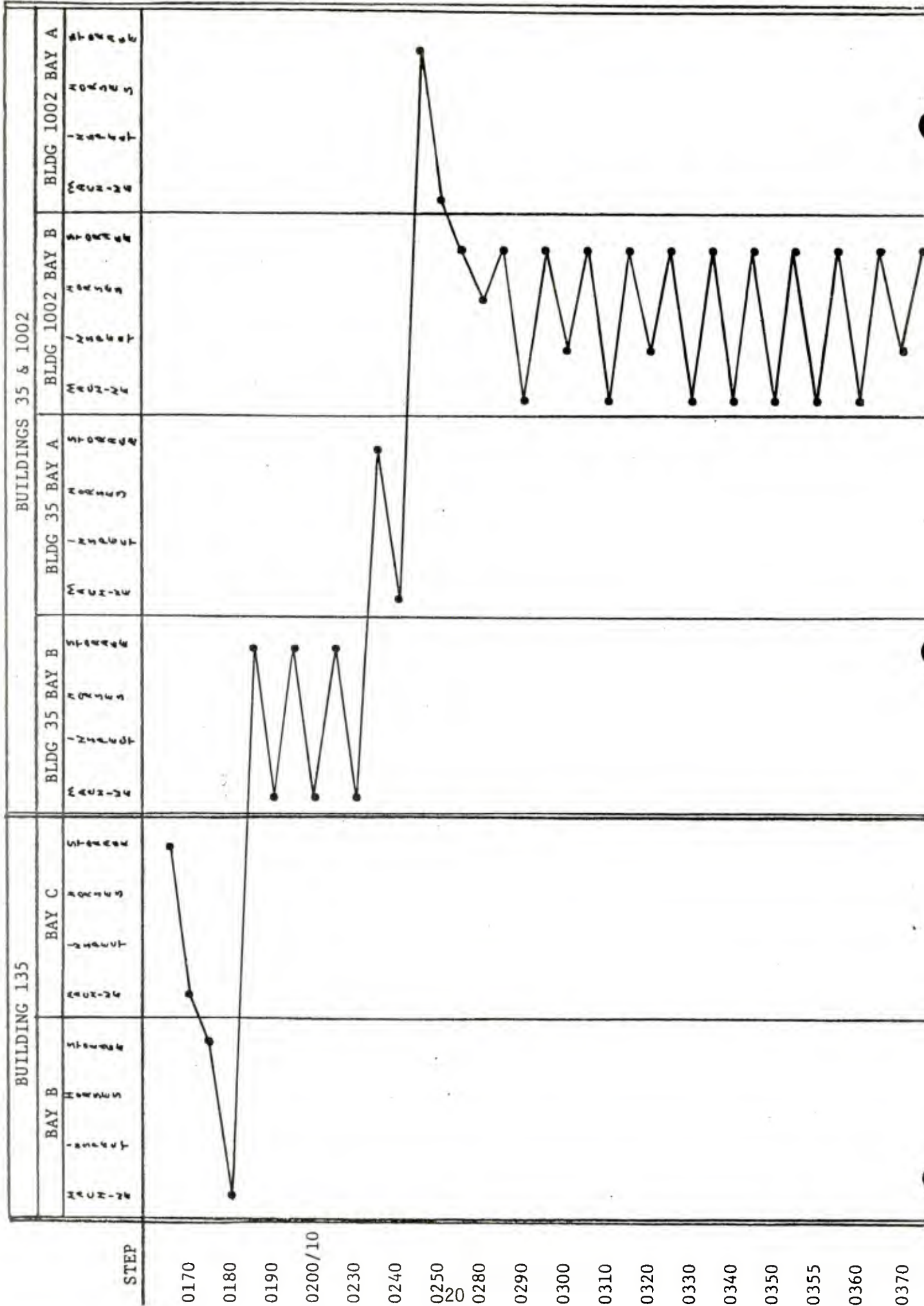
| <u>YEAR</u>     | <u>MONTH</u> | <u>MID SIZE<br/>(BLDGS 135 &amp; 35)</u> | <u>LARGE<br/>(BLDG 110)</u> | <u>SMALL<br/>(PROTO-<br/>TYPE AREA)</u> | <u>TOTAL</u> |
|-----------------|--------------|------------------------------------------|-----------------------------|-----------------------------------------|--------------|
| 1980            | NOV          | 234                                      | 45                          | 25                                      | 304          |
|                 | DEC          | 230                                      | 59                          | 50                                      | 339          |
| 1981            | JAN          | 208                                      | 45                          | 96                                      | 349          |
|                 | FEB          | 202                                      | 45                          | 103                                     | 350          |
|                 | MAR          | 188                                      | 40                          | 95                                      | 323          |
|                 | APR          | 192                                      | 32                          | 185                                     | 409          |
| 1982            | MAY          | 237                                      | 20                          | 263                                     | 520          |
|                 | JUN          | 208                                      | 9                           | 298                                     | 515          |
|                 | JUL          | 120                                      | 10                          | 203                                     | 333          |
|                 | AUG          | 183                                      | 14                          | 265                                     | 462          |
|                 | SEP          | 192                                      | 15                          | 260                                     | 467          |
|                 | OCT          | 178                                      | 20                          | 270                                     | 468          |
|                 | NOV          | 207                                      | 31                          | 270                                     | 508          |
|                 | DEC          | 188                                      | 15                          | 270                                     | 473          |
|                 | JAN          | 150                                      | 20                          | 270                                     | 440          |
|                 | FEB          | 206                                      | 27                          | 150                                     | 383          |
|                 | MAR          | 222                                      | 34                          | 90                                      | 346          |
|                 | APR          | <u>167</u>                               | <u>46</u>                   | <u>91</u>                               | <u>304</u>   |
| TOTAL           |              | 3512                                     | 527                         | 3254                                    | 7293         |
| MONTHLY AVERAGE |              | 195                                      | 29                          | 181                                     | 405          |



# MONTHLY TUBE PRODUCTION

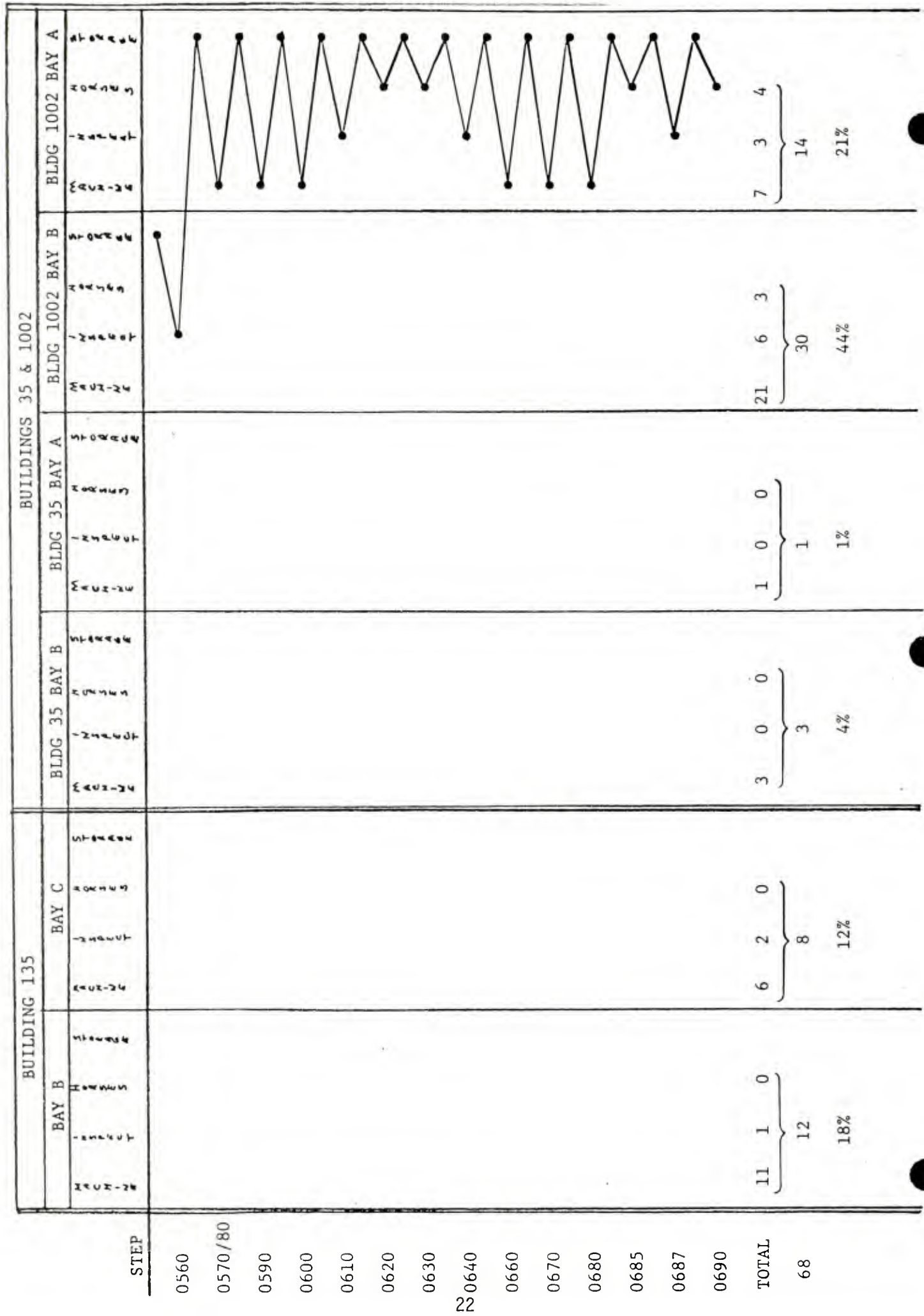














155MM CHIP OPERATIONS

| <u>STEP #</u>       | <u>% IF<br/>NEEDED</u> | <u>OPERATION</u>     | <u>MACHINE</u>              | <u>STD<br/>HOURS</u> | <u>ADD'L<br/>HOURS</u> |
|---------------------|------------------------|----------------------|-----------------------------|----------------------|------------------------|
| 0007                |                        | Turn roller spot     | Hollow spindle lathe        | 1.310                |                        |
| 0010                |                        | Straighten           | Hydraulic press             | 2.500                |                        |
| 0020                |                        | Face & chamfer       | Lehman hollow spindle lathe | 1.630                |                        |
| 0030                |                        | Turn                 | Engine lathe w/ 2 carriages | 3.800                |                        |
| 0035                |                        | Straighten           | Hydraulic press             | 1.000                |                        |
| 0040                |                        | Turn                 | Engine lathe                | 3.850                |                        |
| 0045                |                        | Straighten           | Hydraulic press             | 1.000                |                        |
| 0050                |                        | Bore 5.878 Dia.      | { Guided boring machine     | 1.720                |                        |
| 0070                |                        | Bore 5.935 Dia.      | { Guided boring machine     | 1.930                |                        |
| 0080                |                        | Bore powder chamber  | Lehman 2 end hollow spindle | 1.250                |                        |
| 0090                |                        | Hone 5.888 Dia.      | Barnes horiz. hone          | 1.000                |                        |
| 0100                |                        | Inspect              | Wooden horses               | --                   |                        |
| 0120                |                        | Clean, grease, swage | Swage                       | 4.020                |                        |
| 0130                |                        | Inspect              | Wooden horses               | --                   |                        |
| 0140                |                        | Thermal treat        | Elec. furnace               | 1.110                | 3.000                  |
| 0145                |                        | Inspect              | Wooden horses               | --                   |                        |
| 0150                |                        | Straighten           | Hydraulic press             | 1.490                |                        |
| 0153                |                        | Turn                 | Engine lathe w/ roller nest | 1.000                |                        |
| 0160                |                        | Bore 6.085 Dia.      | Guided boring machine       | 2.300                |                        |
| 0170                |                        | Rough hone           | Barnes horiz. hone          | 1.100                |                        |
| 0180                |                        | Saw excess stock     | Band saw                    | .690                 |                        |
| TRANSFER TO BLDG 35 |                        |                      |                             |                      |                        |

155MM CHIP OPERATIONS

| <u>STEP #</u> | <u>% IF<br/>NEEDED</u> | <u>OPERATION</u>           | <u>MACHINE</u>                                   | <u>STD.<br/>HOURS</u> | <u>ADD'L<br/>HOURS</u> |
|---------------|------------------------|----------------------------|--------------------------------------------------|-----------------------|------------------------|
| 0190          |                        | Bore powder chamber        | Lehman hollow spindle                            | 2.770                 |                        |
| 0200          |                        | Rough grind powder chamber | { 2440RY Bryant grinder<br>2440RY Bryant grinder | 2.730                 |                        |
| 0210          |                        | Inspect powder chamber     |                                                  | --                    |                        |
| 0230          |                        | Turn & spot                | Engine lathe                                     | 4.630                 |                        |
| 0240          |                        | Turn                       | Engine lathe w/ tracing                          | 1.690                 |                        |
| 0250          |                        | Turn                       | LeBland NC lathe                                 | 4.000                 |                        |
| 0280          |                        | Bench                      | Hand tools                                       | .650                  |                        |
| 0290          |                        | Mill breech thread         | Threadmill                                       | 3.550                 |                        |
| 0300          |                        | Inspect                    |                                                  | --                    |                        |
| 0310          |                        | Mill breech key            | Horiz. bore mill & drill                         | 2.060                 |                        |
| 0320          |                        | Inspect                    |                                                  | --                    |                        |
| 0330          |                        | Mill sectors               | Milling machine                                  | 2.000                 |                        |
| 0340          |                        | Mill muzzle keyway         | Rise & fall milling mach.                        | .500                  |                        |
| 0350          |                        | Rough mill slide keyway    | Milling M. w/ tracer                             | 2.370                 |                        |
| 0355          |                        | Chamfer muzzle end         | Engine lathe                                     | .500                  |                        |
| 0360          |                        | Finish hone                | Horiz. hone                                      | 2.230                 |                        |
| 0370          |                        | Inspect                    |                                                  | --                    |                        |
| 0380          |                        | Rifle                      | Rifler                                           | 2.930                 |                        |
| 0390          |                        | Bench                      | Hand tools                                       | 1.030                 |                        |
| 0400          | 20                     | Re-hone                    | Hone                                             | .500                  |                        |
| 0410          |                        | Inspect                    |                                                  | --                    |                        |
| 0420          |                        | Finish muzzle end          | Engine lathe                                     | 1.180                 |                        |
| 0430          |                        | Drill 10 evacuator holes   | Special mill & drill                             | 2.860                 |                        |
| 0440          |                        | Drill 3 evacuator holes    | Special mill & drill                             | 1.950                 |                        |

155MM CHIP OPERATIONS

| <u>STEP #</u> | <u>% IF<br/>NEEDED</u> | <u>OPERATION</u>          | <u>MACHINE</u>           | <u>STD.<br/>HOURS</u> | <u>ADD'L<br/>HOURS</u> |
|---------------|------------------------|---------------------------|--------------------------|-----------------------|------------------------|
| 0445          | 10                     | Burn out broken drills    | Tap burn out machine     | 2.000                 |                        |
| 0447          |                        | Mill quadrant flat        | Mill, tracer controlled  | .750                  |                        |
| 0480          |                        | Bore chamber offset       | Gisholt hollow spindle   | 3.150                 |                        |
| 0490          |                        | Grind chamber offset      | Powder chamber grinder   | 3.220                 |                        |
| 0492          |                        | Grind powder chamber      | { Powder chamber grinder | 3.990                 |                        |
| 0494          |                        | Polish powder chamber     | { Powder chamber grinder | .750                  |                        |
| 0510          |                        | Turn breech end bearings  | Engine lathe w/ revolve  | 1.000                 |                        |
| 0520          |                        | Bench-apply thread ring   | { Hand tools             | 2.860                 |                        |
| 0525          |                        | Bench-clean               | { Hand tools             | .500                  |                        |
| 0530          |                        | Electro polish chamber    | Chrome tanks             | 1.600                 |                        |
| 0540          |                        | Chrome plate chamber      | Chrome tanks             | 3.710                 | 7.500                  |
| 0550          |                        | Thermal treat             | Gas furnace              | 1.150                 | 16.000                 |
| 0560          |                        | Inspect                   |                          | --                    |                        |
| 0570          |                        | Grind powder chamber      | { Grinder                | 2.760                 |                        |
| 0580          |                        | Inspect                   | { Grinder                | --                    |                        |
| 0590          |                        | Grind slide surface       | Grinder                  | 3.560                 |                        |
| 0600          |                        | Finish mill slide keyway  | Mill w/ tracer           | 2.330                 |                        |
| 0610          |                        | Magnetic particle inspect |                          | --                    |                        |
| 0620          |                        | Bench-drill qtr. marks    | Hand tools               | 1.240                 |                        |
| 0630          |                        | Bench-keyway              | Hand tools               | 2.200                 |                        |
| 0640          |                        | Inspect                   |                          | --                    |                        |

155MM CHIP OPERATIONS

| <u>STEP #</u> | <u>% IF<br/>NEEDED</u> | <u>OPERATION</u>      | <u>MACHINE</u>      | <u>STD.<br/>HOURS</u> | <u>ADD'L<br/>HOURS</u> |
|---------------|------------------------|-----------------------|---------------------|-----------------------|------------------------|
| 0660          |                        | Vapor hone            | Vapor blast cabinet | 1.000                 |                        |
| 0670          |                        | Apply solid film lube | Solid film cabinet  | .960                  | 1.000                  |
| 0680          |                        | Cure solid film lube  | Gas furnace         | .960                  |                        |
| 0685          |                        | Bench-grooves         | Hand tools          | .960                  |                        |
| 0687          |                        | Inspect               | --                  | --                    |                        |
| 0690          |                        | Bench-stamp & lube    | Hand tools          | 1.750                 |                        |

STATISTICS

CRANE OPERATORS - TUBE OPERATION:

|          |              |
|----------|--------------|
| 21       | DAY SHIFT    |
| 10       | MIDDLE SHIFT |
| <u>2</u> | NIGHT SHIFT  |
| 33       | TOTAL        |

14 CRANE OPERATORS IN MACHINE BAYS OF BUILDINGS 35 & 135

FOLLOWERS - GROUNDSMEN:

| <u>DAY</u> | <u>NIGHT</u> | <u>TOTAL</u> |              |
|------------|--------------|--------------|--------------|
| 1          | 1            | 2            | BUILDING 135 |
| <u>2</u>   | <u>-</u>     | 2            | BUILDING 110 |
| 3          | 1            | 4            |              |

AVERAGE WAGE:

\$12/HOUR

\$25,000/YEAR



ALLOWED CRANE WAIT TIME IN STANDARD TIMES:\*

5 MIN. BUILDING 35  
 10 MIN. BUILDING 135  
 10 MIN. BUILDING 110

TUBE DIMENSIONS:

|                | <u>LENGTH</u> | <u>STARTING WEIGHT</u> | <u>FINISHED WEIGHT</u> |
|----------------|---------------|------------------------|------------------------|
| MID SIZE TUBES |               |                        |                        |
| 105MM          | 220"          | 2,800 LBS.             | 1,600 LBS.             |
| 155MM          | 250"          | 6,600 LBS.             | 2,500 LBS.             |
| LARGE TUBES    |               |                        |                        |
| 8"             |               | 14,000 LBS.            | 10,000 LBS.            |

\* CRANE WAIT DELAYS LARGER THAN ALLOWANCE ARE LOGGED IN THE LABOR REPORTING SYSTEM. MANY ARE IN EXCESS OF ONE HOUR.

## ALTERNATIVES

### MID SIZE TUBES

#### ALTERNATIVE ONE: MASTED CRANES

CONVERT 10 CRANES TO MASTED CRANES. ESTABLISH A RACKED CENTRAL STORAGE AREA WITHIN EACH BAY. STORE ALL TUBES INACTIVE BETWEEN PROCESSING STEPS IN THE CENTRAL STORAGE AREA OF THE BAY WITH THE NEXT PROCESSING STEP.

#### ADVANTAGES COMPARED TO CURRENT METHODS:

- MACHINISTS, INSPECTORS, AND FOLLOWERS WOULD NOT BE REQUIRED TO ATTACH/REMOVE SLINGS AND FOLLOW TUBES FROM POINT TO POINT.
- RIGGING TIME WOULD BE SAVED.
- POINT TO POINT MOVEMENT TIME WOULD DECREASE BECAUSE THE CRANE MOVES FASTER THAN THE FOLLOWER WALKS.
- 100% SELECTABILITY OF TUBES, ELIMINATING THE NEED TO MOVE TUBES ON TOP OF THE STACK TO OBTAIN THE DESIRED TUBE BURIED UNDERNEATH.
- INCREASED UTILIZATION OF STORAGE SPACE.
- A STORAGE METHOD COMPATIBLE WITH INVENTORY CONTROL SYSTEMS.

ALTERNATIVE ONE: MASTED CRANES (CONT'D)

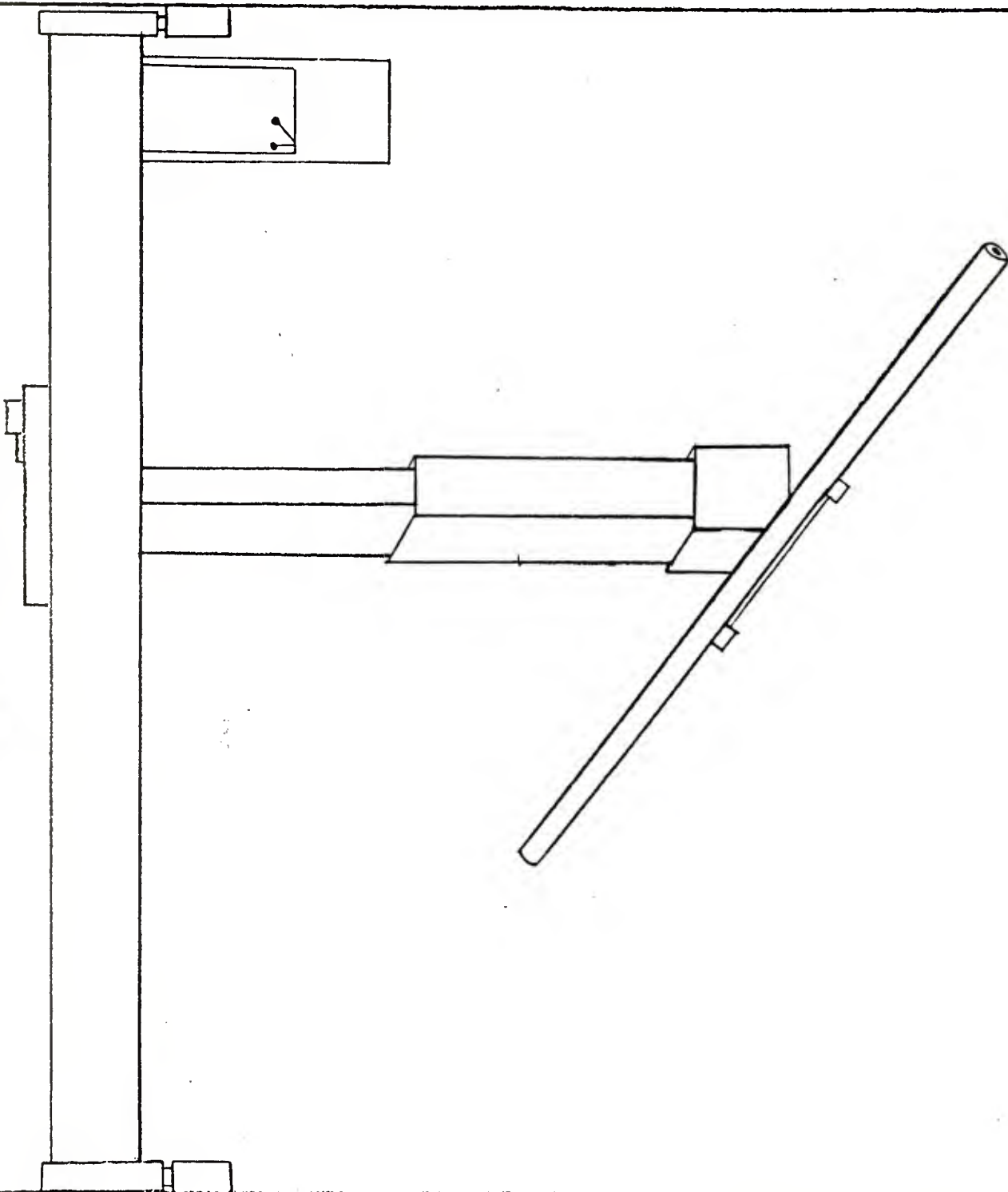
DISADVANTAGES COMPARED TO CURRENT METHODS:

- AVERAGE DISTANCE PER MOVE WOULD INCREASE SLIGHTLY.

PROBLEMS NOT RESOLVED:

- INTER-BAY MOVEMENTS ARE STILL A MULTIPLE STEP OPERATION REQUIRING A FLOOR MOVEMENT.
- TOTAL HANDLING TIME IS DEPENDENT ON LOCATION OF MACHINERY AS IT PERTAINS TO BAY ASSIGNMENT.
- THE OPERATION OF MORE THAN ONE CRANE IN A BAY CAUSES INTERFERENCE DUE TO ONE CRANE BLOCKING THE TRAVEL OF THE OTHER.
- THE CRANE OPERATORS AND MACHINE OPERATORS ARE TIED TO EACH OTHER. NEITHER WORKS WHEN THE OTHER IS WORKING. THEY WAIT ON EACH OTHER.

MASTED OVERHEAD CRANE



ALTERNATIVE ONE: MASTED CRANES

1981 DOLLARS

EQUIPMENT COSTS

CONVERSION OF CRANES TO MASTED CRANES

10 @ \$200,000

\$ 2,000,000

STORAGE RACKS

600 POSITIONS @ \$200/POSITION

120,000

TOTAL EQUIPMENT COSTS

\$ 2,120,000

ANNUAL SAVINGS (COSTS)

SAVINGS

MACHINISTS AND INSPECTORS

195 TUBES/MONTH

68 MOVES/TUBE

3 MINUTES/MOVE, ESTIMATED TIME REDUCTION

\$25,000/YEAR, WAGE RATE

\$ 99,500

CRANE OPERATORS

8 MOVES/HOUR

4 MAN REDUCTION, FROM 14 TO 10

\$25,000/YEAR, WAGE RATE

100,000

COSTS

MAINTENANCE ON NEW EQUIPMENT

3% OF MECHANICAL EQUIPMENT COST FOR PARTS & LABOR

(60,000)

TOTAL ANNUAL SAVINGS

\$ 139,500

PAYBACK

15.2 YEARS



ALTERNATIVE TWO: SIDELOAD TRUCKS

USE 5 SIDELOAD TRUCKS FOR INTER AND INTRA BAY TRANSPORTATION OF TUBES. HANDLE TUBES TWO AT A TIME IN A FIXTURE FOR ALL TRANSPORTATION MOVES. ZONE CRANES BY DIVIDING BAYS INTO SEGMENTS. LOAD AND UNLOAD MACHINES BY MACHINIST OPERATING CRANE FROM THE FLOOR. ESTABLISH A RACKED CENTRALIZED STORAGE AREA IN EACH BAY.

THE GENERAL METHODS OF OPERATION CONSIST OF THE SIDELOAD TRUCK DEPOSITING A THREE POSITION FIXTURE WITH AN EMPTY TUBE POSITION AND TWO TUBES TO BE PROCESSED ON THE FLOOR NEAR THE MACHINE TO BE USED FOR THAT PROCESS. THE MACHINIST WHEN FINISHED WITH THE TUBE ON HIS MACHINE WOULD WALK TO AN OVERHEAD CRANE SERVICING HIS MACHINE GROUP, OBTAIN THE FLOOR CONTROLS, MOVE THE CRANE TO HIS MACHINE, ATTACH THE SLINGS TO THE OLD TUBE, DEPOSIT THE OLD TUBE ON THE FIXTURE, REMOVE THE SLINGS, ATTACH THE SLINGS TO THE NEW TUBE, POSITION THE NEW TUBE IN THE MACHINE, REMOVE THE SLINGS, RELEASE THE CRANES FLOOR CONTROLS. THE MACHINIST REPEATS THIS PROCESS FOR THE SECOND TUBE. WHEN THE SECOND TUBE IS MOUNTED ON THE MACHINE THE MACHINISTS TURNS HIS RED SERVICE LIGHT ON. A SIDELOAD TRUCK DRIVER SEEING THE SERVICE LIGHT WOULD DRIVE TO THE FIXTURE CONTAINING TWO OLD TUBES, PICK IT UP, MOVE IT TO THE CENTRAL STORAGE AREA, PLACE IT IN A RACK POSITION, FIND A FIXTURE WITH TWO NEW TUBES, PICK IT UP, AND MOVE IT TO THE MACHINE'S FLOOR STAGING AREA. THE SIDELOAD TRUCK DRIVER HAS THE PROCESSING TIME OF A TUBE AT THIS STEP TO COMPLETE THE REPLACEMENT OF OLD TUBES WITH NEW TUBES. THIS IS USUALLY ONE TO THREE HOURS.

ALTERNATIVE TWO: SIDELOAD TRUCKS (CONT'D)

ADVANTAGES COMPARED TO CURRENT METHODS:

- OVERHEAD CRANE OPERATORS WOULD NOT BE REQUIRED FOR MACHINE BAY OPERATIONS.
- HIGHER UTILIZATION COULD BE MADE OF SIDELOAD VEHICLES VERSUS PRESENT USE OF CRANES. SIDELOAD VEHICLES COULD BE 90% UTILIZED WITHOUT SIGNIFICANT DELAY TIMES. PRESENTLY AT ALMOST ANY LEVEL OF UTILIZATION THERE IS DELAY TIME, AT 65% UTILIZATION THERE IS A DELAY AVERAGING 10 MINUTES PER MOVE, DELAYS AT UTILIZATIONS ABOVE 65% INCREASE RAPIDLY.
- MACHINISTS WOULD NOT WAIT FOR TUBE REPLACEMENT SERVICE.
- SIDELOAD DRIVERS WOULD NOT WAIT FOR MACHINISTS.
- EVERY JOB BECOMES A ONE MAN OPERATION.
- MULTIPLE HANDLINGS OF INTER-BAY MOVEMENTS WOULD BE ELIMINATED.
- MULTIPLE HANDLINGS OF INTER-BUILDING MOVES COULD BE ELIMINATED.
- THE NUMBER OF SIDELOADERS SERVICING AN AISLE ARE NOT FIXED. IMBALANCES OF WORKLOADS BETWEEN BAYS OR BUILDINGS CAN BE ADDRESSED BY REASSIGNING VEHICLES.
- THE LAYOUT OF MACHINERY BECOMES LESS IMPORTANT TO THE HANDLING SYSTEM.
- THE NUMBER OF MOVEMENTS WOULD DECREASE BY 50%.
- 100% SELECTABILITY OF TUBES, ELIMINATING THE NEED TO MOVE TUBES ON TOP OF THE STACK TO OBTAIN THE DESIRED TUBE BURIED UNDERNEATH.
- INCREASED UTILIZATION OF STORAGE SPACE.

ALTERNATIVE TWO: SIDELOAD TRUCKS (CONT'D)

- A STORAGE METHOD COMPATIBLE WITH INVENTORY CONTROL SYSTEMS.
- EQUIPMENT PURCHASED FOR THIS ALTERNATIVE WOULD ADD TO THE TOTAL CAPACITY FOR TUBE HANDLING.

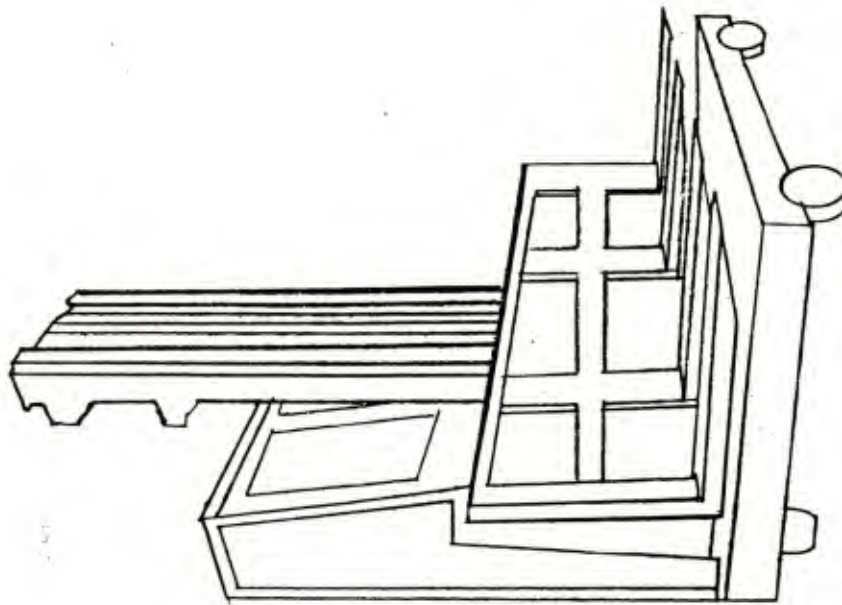
DISADVANTAGES COMPARED TO CURRENT METHOD:

- MACHINISTS WOULD HAVE TO KNOW HOW TO OPERATE CRANES.
- PATHWAYS WOULD HAVE TO BE ESTABLISHED FOR SIDELOAD TRUCKS.
- GROUND TRAFFIC WOULD INCREASE.

PROBLEMS NOT RESOLVED:

- TOTAL HANDLING TIME IS STILL DEPENDENT TO SOME EXTENT ON MACHINERY LOCATION, ALTHOUGH SIGNIFICANTLY REDUCED FROM CURRENT DEPENDENCY.

SIDELOAD TRUCK



ALTERNATIVE TWO: SIDELOAD TRUCKS

1981 DOLLARS

| <u>EQUIPMENT COSTS</u>         |                   |
|--------------------------------|-------------------|
| SIDELOAD TRUCKS                |                   |
| VEHICLES                       |                   |
| 5 @ \$69,000                   | \$ 345,000        |
| BATTERIES                      |                   |
| 5 @ \$5,000                    | 25,000            |
| CHARGERS                       |                   |
| 5 @ \$1,500                    | 7,500             |
| STORAGE RACKS                  |                   |
| 300 POSITIONS @ \$250/POSITION | 75,000            |
| TUBE HOLDING FIXTURES          |                   |
| 400 @ \$600                    | 240,000           |
| TOTAL EQUIPMENT COSTS          | <u>\$ 692,500</u> |

ANNUAL SAVINGS/(COSTS)

|                                                            |            |
|------------------------------------------------------------|------------|
| SAVINGS                                                    |            |
| MACHINISTS AND INSPECTORS                                  |            |
| 195 TUBES/MONTH                                            |            |
| 68 MOVES/TUBE                                              |            |
| 5 MINUTES/TUBE, ESTIMATED SAVINGS                          |            |
| \$25,000/YR. WAGE RATE                                     | \$ 165,700 |
| CRANE OPERATORS/SIDELOAD TRUCK DRIVERS                     |            |
| 8 MOVES/HOUR                                               |            |
| 2 TUBES/MOVE                                               |            |
| 9 MAN REDUCTION, 14 CRANE OPERATORS VS. 5 SIDELOAD DRIVERS |            |
| \$25,000/YR. WAGE RATE                                     | 225,000    |



1981 DOLLARS

ANNUAL SAVINGS/(COSTS) (CONT'D)

COSTS

MAINTENANCE ON NEW EQUIPMENT  
3% OF MECHANICAL EQUIPMENT COST FOR PARTS & LABOR  
TOTAL ANNUAL SAVINGS

\$ (11,300)  
\$ 379,400

PAYBACK

1.8 YEARS

ALTERNATIVE THREE: AUTOMATIC GUIDED VEHICLE SYSTEM (AGVS) AND SIDELOAD TRUCKS

USE 2 SIDELOAD TRUCKS FOR INTER AND INTRA BAY TRANSPORTATION OF TUBES IN BUILDING 135. INSTALL AN AUTOMATIC GUIDED VEHICLE SYSTEM CONSISTING OF 4 VEHICLES WITH TRAILERS HAVING AUTOMATED LOAD AND UNLOAD DEVICES IN BUILDINGS 35 AND 1002 FOR INTER AND INTRA BAY MOVEMENTS. CONSTRUCT 60 PICKUP AND DEPOSIT STATIONS THROUGHOUT BUILDINGS 35 AND 1002 FOR AUTOMATIC LOADING AND UNLOADING OF TUBES. HANDLE TUBES TWO AT A TIME IN A FIXTURE FOR ALL TRANSPORTATION MOVES. ESTABLISH A RACKED CENTRALIZED STORAGE AREA IN EACH BAY. IN BUILDINGS 35 AND 1002 USE 2 SIDELOAD TRUCKS FOR MOVES BETWEEN THE STORAGE PICKUP AND DEPOSIT STATIONS, AND THE STORAGE RACKS. ZONE CRANES BY DIVIDING BAYS INTO SEGMENTS. LOAD AND UNLOAD MACHINES BY MACHINIST OPERATING CRANE FROM THE FLOOR.

THE CONSIDERATION OF USING AUTOMATIC GUIDED VEHICLES IS EXCLUDED IN BUILDING 135 BECAUSE OF THE DIFFICULTY IN ESTABLISHING A SATISFACTORY GUIDE PATH. THIS IS DUE TO THE LACK OF AVAILABLE SPACE AT THE END OF THE BAYS REQUIRED FOR THE TURNING RADIUS OF THE VEHICLES AND THE METAL PLATES COVERING UTILITY TRENCHES WHICH WOULD MAKE WIRE GUIDANCE IMPRACTICAL.

THIS ALTERNATIVE HAS THE SAME METHODS OF OPERATION AND EQUIPMENT AS THE PREVIOUS ALTERNATIVE IN BUILDING 135. IN BUILDINGS 35 AND 1002 FROM THE MACHINISTS VIEWPOINT THE ONLY DIFFERENCE IS KEYING IN A COMMAND ON A PAD MOUNTED TO THE PICKUP AND DEPOSIT STATION THAT CALLS THE AUTOMATIC VEHICLE RATHER THAN TURNING ON THE RED SERVICE LIGHT. THE SIDELOAD DRIVER IN THE STORAGE AREA OPERATES SIMILARLY WITH SIGNIFICANTLY REDUCED DRIVING DISTANCES AND THE ADDITIONAL OPERATION OF KEYING THE DESTINATION FOR NEW TUBES TO BE DELIVERED.

ALTERNATIVE THREE: AUTOMATIC GUIDED VEHICLE SYSTEM (AGVS) AND SIDELOAD TRUCKS (CONT'D)

THE AUTOMATIC GUIDED VEHICLES MOVE TWO TUBES AT A TIME ON A FIXTURE BETWEEN PICKUP AND DEPOSIT STATIONS AT THE STORAGE AREAS AND THE MACHINE LOCATIONS. THE VEHICLES MOVE WITHOUT A DRIVER. THEY PICKUP AND DEPOSIT THE FIXTURES WITH THE TUBES AUTOMATICALLY TO OR FROM THE P & D STATIONS. THE ONLY HUMAN INTERVENTION REQUIRED IS KEY ENTERING THE DESTINATION OF THE LOAD ON A PAD MOUNTED ON EACH PICKUP AND DEPOSIT STATION. THE KEYING OF THE DESTINATION CALLS THE NEXT AVAILABLE VEHICLE AND INSTRUCTS IT WHERE TO TAKE AND DEPOSIT THE LOAD.

ADVANTAGES OF THE AGV SYSTEM COMPARED TO THE SIDELOAD TRUCK ALTERNATIVE:

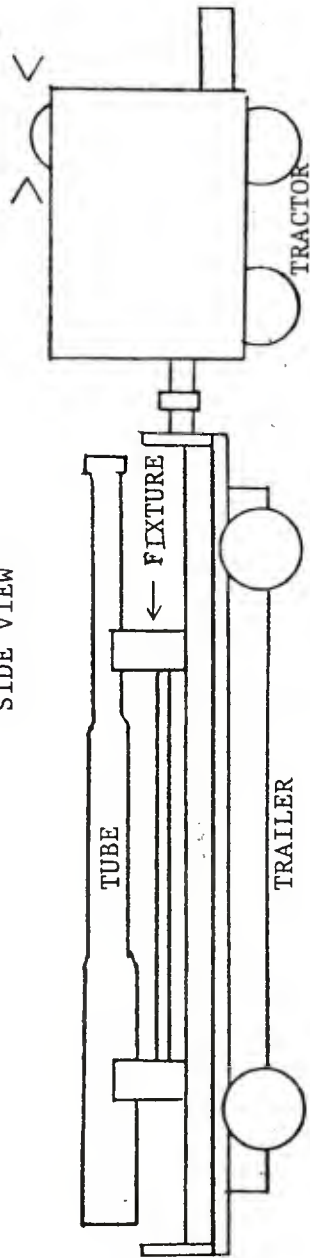
- MANPOWER REQUIRED IN TRANSPORTATION OF TUBES IN MINIMIZED.
- MACHINE LAYOUT HAS NO IMPACT ON MATERIAL HANDLING LABOR. (IT COULD REQUIRE ADDITIONAL VEHICLES.)
- IT WOULD ASSURE FIRST CALLED-FIRST SERVED OPERATING METHODS.

DISADVANTAGES OF THE AGV SYSTEM COMPARED TO THE SIDELOAD TRUCK ALTERNATIVE:

- IT IS NOT AS FLEXIBLE.

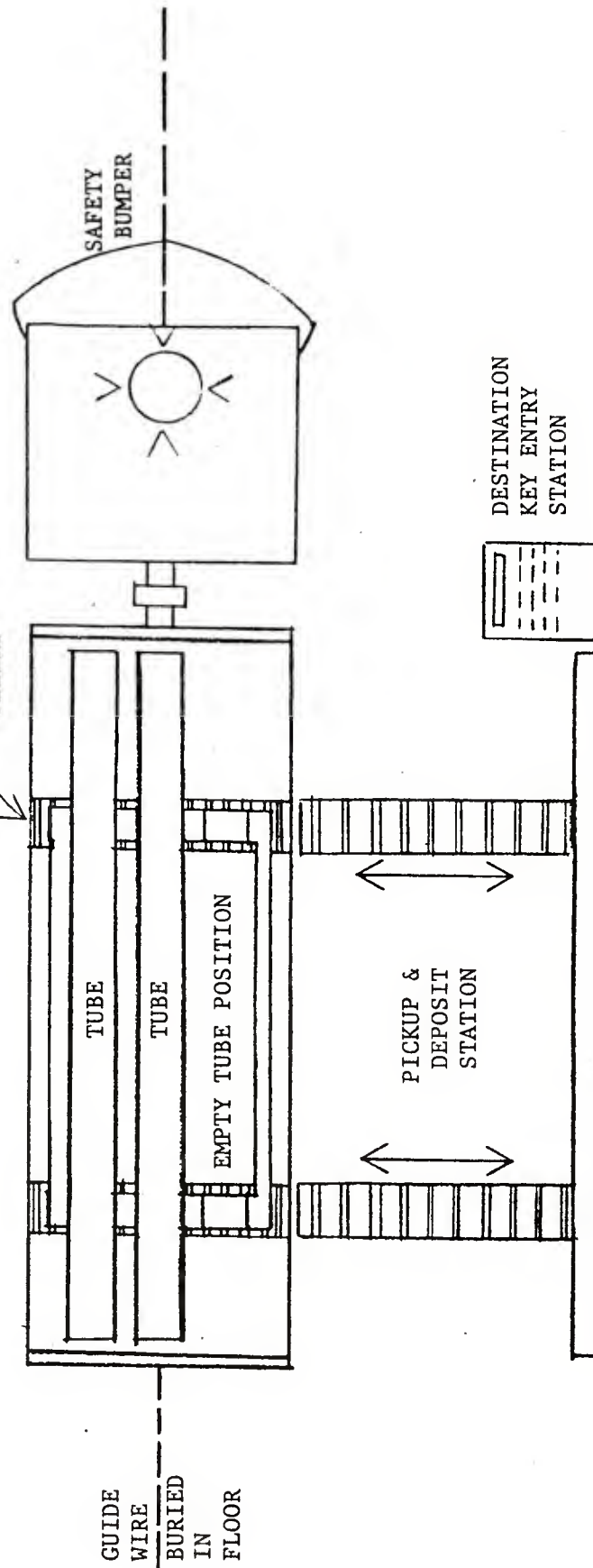
# AUTOMATIC GUIDED VEHICLE SYSTEM (AGVS)

SIDE VIEW



TOP VIEW

POWERED  
ROLLERS



ALTERNATIVE THREE: AUTOMATIC GUIDED VEHICLE SYSTEM AND SIDELOAD TRUCKS

|                                        | <u>1981 DOLLARS</u> |
|----------------------------------------|---------------------|
| <u>EQUIPMENT COSTS</u>                 |                     |
| <u>AUTOMATIC GUIDED VEHICLE SYSTEM</u> |                     |
| TRACTORS                               |                     |
| 4 @ \$19,000                           | \$ 76,000           |
| BATTERIES                              |                     |
| 4 @ \$3,200                            | 12,800              |
| CHARGERS                               |                     |
| 4 @ \$1,500                            | 6,000               |
| TRAILERS                               |                     |
| 4 @ \$5,000                            | 20,000              |
| BATTERIES                              |                     |
| 4 @ \$1,800                            | 7,200               |
| CHARGERS                               |                     |
| 4 @ \$1,500                            | 4,500               |
| WIRE GUIDE PATH                        |                     |
| 3200' @ \$15/FT                        | 48,000              |
| P & D STATIONS                         |                     |
| 60 @ \$500                             | 30,000              |
| <u>SIDELOAD TRUCKS</u>                 |                     |
| VEHICLE                                |                     |
| 4 @ \$69,000                           | 276,000             |
| BATTERIES                              |                     |
| 4 @ \$5,000                            | 20,000              |
| CHARGERS                               |                     |
| 4 @ \$1,500                            | 4,500               |

EQUIPMENT COSTS (CONT'D)

1981 DOLLARS

STORAGE RACKS  
300 POSITIONS @ \$250/POSITION

\$ 75,000

TUBE HOLDING FIXTURES  
400 @ \$600

240,000

TOTAL EQUIPMENT COSTS

\$ 820,000

ANNUAL SAVINGS/(COSTS)

SAVINGS

MACHINISTS AND INSPECTORS

195 TUBES/MONTH

68 MOVES/TUBE

5 MINUTES/MOVE, ESTIMATED TIME REDUCTION

\$25,000/YEAR, WAGE RATE

\$ 165,700

CRANE OPERATORS/SIDELOAD TRUCK DRIVERS

8 MOVES/HOUR, TRANSPORTATION & STORAGE

14 MOVES/HOUR, STORAGE ONLY

2 TUBES/MOVE

10 MAN REDUCTION, 14 CRANE OPERATORS VS. 4 SIDELOAD

\$25,000/YEAR, WAGE RATE

250,000

COSTS

MAINTENANCE ON NEW EQUIPMENT

3% OF MECHANICAL EQUIPMENT COSTS FOR PARTS & LABOR

(15,200)

TOTAL ANNUAL SAVINGS

\$ 400,500

PAYBACK

2.0 YEARS



## ALTERNATIVES

### LARGE TUBES

PHYSICAL RESTRICTIONS IN BUILDING 110, WHERE LARGE TUBES ARE PROCESSED, PROHIBIT THE CONSIDERATION OF ALTERNATIVES INVOLVING MOVEMENT OF TUBES BY SIDELOAD TRUCKS, AUTOMATIC GUIDED VEHICLES, OR OTHER FLOOR RUNNING DEVICES. AN ALTERNATIVE TO CONVERT SOME OF THE PRESENT CRANES TO MASTED CRANES WAS EXPLORED. HOWEVER, CONVERSION OF THE PRESENT CRANES IS NOT POSSIBLE DUE TO THE WEIGHT OF THE TUBES. THE PURCHASE OF NEW MASTED CRANES OF THE CAPACITY REQUIRED WOULD BE PROHIBITIVELY EXPENSIVE AS COMPARED TO THE SMALL SAVINGS THAT WOULD RESULT IN IMPROVED EFFICIENCY OF PROCESSING AN AVERAGE 30 TUBES PER MONTH.

SUMMARY COSTS AND SAVINGS COMPARISON OF MID SIZE TUBE ALTERNATIVES  
(1981 DOLLARS)

|                                         | ALTERNATIVE<br>ONE  | ALTERNATIVE<br>TWO | ALTERNATIVE<br>THREE |
|-----------------------------------------|---------------------|--------------------|----------------------|
| <u>EQUIPMENT COSTS</u>                  |                     |                    |                      |
| MATERIAL HANDLING EQUIPMENT             | \$ 2,000,000        | \$ 377,500         | \$ 505,000           |
| RACKS & FIXTURES                        | 120,000             | 315,000            | 315,000              |
| TOTAL EQUIPMENT COSTS                   | <u>\$ 2,120,000</u> | <u>\$ 692,500</u>  | <u>\$ 820,000</u>    |
| <br><u>ANNUAL SAVINGS/(COSTS)</u>       |                     |                    |                      |
| <u>SAVINGS</u>                          |                     |                    |                      |
| MACHINISTS & INSPECTOR WAGES            | \$ 99,500           | \$ 165,700         | \$ 165,700           |
| CRANE OPERATOR (MATERIAL HANDLER) WAGES | 100,000             | 225,000            | 250,000              |
| <br><u>COSTS</u>                        |                     |                    |                      |
| MAINTENANCE, PARTS & LABOR              | (60,000)            | (11,300)           | (15,200)             |
| TOTAL ANNUAL SAVINGS                    | <u>\$ 139,500</u>   | <u>\$ 379,400</u>  | <u>\$ 400,500</u>    |

## RECOMMENDATIONS

THIS STUDY IDENTIFIES TWO ALTERNATIVE SYSTEMS FOR TRANSPORTING TUBES THAT RESULT IN SUBSTANTIAL PRODUCTIVITY IMPROVEMENTS AS COMPARED TO THE PRESENT SYSTEM OF CAB OPERATED OVERHEAD CRANES. THESE ALTERNATIVE SYSTEMS USE SIDELOAD TRUCKS OR AUTOMATIC GUIDED VEHICLES AS THE PRIMARY TUBE TRANSPORTATION DEVICES. THE ESTIMATED EQUIPMENT COSTS AND ANNUAL SAVINGS OF THESE ALTERNATIVES ARE SIMILAR WITH A PAYBACK PERIOD OF 1.8 YEARS FOR SIDELOAD TRUCKS AND 2.0 YEARS FOR AN AUTOMATED GUIDED VEHICLE SYSTEM.

THE ALTERNATIVE TO USE SIDELOAD TRUCKS AS THE MAJOR TUBE TRANSPORTATION DEVICE AND TO ESTABLISH CENTRAL STORAGE AREAS IS RECOMMENDED. THE REASONS FOR RECOMMENDATION ARE:

- BEST COST/BENEFIT RELATIONSHIP OF ALL ALTERNATIVES
- IMPROVED PRODUCTIVITY
- INCREASE OF TUBE HANDLING CAPACITY
- INCREASE OF TUBE STORAGE CAPACITY
- PROVEN EQUIPMENT
- FLEXIBILITY

THE ESTIMATED EQUIPMENT COST TO IMPLEMENT THIS ALTERNATIVE IS \$692,500 WITH AN EXPECTED ANNUAL SAVINGS OF \$379,400. THE SAVINGS RESULT FROM INCREASED PRODUCTIVITY DUE TO

SIGNIFICANT OPERATIONAL ADVANTAGES THE RECOMMENDED ALTERNATIVE HAS OVER THE CURRENT SYSTEM:

- REDUCES THE INTERDEPENDENCY OF MACHINING OPERATIONS AND TUBE TRANSPORTATION.
- MINIMIZES THE IMPACT MACHINERY LOCATIONS HAVE ON TUBE TRANSPORTATION TIME.
- ALLOWS TWO TUBES TO BE MOVED SIMULTANEOUSLY, CUTTING THE TOTAL NUMBER OF TUBE MOVEMENTS IN HALF.

THE ALTERNATIVE TO INSTALL AN AUTOMATIC GUIDED VEHICLE SYSTEM IS ALSO COST JUSTIFIABLE AND HAS THE SAME OPERATIONAL ADVANTAGES. IT IS A FEASIBLE ALTERNATIVE. HOWEVER, IT IS NOT RECOMMENDED BECAUSE THE SIDELOAD TRUCK ALTERNATIVE ACCOMPLISHES NEARLY THE SAME RESULT IN A LESS COSTLY AND COMPLEX MANNER.

IMPLEMENTATION OF THE RECOMMENDED ALTERNATIVE CAN BE MADE WITH MINIMUM DISRUPTION TO DAILY OPERATIONS. IT DOES NOT REQUIRE ANY MODIFICATIONS TO THE BUILDINGS. IT WILL REQUIRE, TO SOME EXTENT, THE RELOCATION OF MACHINERY TO DEVELOP ADEQUATE TRANSPORTATION AISLES AND STORAGE LOCATIONS.

IT IS POSSIBLE TO IMPLEMENT THE ALTERNATIVE IN STAGES WITH MINIMAL COST PENALTIES. STAGED IMPLEMENTATION COULD YIELD SEVERAL ADVANTAGES. THE COST BENEFITS COULD BE VERIFIED BEFORE A TOTAL EXPENDITURE IS MADE. OPERATIONAL TECHNIQUES COULD BE DEVELOPED AND DEBUGGED ON A SMALL GROUP OF OPERATIONS AVOIDING TRIAL AND ERROR SITUATIONS INVOLVING THE TOTAL FACILITIES.

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