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Portsmouth Fastener Manufacturing Workstation

Fastener Engraving System (Design, Construction, and Operation)

**Mahn Hee Hahn
Michael Huff**

U.S. DEPARTMENT OF COMMERCE
Technology Administration
National Institute of Standards
and Technology
Automated Production Technology Division
Gaithersburg, MD 20899

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NIST



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February 1993



**U.S. DEPARTMENT OF COMMERCE
Ronald H. Brown, Secretary**

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Mary L. Good, Under Secretary for Technology**

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AND TECHNOLOGY
Arati Prabhakar, Director**

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The continuous support from the Office of the Assistant Secretary of the Navy's Manufacturing Technology program to the Automated Manufacturing Research Facility (AMRF) at the National Institute of Standards and Technology is appreciated. The support has been essential to the success of the Portsmouth Fastener Manufacturing Workstation project, the transfer of technology to other Naval facilities, and other research activities in the AMRF.

The authors wish to thank the Naval Sea Systems Command (NAVSEA 07) for their participation in the project.

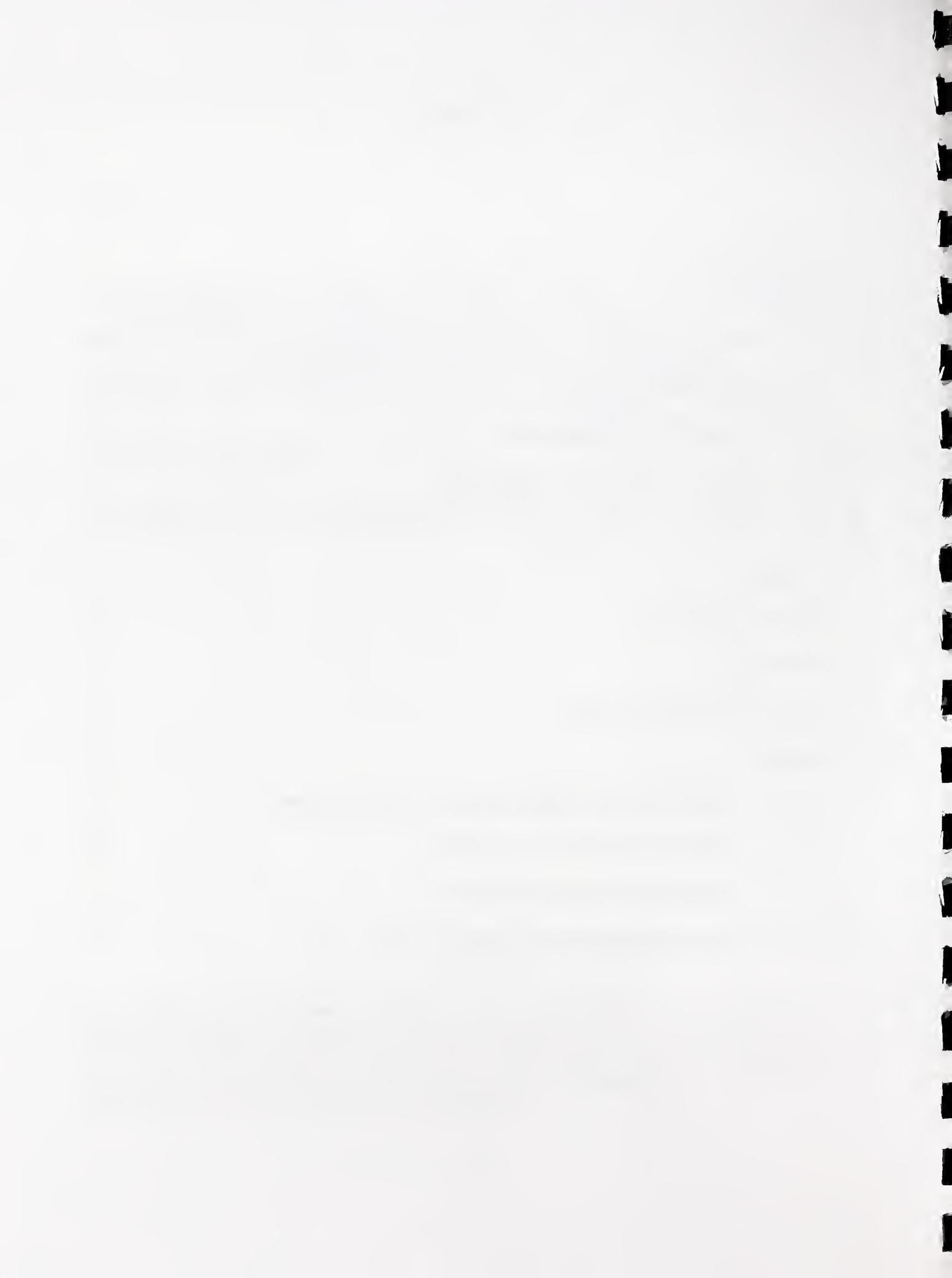
The authors also wish to express special appreciation and gratitude to Mary Mareello for her tireless effort and assistance in the preparation of this manuscript.

Disclaimer

Certain commercial equipment, instruments, or materials are identified in this paper in order to adequately specify the experimental setup and workstation capability. Such identification does not imply recommendation or endorsement by the National Institute of Standards and Technology, nor does it imply that the equipment identified are necessarily the best available for the purpose or the only equipment that can be used.

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**Portsmouth Fastener Manufacturing Workstation
Fastener Engraving System
(Design, Construction, and Operation)**

1. Introduction

The Portsmouth Fastener Workstation is an applied research and development project conducted in the Automated Manufacturing Research Facility (AMRF) by the Automated Production Technology Division in collaboration with the Portsmouth Naval Shipyard (PNS) and industry partners. This project is funded in part by both the Navy Manufacturing Technology program and the National Institute of Standards and Technology (NIST). At the request of our sponsor, the U.S. Navy, we are applying the technology pioneered in the AMRF into a workstation that will provide immediate benefits to the Navy by meeting the naval shipyard's need for advanced fastener manufacturing technology. The goal of the project is to develop an on-line, error-compensated machining system equipped with the necessary technology and computer control systems for the efficient production of highly-accurate, Level-1[1], SUBSAFE, threaded fasteners of various types and sizes.

The Portsmouth Naval Shipyard, New Hampshire and other naval shipyards around the country currently manufacture fasteners such as hex-head cap screws, socket-head cap screws, and studs, from the materials k-monel, nickel copper, and alloy steel. Level-1 fasteners made from K-monel and nickel-copper are difficult to procure from vendors because of very stringent specifications. These fasteners must conform to FED-STD-H28, MIL-S-1222h, and ANSI-18.2 specifications. All naval shipyards manufacture these fasteners by a conventional machining process requiring several machines, different setups, many part-handling, and frequent inspections. This way of making Level-1 fasteners is very time-consuming and expensive.

Based on MIL-S-1222H and PROCESS INSTRUCTION 9200-942-500H, every manufactured fastener which passes inspection must be engraved with the manufacturer's identification, lot number, material symbol, and nylon insert hole symbol (if applicable) on the fastener head. Currently, the shipyard marks each fastener manually either with a vibrating marking pen, which can produce inconsistent results, or a stamping die. Both methods are very labor intensive and expensive.

The Portsmouth Fastener Manufacturing Workstation [2], developed by NIST, consists of a CNC turning/milling machining center to manufacture the fasteners. The fasteners are machined using a closed-loop, quality-control process. The completed fasteners are engraved with identification codes on the head of the fastener using a computerized engraving machine. This document describes the design, construction, and operation of the engraving system.

2. Design Goal

A. Conceptual Design:

The fastener workstation and engraving system are designed to be run by a single operator. To increase productivity and minimize engraving costs, the engraving system;

- 1) must be simple and reliable,
- 2) must be easy to operate,
- 3) requires minimum set-up and engraving time,
- 4) produces quality engraved characters on fasteners,
- 5) requires minimal maintenance.

Since fasteners are normally manufactured in batches or lots, it is desirable to engrave the fasteners in batches or lots to increase productivity. Engraving is the last operation after the fasteners are made and pass final inspection. Therefore, minimizing engraving errors is critical to productivity. The operator engraves the fasteners at the end of each 8-hour shift or at the end of a batch. The maximum number of fasteners manufactured in an 8-hour shift (net 7 hour's work) is estimated at about 42 pieces (10 minutes per piece). To carry out this task, a single set-up with a multi-spindle engraving system is desired.

B. Implementation:

Although the turning/milling center had demonstrated engraving capabilities using rotary tooling in the machine, this operation was judged impractical. A few hi-tech marking systems, such as laser engraving, electrical discharge machining, or dot matrix impact marking were examined, but not considered because of the high cost, impracticality, and/or marking specification requirements.

A computer-controlled, single-point rotary-cutter-type engraver was chosen. Out of more than a dozen engraving systems of this type on the market, the NEWING-HALL Model TLC300 was selected. The TLC300 is a fully computerized 2-axis, flat-bed, and through-the-table engraving system. The host computer is PC-compatible with a DOS operating system. Some features and capabilities are:

- a. The engraving work area of the flat bed table is X-400 mm (16.5 in.), Y-380 mm (15 in.).

- b. Two rotary spindles with variable speed. Easily converted from single-spindle to dual-spindle operation.
- c. The depth of cut is adjustable either by a fixed depth with solid stop or a fixed depth with floating spindle riding on the engraving surface.
- d. Continuous and repeated cutting in matrix pattern (row and column).
- e. Built-in vacuum chip-removal system.
- f. Engraving pattern, size, and font can be easily generated and viewed on the computer CRT screen.
- g. Engraving files can be easily modified and revised.

Three general types of fasteners (hex-head cap screw, socket-head cap screw, and stud) are primarily engraved in the workstation. The size of the fastener is limited by the capacity of the machining center. The largest blank rod diameter is 41.3 mm (1.625 in.). The nominal size of the fasteners range from 6.35 mm (0.25 in.) to 38.1 mm (1.5 in.). However, due to the head size, the largest size of hex head screws is limited to 22.2 mm (7/8 in.) and the socket head screws is 25.4 mm (1 in.). The length of the fasteners range from 19 mm (3/4 in.) to 114.3 mm (4.5 in.), but the part fixture can clamp any length of fastener. Engraving is done on the surface of the screw head. For the stud, engraving is done on the end face. Typical examples of engraving are shown in figure 1.

3. Part Fixture Design and Construction

Since there were no commercial fixturing devices available for this type of application, a part clamping fixture was designed and constructed at NIST. To design the part clamping fixture, the following design criteria and features were considered:

- 1. Maximize the use of the engraving work area - load as many parts as possible per engraving run.
- 2. Accommodate the variations of body diameter within the allowable tolerance for each size.
- 3. Provide enough clamping force to prevent any lateral and/or rotational movements, but not enough to leave any clamping marks.
- 4. Provide a solid stop to maintain a uniform engraving height, especially for the studs which do not have a head.
- 5. Quick and easy part loading and unloading.

6. Provide a fixed array of fixturing locations to simplify the programming.
7. Free of maintenance.

In order to automate the engraving process, the fasteners must be firmly fixtured in the engraving machine. The desired fixturing method is a quick-clamping and quick-unclamping of the fasteners.

The key to the fixture design is the selection of the clamping actuator. Among many types of actuators (mechanical, pneumatic, hydraulic), a pneumatic inflatable gasket was selected for its physical size, ability to accommodate diameter variations, uniform clamping force, and easy control of clamping force.

The basic design of the part fixture is shown in figure 2. A total of 42 fixturing locations is arranged in 6 columns and 7 rows. The overall assembly and the component part numbers are shown in assembly drawing No. 1000 of Appendix A.

The engraving fixture system was designed and constructed at NIST. Detailed engineering drawings for the engraving fixture are shown in Appendix A.

The basic principle of the clamping scheme is as follows:

1. For the left two columns, seven pairs of movable clamping blocks (figure 2, Part No. 5A) are placed in a column facing out with an inflatable gasket in the middle.
2. A fixed block (figure 2, Part Nos. 3 and 4) is placed on the outside of each of two moving blocks to form a nominal 38.1 mm (1.5 in.) diameter clamping collet.
3. When the inflatable gasket is pressurized by regulated air pressure, it pushes the moving blocks against the fixed block to hold the part. The maximum movement of the moving block is 1.27 mm (0.050 in.). The variations in the fastener's body diameter within the allowable tolerance are automatically accommodated. Two small spring plungers in each moving block keep the maximum hole opening when the gasket is deflated, but its spring force is easily overcome when the gasket is inflated. The surface area of each gasket per block is about 12.9 cm² (2 in.²). The maximum air pressure can be up to 550 kPa (80 lbf/in.²) which provides approximately 700 N (160 pound-force per block). Normally, an air pressure of 275 kPa (40 lbf/in.² gage) is sufficient for holding the fasteners.
4. To clamp the various sizes of body diameter, different hole size insert pairs (figure 2, Part No. 5B) are used. An insert pair is made from a full cylindrical insert cut in two halves.
5. A cover plate (Appendix A, Part No. 8) with matching body diameter holes is placed

on top of the fixture to prevent chips from falling down. It also works as a solid stop for the hex and socket head cap screws to provide a uniform engraving height.

6. For the studs, a parallel jack with a stop plate (Appendix A, Part No. 10) is used to hold the studs up and adjust the engraving height. A linear scale attached to the front plate (Part No. 11A) with a pointer attached to the stop plate provides a simple means of adjusting the proper height of the stop plate.
7. For chip removal, a venturi-type vacuum pump was used. This pump runs on shop compressed air. It is very compact and quiet, and requires very little maintenance.

4. Homing Sensor System Design and Construction

The engraving machine as delivered from the manufacturer provides no fixed reference or starting position. A starting position has to be set for each job. Establishing a starting position and maintaining it every time the engraving system is used is time consuming and a very tedious process. To engrave a set of fasteners in a 6 by 7 matrix, a reference starting (home) position has to be established and be easily reset. Particularly, engraving the socket-head cap screws of smaller size requires more precise reference positioning because of the circular pattern and narrower width of the engraving area. Since the center of the upper left hole is the starting position of the cutter spindle, this position is selected as the home position.

To maintain, monitor, and adjust the home position, an electronic inductive proximity sensor was mounted on each axis as shown in assembly drawing No. 2000 of Appendix A. This sensor is mounted in the spring plunger so that the cutter spindle can move beyond the home position. A LED lamp is used to indicate the home position of each axis. This homing sensor is mounted in the upper left corner to minimize visual obstruction as well as physical interference. By using a simple reference bushing insert, as shown in Appendix B, and a blank cutter, the cutter spindle can be easily aligned to the home position within 0.05 mm (0.002 in.). The engraving machine, fixture, pneumatic system, and the computer were integrated as one unit and installed in a work bench.

5. Software Development

Using a PC-type computer system, it is very easy to generate various engraving texts, patterns, and character sizes, which can be saved as job files. However, for each batch or job, a new text is required, such as batch number, material symbol, nylon insert hole symbol, etc. To further reduce engraving set-up time and make it operator friendly, an interface software featuring a menu driven system was developed. The basic concept of engraving software set-up and scheme is as follows:

- a. A series of blank engraving patterns for each size and type of fastener was pre-generated and stored as files.

- b. The interface software program allows the operator to access the computer directly without going through a lengthy initial engraving setup procedure. All engraving features and selections are displayed in a menu. The operator needs only to respond to the menu to select a type and size of fastener, and type in the necessary text. This program was written in the C-programming language.
- c. The text import function receives the menu inputs and generates a complete engraving file. This file is then executed by the engraving controller to engrave the fasteners.

This interface software program not only simplifies the engraving file setup, it also minimizes the engraving setup errors. The detailed procedures and setup menu are described in Appendix B.

6. Operation

The basic operations of the engraving machine are the mechanical setup and software operation. The detailed procedures are described in Appendix B. Appendix B, an operator's manual, can be used as a separate document to train the operators.

7. Engraving Other Objects

To engrave other types of fasteners, such as a flat-head screw, the operator simply creates a new job file. The engraving machine was originally designed to engrave on a flat plate or cylindrical surface. To engrave on a flat plate, place the original clamping plate on the engraving machine above the part fixture system and engrave it with the original machine setup procedures. To engrave on cylindrical objects, the cylindrical attachment must be used. Detailed procedures are described in the NEWING-HALL Manual.

8. Conclusion

The engraving system was tested and debugged at NIST and was put in production use as a part of the fastener workstation. The results of production tests were excellent. A typical batch of 42 fasteners can be engraved in 15 minutes. The quality and uniformity of engravings were far better than manual engravings. The fastener workstation, including the engraving system, was transferred to PNS and put into service in their production line in June, 1992. Production runs for six months proved that the engraving system is very reliable and easy to use. PNS is continually expanding use of this engraving system for other types of fasteners.

9. Discussion and Recommendation

The engraving cutter is a micro-grained, solid carbide cutter from a commercial source. Since the smallest width of the cutter tip is 0.13 mm (0.005 in.), the cutter has a tendency to break or wear off easily. In particular, K-Monel fasteners are hard to engrave because of the

characteristics of the material. To prevent the premature tip wear or breakage, the use of a cutting oil is strongly recommended. However, the selection of oil is very limited because of the possibility of contamination by the cutting oil, particularly for nuclear submarine application. Presently, a 100% concentrated machine coolant for fastener machining is used. However, the number of engravings per cutter varies from one cutter to another. One cutter may engrave about 100 fasteners, another cutter may cut less than five. Normally, a new cutter will engrave a batch of 42 fasteners. The type of fastener material plays a major role on tool life. There are many factors involved in cutter wear and breakage. Mainly they are:

- a. Cutter material.
- b. Geometry of cutter tip (cutting angles).
- c. Method and uniformity of the grinding cutter tips.
- d. Spindle speed (RPM) and feed rate.
- e. Spindle push down speed based on air pressure and needle valve control.
- f. Type of cutting oil.
- g. Chip removal condition.

When running a batch job, early detection of tool wear and breakage are very critical in preventing mass engraving failures. In most cases, re-engraving by refinishing the head is conceivable, but not always possible due to the head height tolerance. The main goal is to eliminate any re-work at the final stage of fastener manufacturing. The authors strongly recommend that cutter wear and breakage be further studied by experimenting in the following areas:

- a. Develop cutter resharpening/regrinding techniques to obtain consistent cutting angles and sharp cutting edges.
- b. Optimize the spindle speed and feed rate for various fastener materials.
- c. Study the variations of cutting angles.
- d. Experiment with other cutter material, such as synthetic diamond.

References

- [1] As defined in Submarine Safety Requirements in NAVSEA Manual 0924-0010.
- [2] To be published as a National Institute of Standards and Technology Internal Report, 1993.

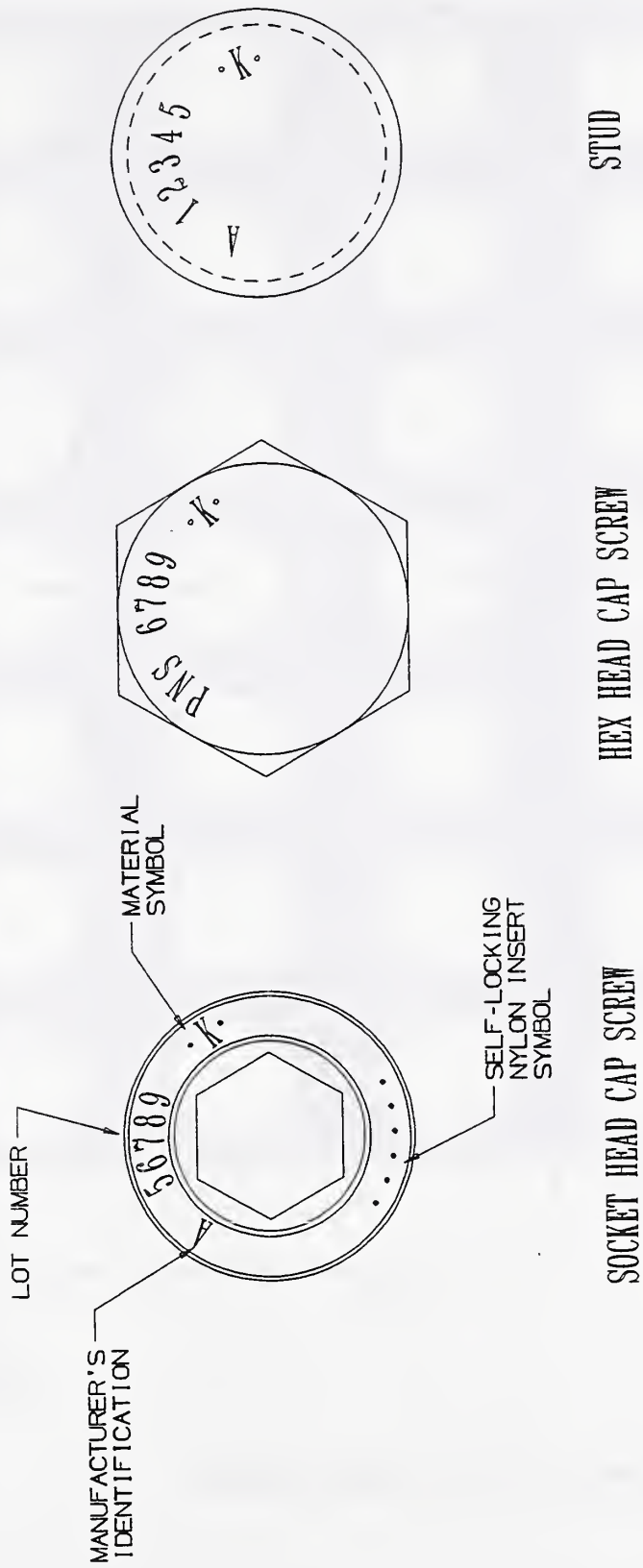


Figure 1. Typical Example of Engravings on the Head of Fasteners

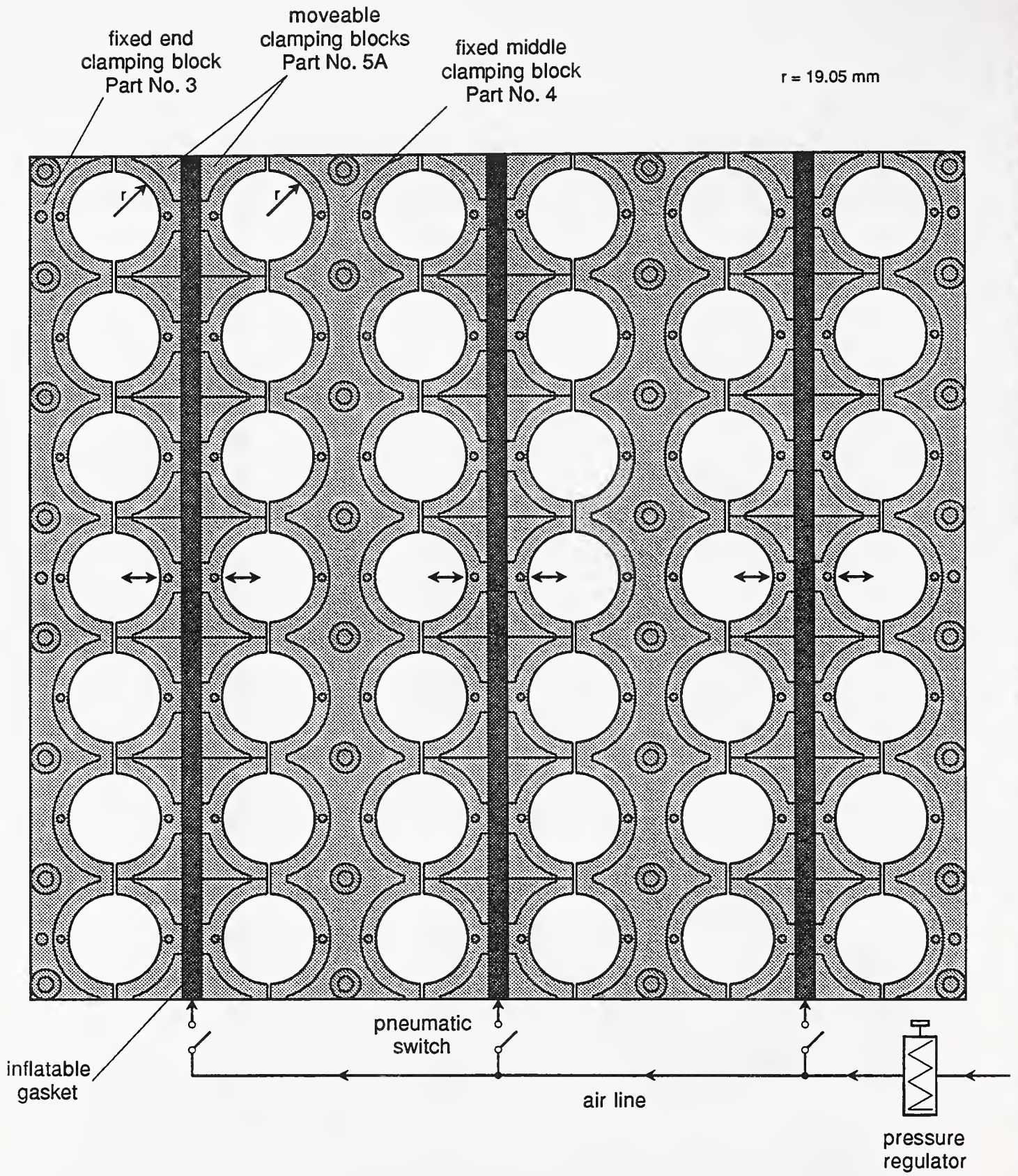
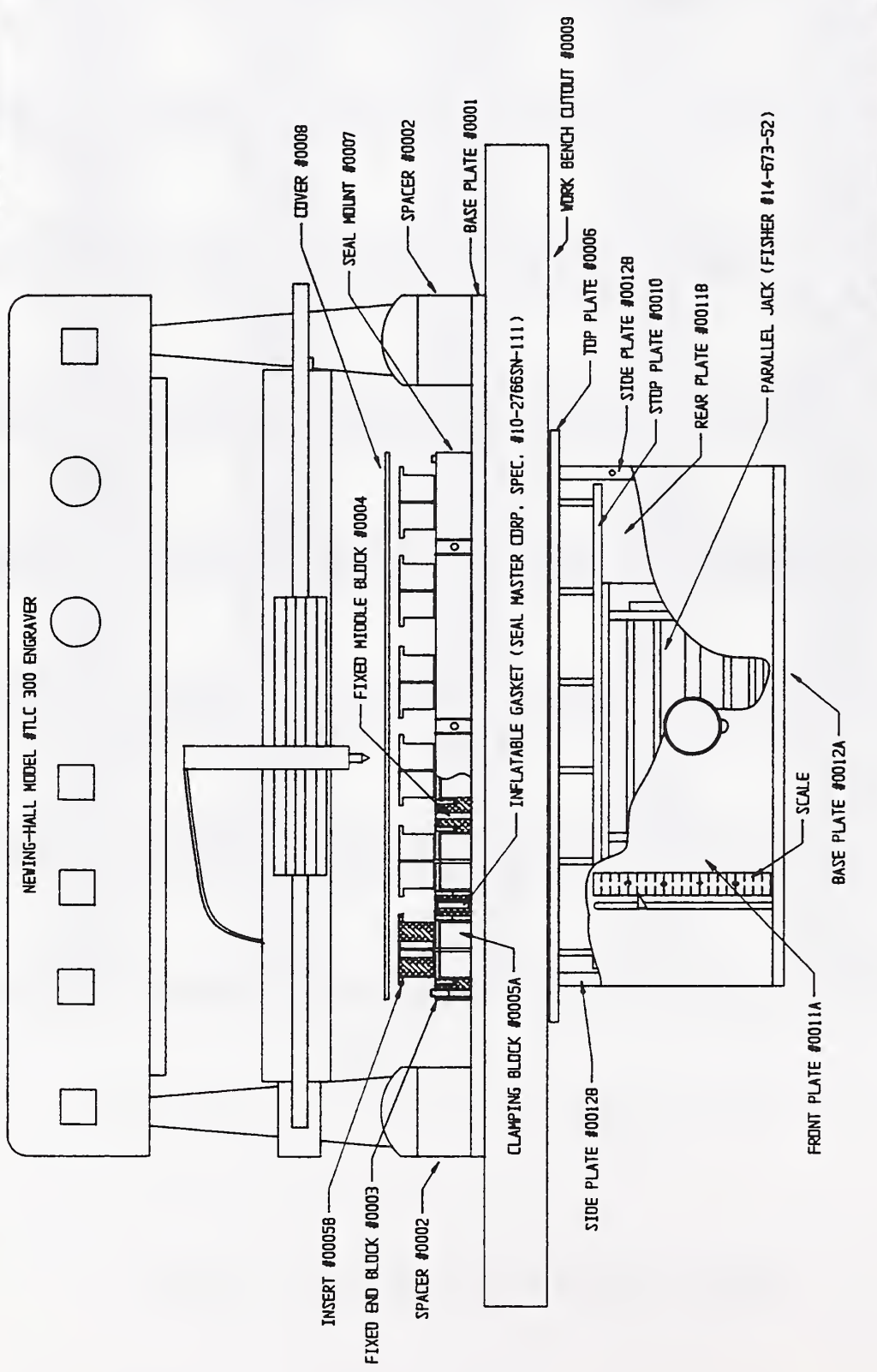


Figure 2. Basic Design of Part Fixturing System

Appendix A

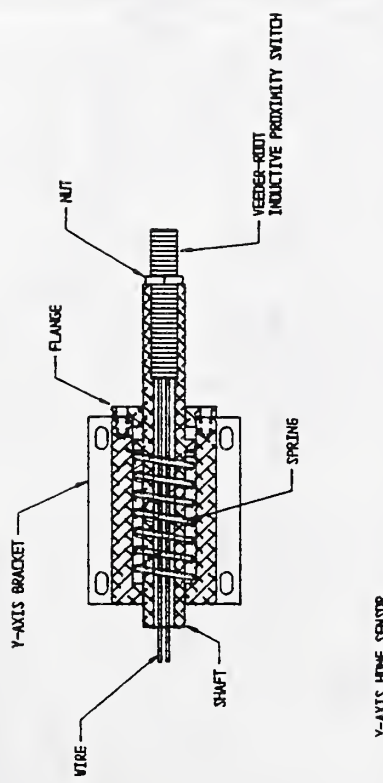
Engineering Drawings of Part Fixture

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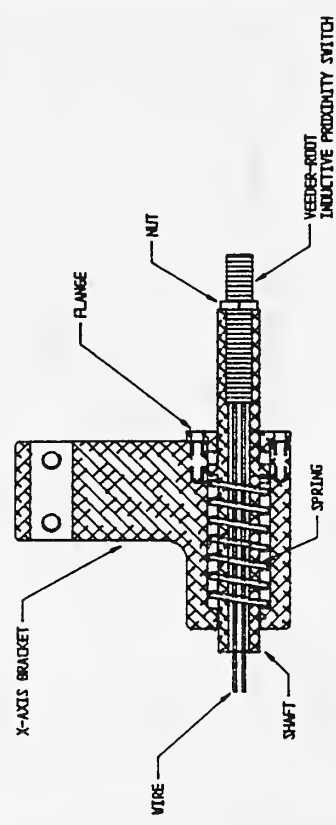
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TITLE: ENGRAVING FIXTURE FOR FASTENER PART NO.: 1000 SCALE: 1/2	DATE: 10/1/80 BY: J. J. ... CHECKED: ... APPROVED: ...

REV	DESCRIPTION	DATE	APPROVED

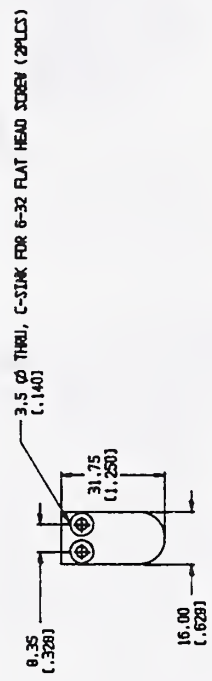


Y-AXIS HOME SENSOR

SPRING SPEC.
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 PITCH 7MM (1.275), LENGTH 50.8MM (2.000)



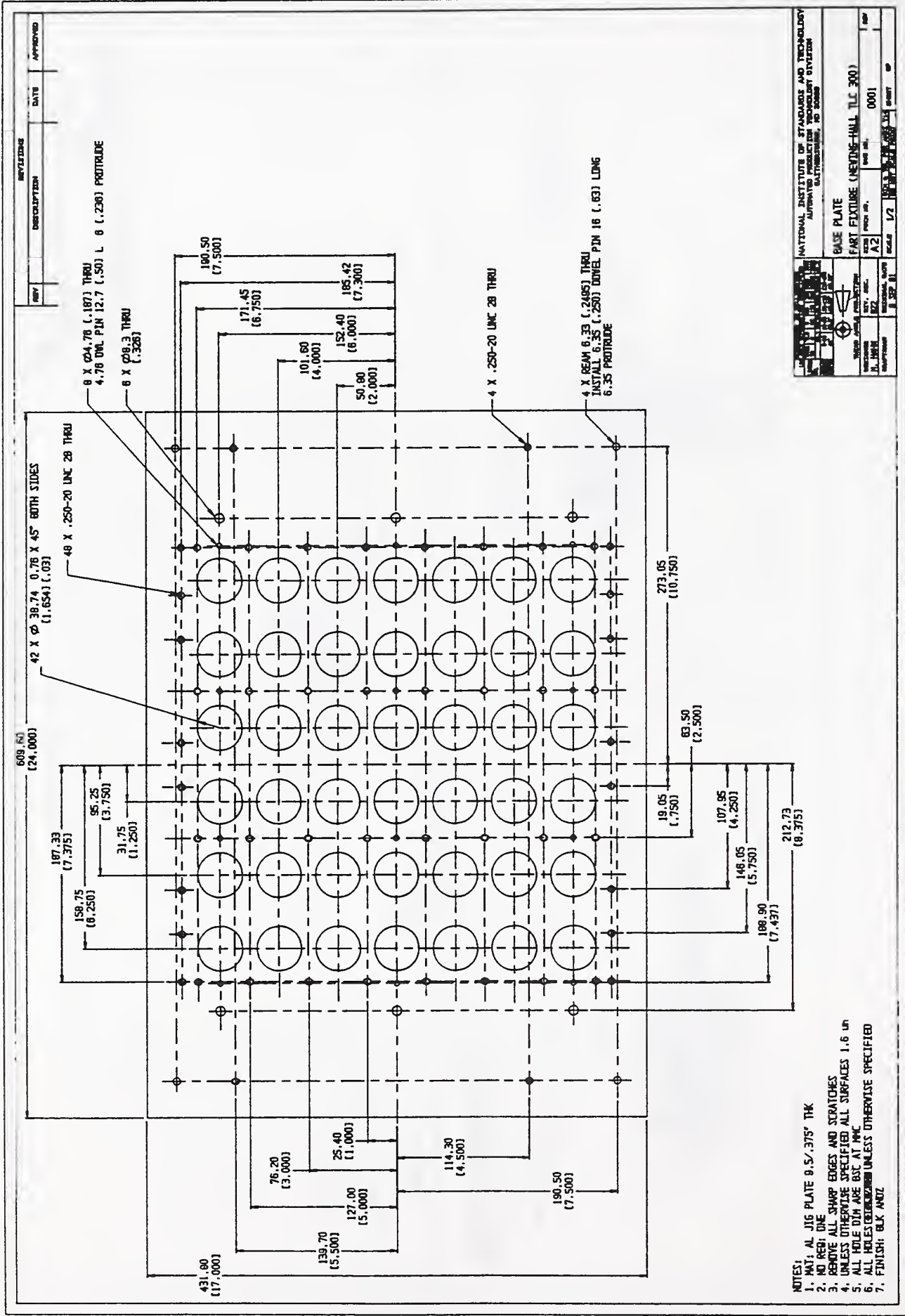
X-AXIS HOME SENSOR



Y-AXIS SENSOR PLATE

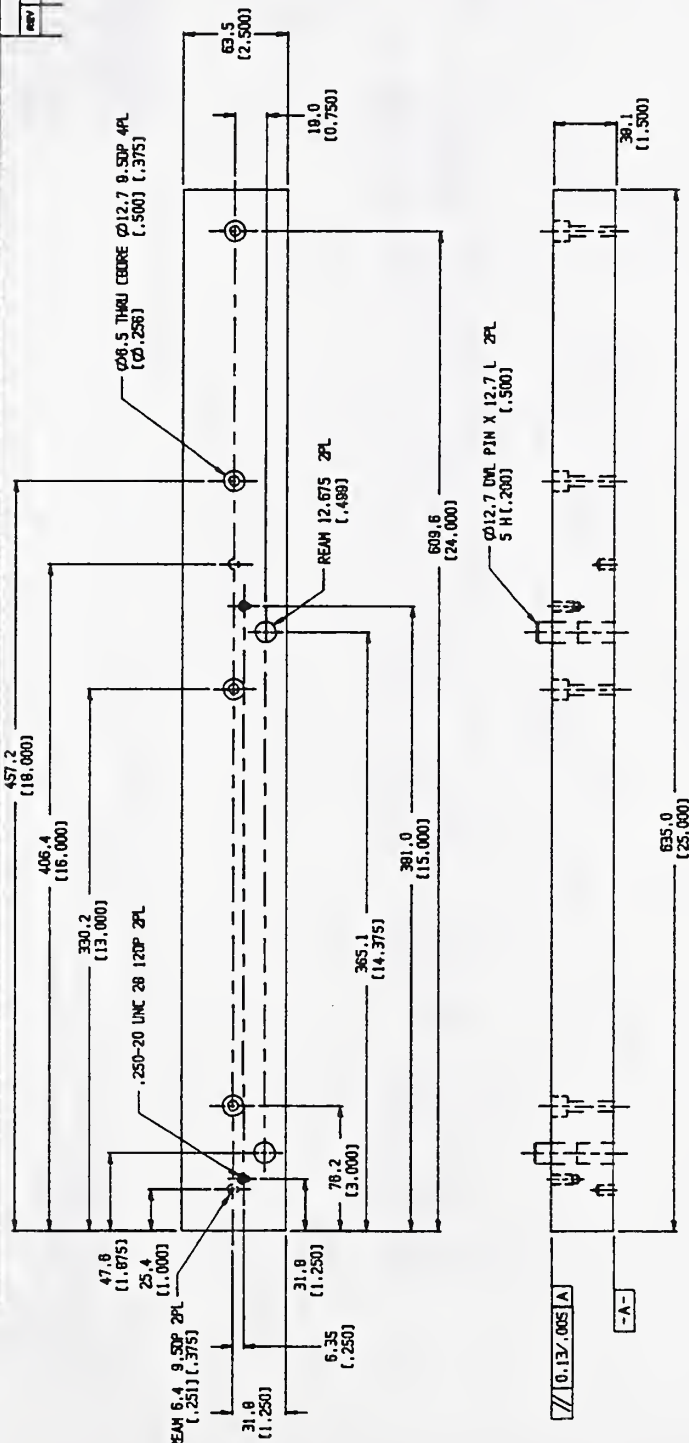
NOTE:
 MATERIAL: MILD STEEL 1/8" THICK

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ASSEMBLY	
HOME SENSOR SYSTEM	
TITLE: A2	DATE: 2000
DESIGNED BY:	DRAWN BY:
CHECKED BY:	APPROVED BY:



- NOTES:
1. MAT: AL JIG PLATE 9.5/.375" THK
 2. NO REQ: DNE
 3. REMOVE ALL SHARP EDGES AND SCRATCHES
 4. UNLESS OTHERWISE SPECIFIED ALL SURFACES 1.6 UN
 5. ALL HOLE DIM ARE GST AT MMC
 6. ALL HOLES (Ø) UNLESS OTHERWISE SPECIFIED
 7. FINISH: BLK ANOZ

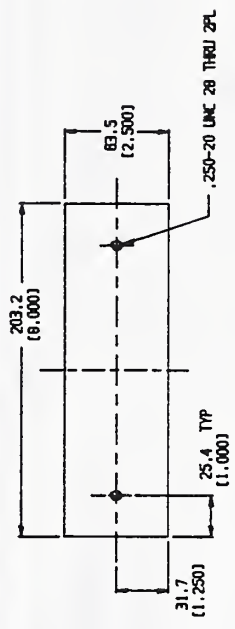
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 4. SURFACE TEXTURE: UNLESS OTHERWISE SPECIFIED 1.6um
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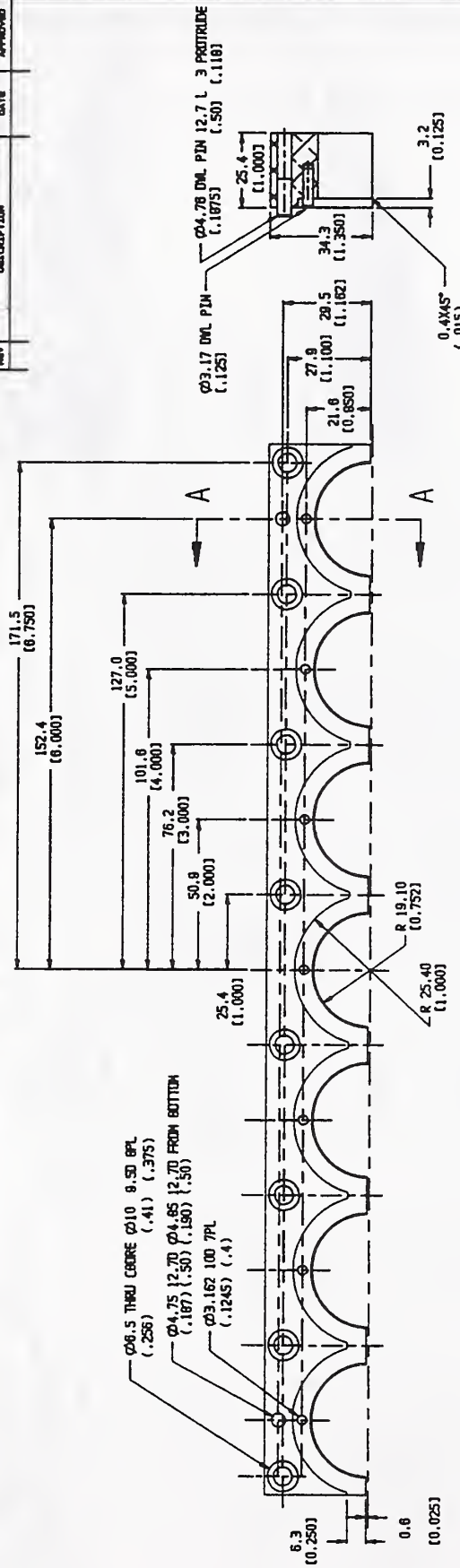
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PROJECT	ENGRAVING FIXTURE		
SCALE	1:1	UNIT	MM
DR	JL	CHK	JL
APP	JL	DATE	2024-10-10



B1 SKIN

- NOTES:
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 4. SURFACE TEXTURE: UNLESS OTHERWISE SPECIFIED 1.6um
 5. ALL HOLE DIM ARE BSC AT MMC
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REV	DESCRIPTION	DATE	APPROVED



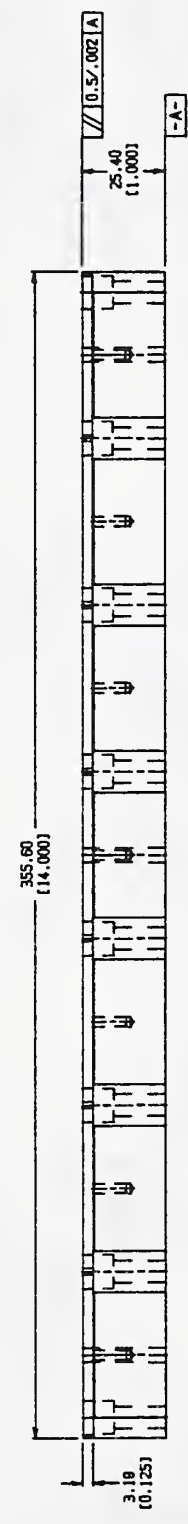
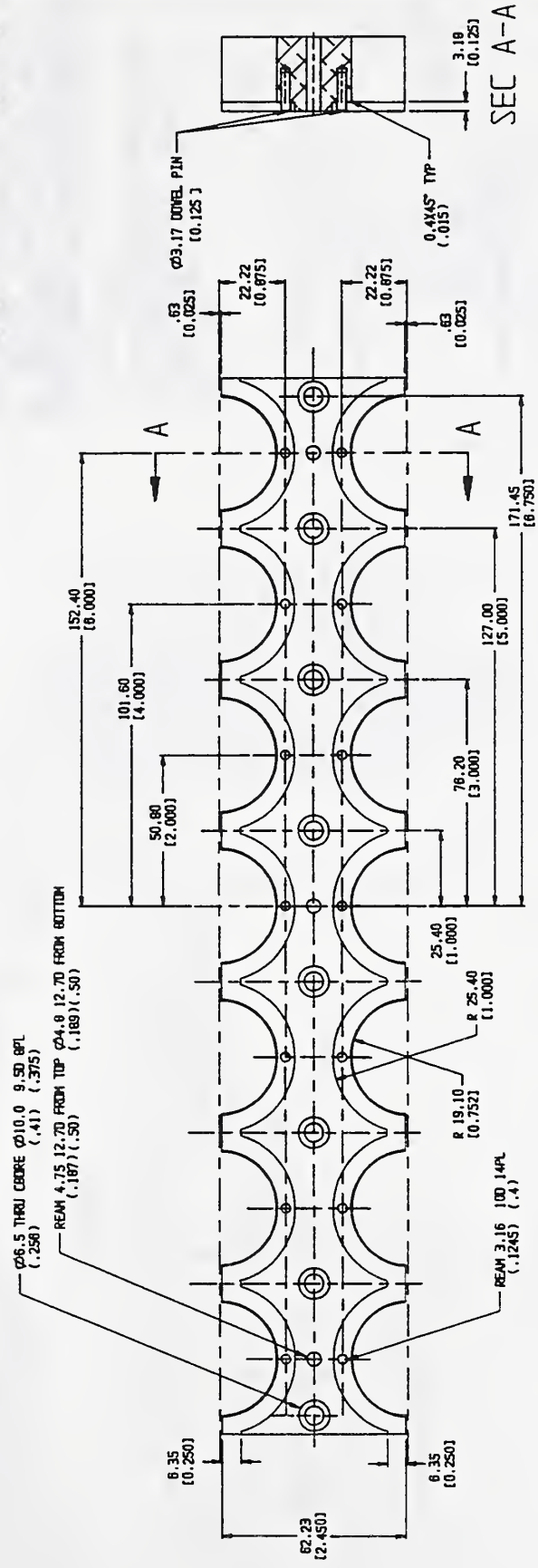
SEC A-A

REV		DESCRIPTION	DATE	APPROVED

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FIXED END BLOCK			
PART FIXTURE (NEVING-HALL TLC 300)			
DATE	REV.	ISSUE NO.	REV.

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 6. ALL HOLES $\text{Ø} 0.15/0.008$ UNLESS OTHERWISE SPECIFIED
 7. ANODIZE BLK

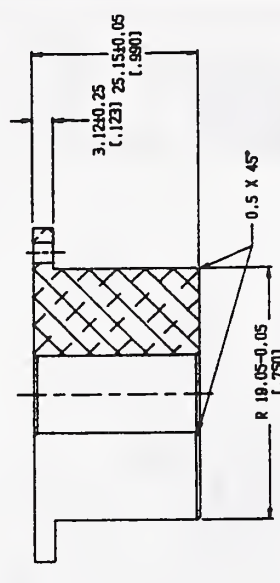
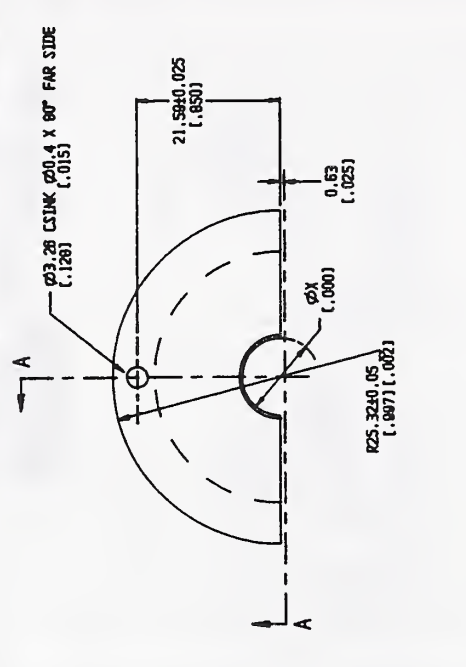
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DATE	REV
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DESIGNER	DRWING
J. H. HALL	
CHECKED	
APPROVED	

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 4. UNLESS OTHERWISE SPECIFIED ALL SURFACES 1.6um
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 7. FINISH: ANODIZE BLK

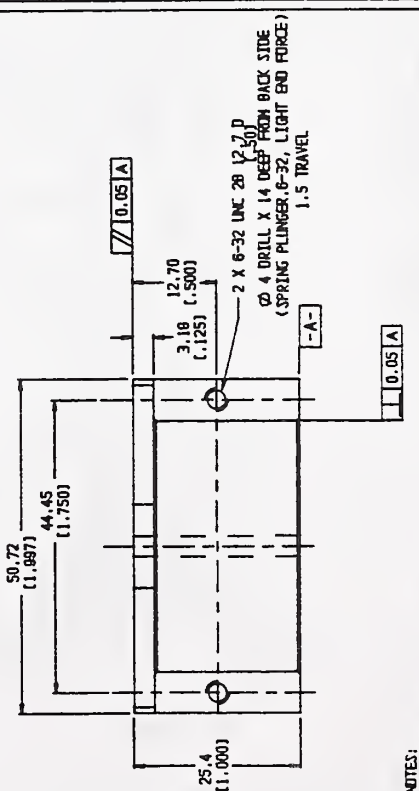
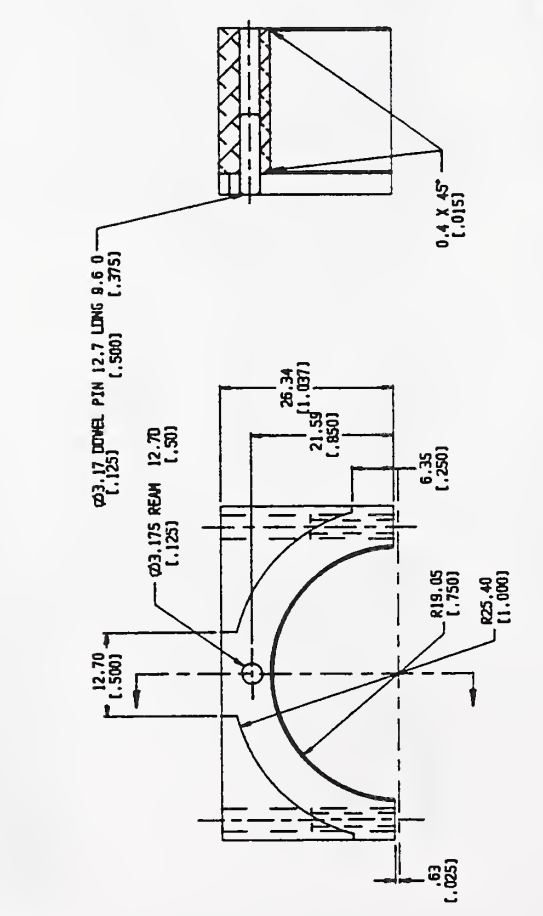
REV	DESCRIPTION	DATE	APPROVED



- NOTES:
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 4. UNLESS OTHERWISE SPECIFIED ALL SURFACES 1.6μm
 5. ALL HOLES WITH ARE EST AT MMC
 6. ALL HOLES $\text{\textcircled{H}}$ UNLESS OTHERWISE SPECIFIED
 7. FINISH: BLK ANOZ

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY AUTOMATED PRODUCTION TECHNOLOGY DIVISION GAITHERSBURG, MD 20899			
CLAMPING BLOCK (A) AND INSERT (B)	FORM NO.	REV	DATE
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ISSUED BY	DESIGNED BY	APPROVED BY	
J. J. HUB			

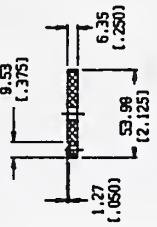
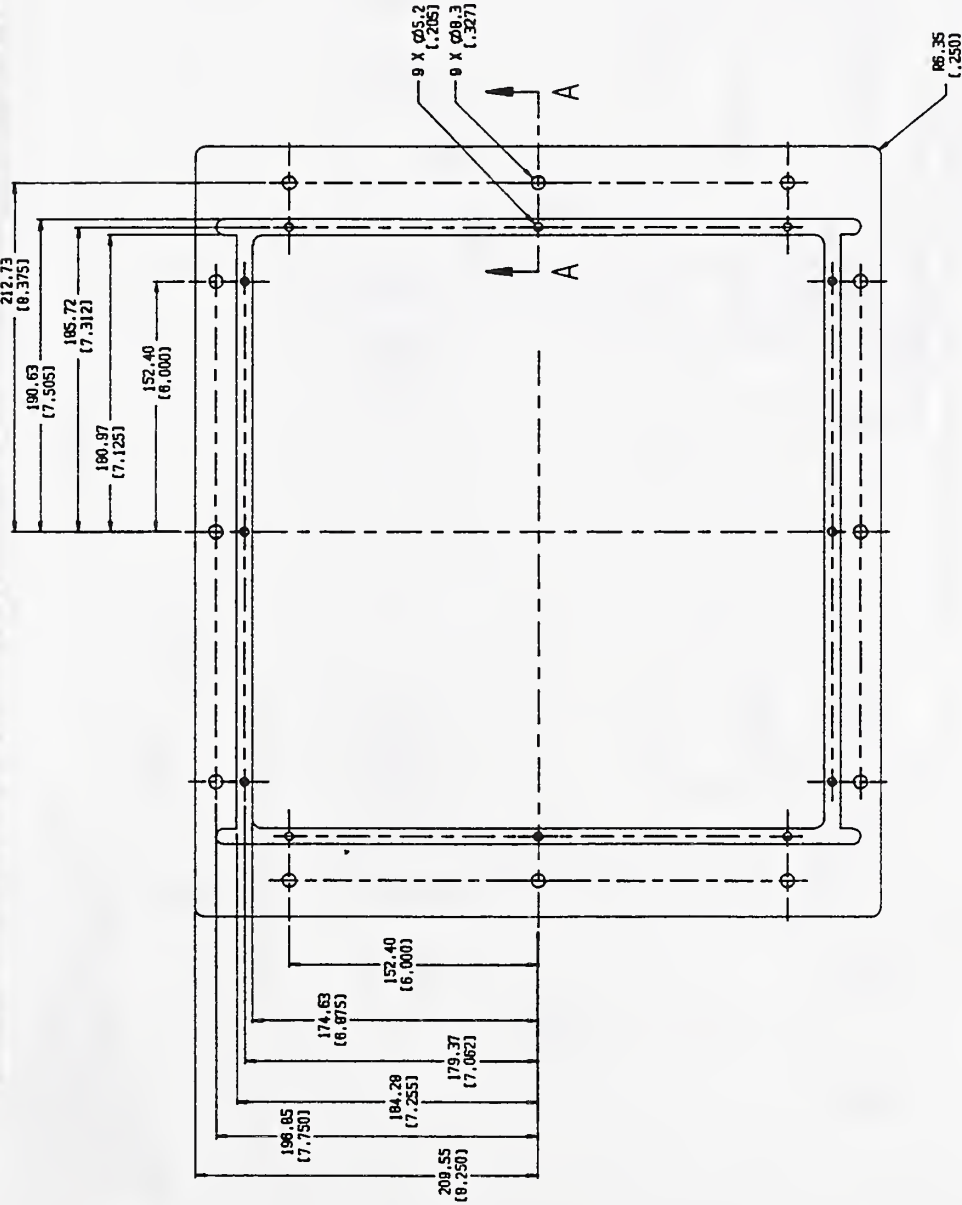
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3/8"	9.52	90
7/16"	11.1	90
1/2"	12.7	90
9/16"	14.3	90
5/8"	15.9	90
3/4"	19.05	90
7/8"	22.22	90
1"	25.4	90
1 1/8"	28.57	90
1 1/4"	31.75	90
1 3/8"	34.92	90



- NOTES:
1. MAT: AL 6061
 2. NO REB: 50
 3. REMOVE ALL SHARP EDGES AND SCRATCHES
 4. UNLESS OTHERWISE SPECIFIED ALL SURFACES 1.6μm
 5. ALL HOLES WITH ARE EST AT MMC
 6. ALL HOLES $\text{\textcircled{H}}$ UNLESS OTHERWISE SPECIFIED
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A: CLAMPING BLOCK

REV	DESCRIPTION	DATE	APPROVED

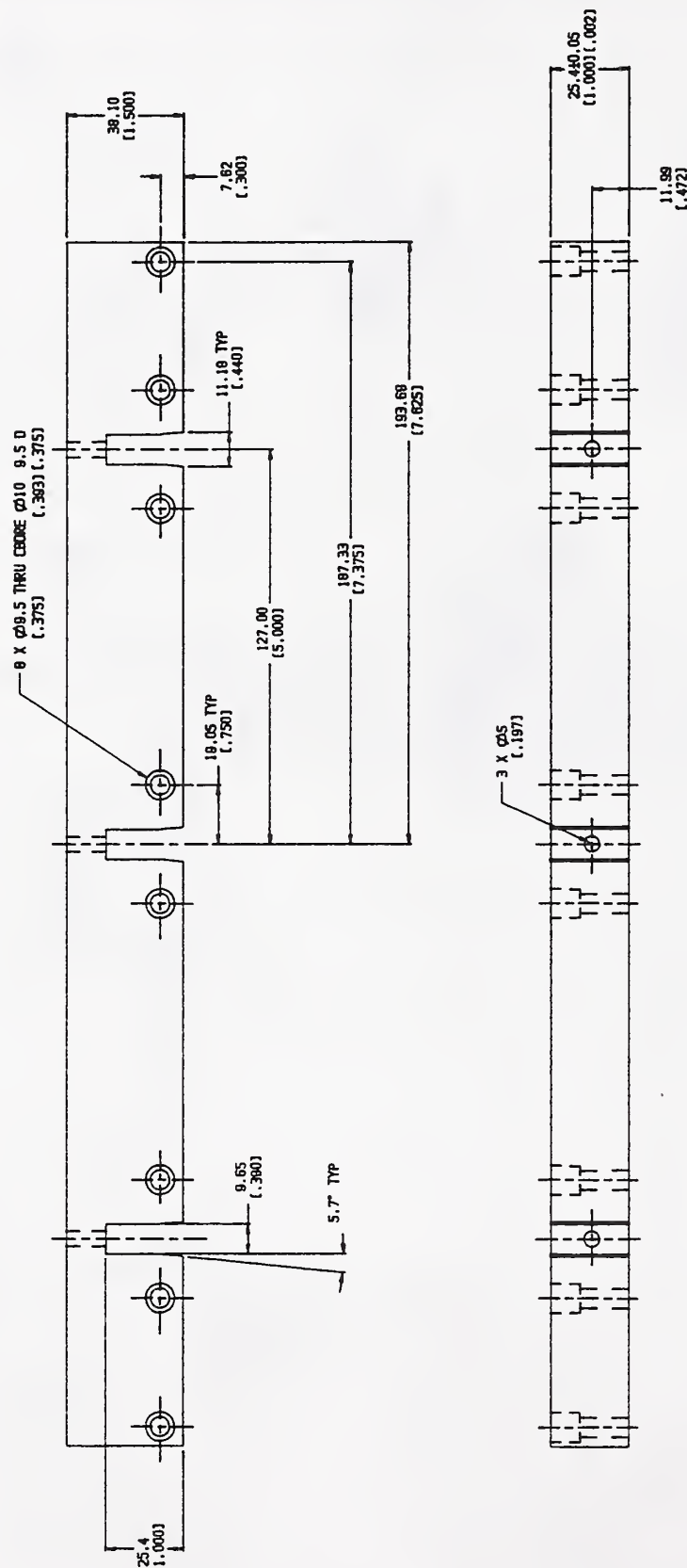


SEC A-A

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY AUTOMATED PRODUCTION TECHNOLOGY DIVISION GAITHERSBURG, MD 20899	
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DRAWN BY: [Signature] CHECKED BY: [Signature]	DATE: 0008
SCALE: 1/2	SHEET NO: 1

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 3. REMOVE ALL SHARP EDGES AND SCRAPERS
 4. UNLESS OTHERWISE SPECIFIED, ALL SURFACES 1.6um
 5. ALL HOLE DIA ARE DEC AT MIC
 6. ALL HOLES \pm [00.400] UNLESS OTHERWISE SPECIFIED

REV	DESCRIPTION	DATE	APPROVED



- NOTES:
1. MAT. AL J16 PLATE
 2. NO RES. 2
 3. REMOVE ALL SHARP EDGES AND SCRATCHES
 4. UNLESS OTHERWISE SPECIFIED, ALL SURFACES 1.6um
 5. ALL HOLES UNLESS OTHERWISE SPECIFIED
 6. ALL HOLES ϕ (Ø) UNLESS OTHERWISE SPECIFIED
 7. FINISH: BLK ANOT

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 Gaithersburg, MD 20899

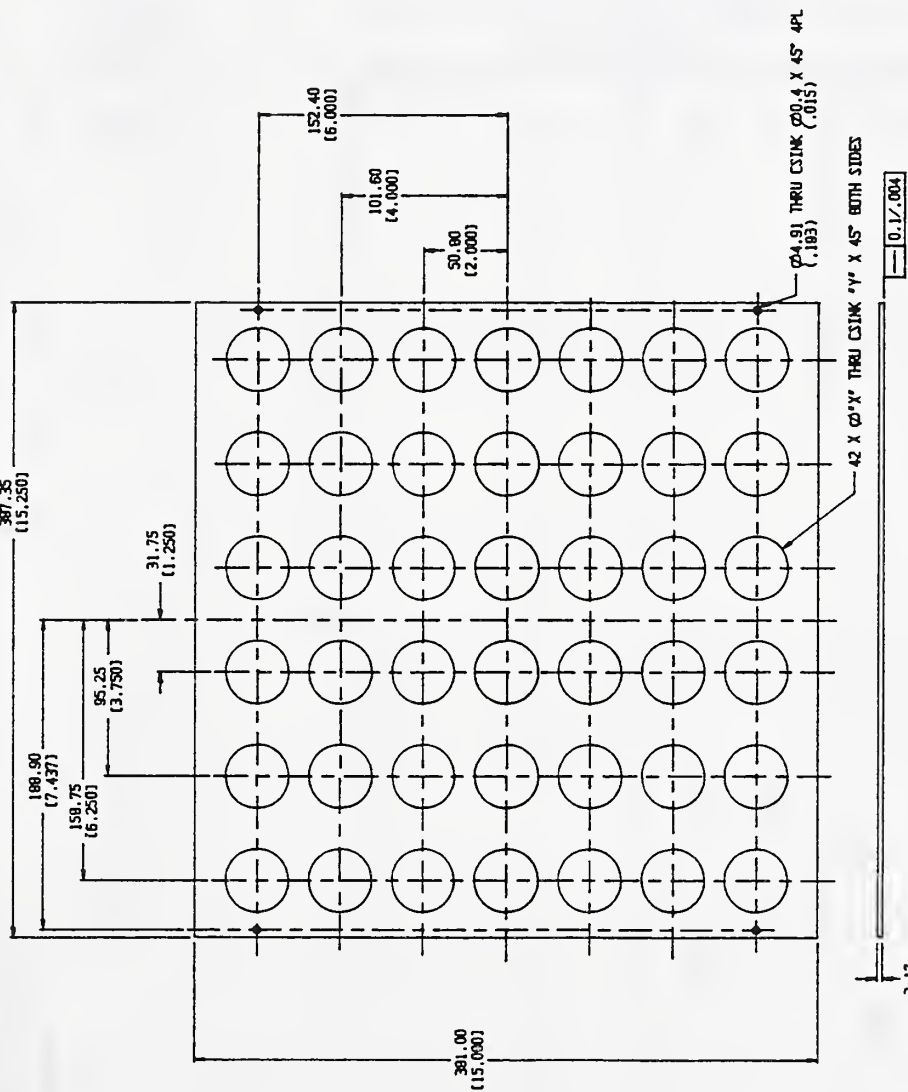
SEAL MOUNT
 PART FEATURE (HEATING-HALL TLC 300)

DATE: 9 SEP 81
 DRAWN BY: J. J. ...
 CHECKED BY: ...
 APPROVED BY: ...

FORM NO. 100-108-01
 11/80

REV	DESCRIPTION	DATE	APPROVED

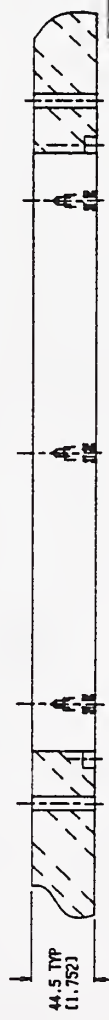
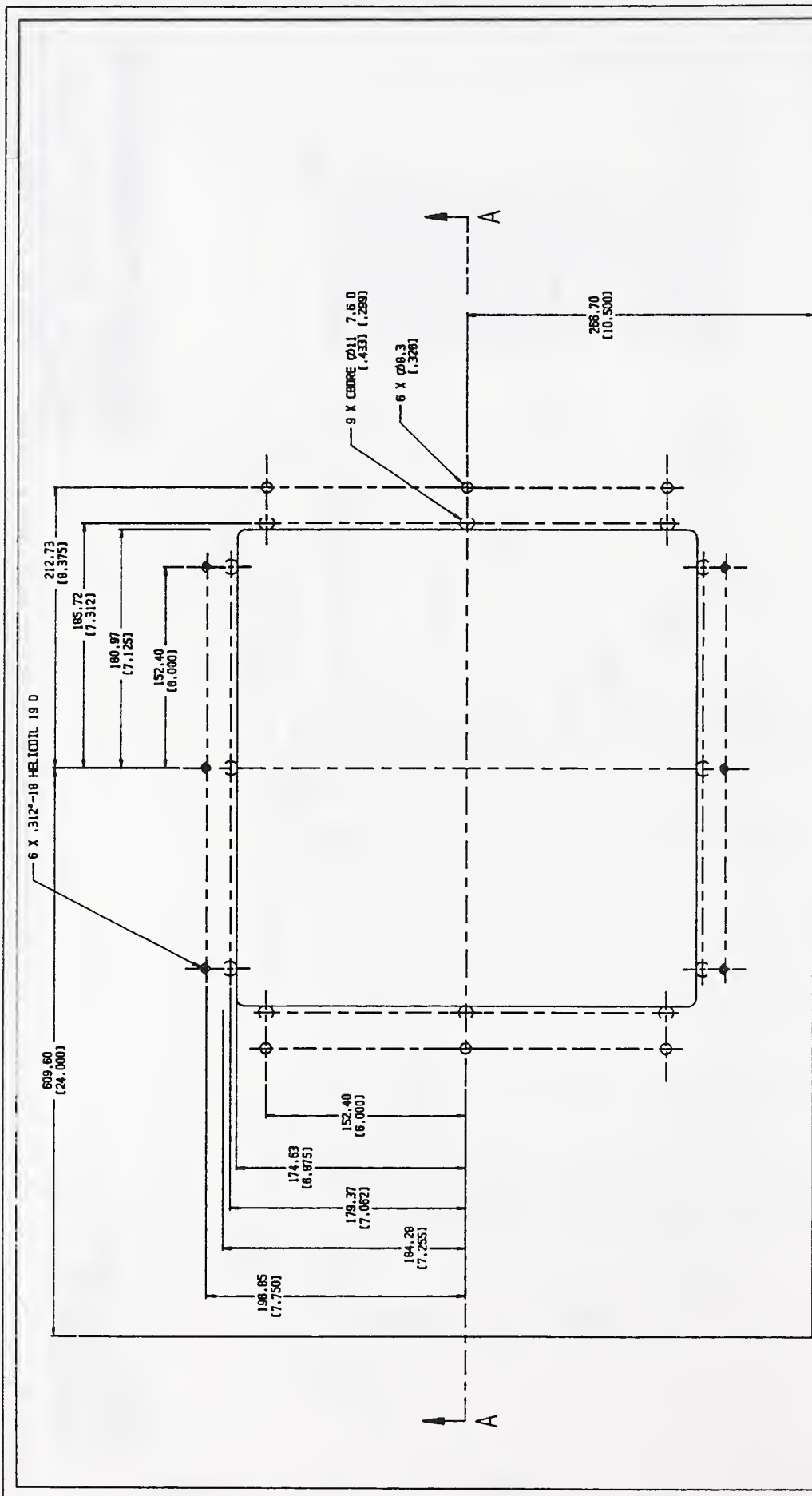
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8.8/ .390	0.4/ .015		1
11.5/ .453	0.5/ .020		1
13/ .515	0.5/ .020		1
14.7/ .578	0.64/ .025		1
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29/ 1.140	1.14/ .045		1
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35.3/ 1.390	1.4/ .055		1
38.5/ 1.515	1.5/ .060		1



- NOTES:
1. MAT: AL 6061
 2. NO REDD TIME
 3. REMOVE ALL SHARP EDGES AND SQUARES
 4. UNLESS OTHERWISE SPECIFIED ALL SURFACES 1.6 um
 5. ALL HOLE DIM ARE BSC AT MMC
 6. ALL HOLES EXTEND TO THE OTHER SIDE
 7. FINISH: BLK ANOZ UNLESS OTHERWISE SPECIFIED

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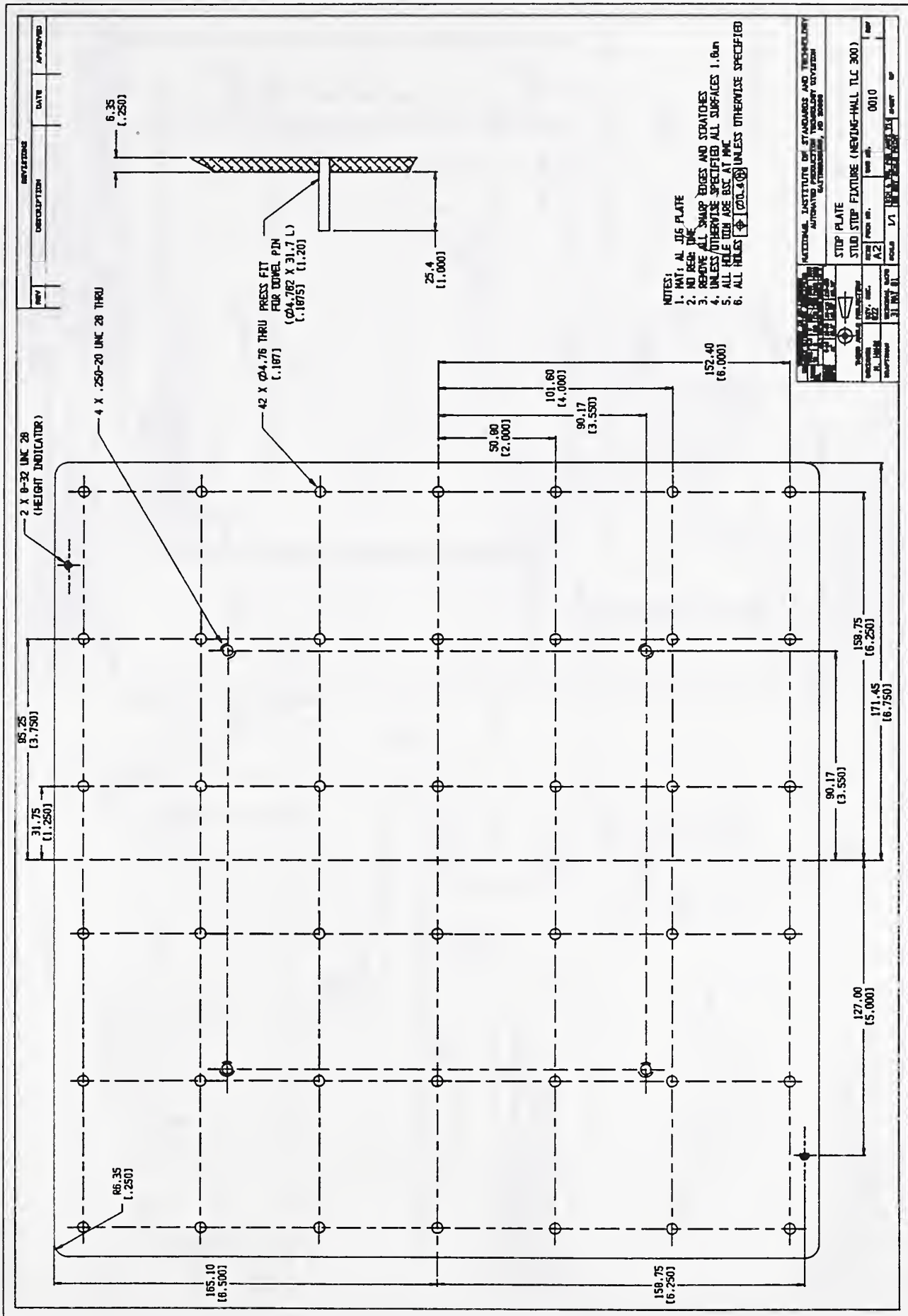
DATE: 11/11/81
 DRAWING NO: 0008
 PART: PART FIXTURE (NEWING-HALL, T.L.C. 300)
 REV: A2
 DESIGNED BY: J. S. B. JR.
 CHECKED BY: J. S. B. JR.
 APPROVED BY: J. S. B. JR.



NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY AUTOMATIC PRODUCTION TECHNOLOGY DIVISION GAITHERSBURG, MD 20899	
WORK BENCH OUTRIG	
STUD STOP FIXTURE (HEWING HALL T.L.C. 300)	
DATE: 11/11/81	SCALE: 1/2
DESIGNER: J.L.	DRWING NO.: 0009
CHECKER: J.L.	DATE: 11/11/81
APPROVED: J.L.	BY: J.L.

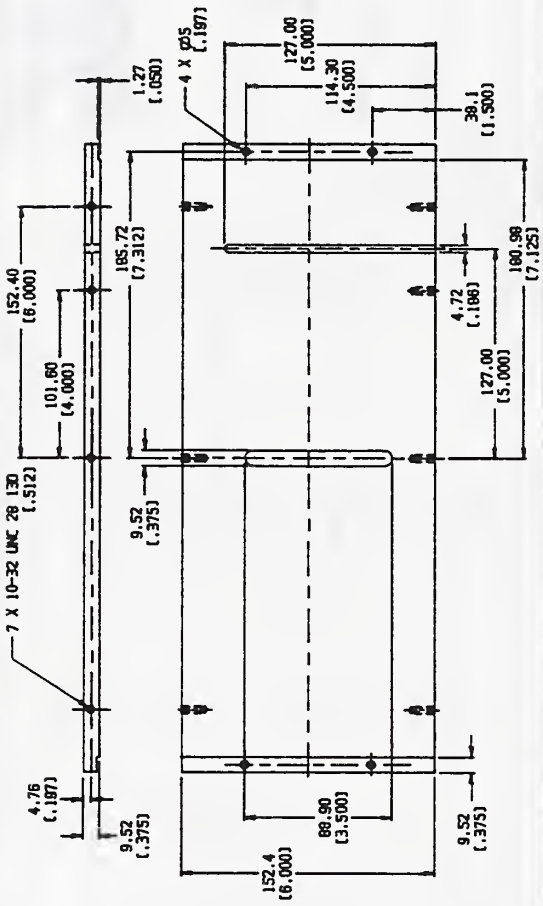
SEC A-A

- NOTES:
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 2. FIN. SURF. ONE
 3. REMOVE ALL SHARP EDGES AND SCRATCHES
 4. UNLESS OTHERWISE SPECIFIED ALL SURFACES 1.6um
 5. ALL HOLE DIA ARE BSC AT PKL
 6. ALL HOLES (Ø) UNLESS OTHERWISE SPECIFIED



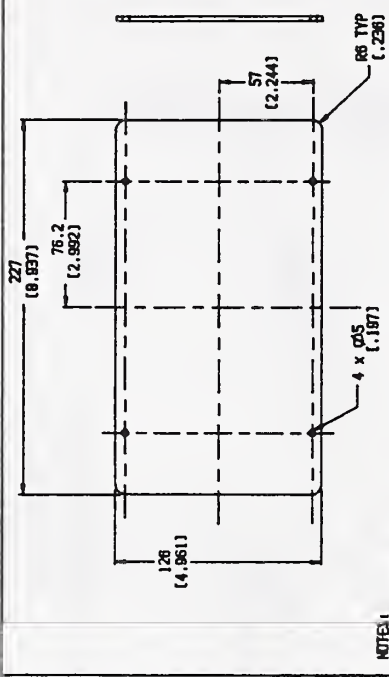
- NOTES:
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 3. REMOVE ALL SHARP EDGES AND SCRATCHES
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 5. ALL HOLES TO BE BSC AT MMC
 6. ALL HOLES $\text{Ø}(\text{L} \pm \text{T})$ UNLESS OTHERWISE SPECIFIED

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY AUTOMATIC PRODUCTION TECHNOLOGY DIVISION Gaithersburg, MD 20899	
STOP PLATE	
STUD STOP FIXTURE (NEWING-HALL TLC 300)	Part no. 0010
DATE: 02/11/81	REV: 01
DESIGNED BY: J. J. ...	DRAWN BY: J. J. ...
CHECKED BY: J. J. ...	APPROVED BY: J. J. ...



A1: FRONT PLATE

- NOTES:
1. MAT: AL JIG PLATE
 2. NO REQ: 2
 3. REMOVE ALL SHARP EDGES AND SCRATCHES
 4. UNLESS OTHERWISE SPECIFIED ALL SURFACES 1.6um
 5. ALL HOLE DIM ARE BS1 AT MMC
 6. ALL HOLES $\text{Ø} (20.40)$ UNLESS OTHERWISE SPECIFIED
7. SCALE 1/2

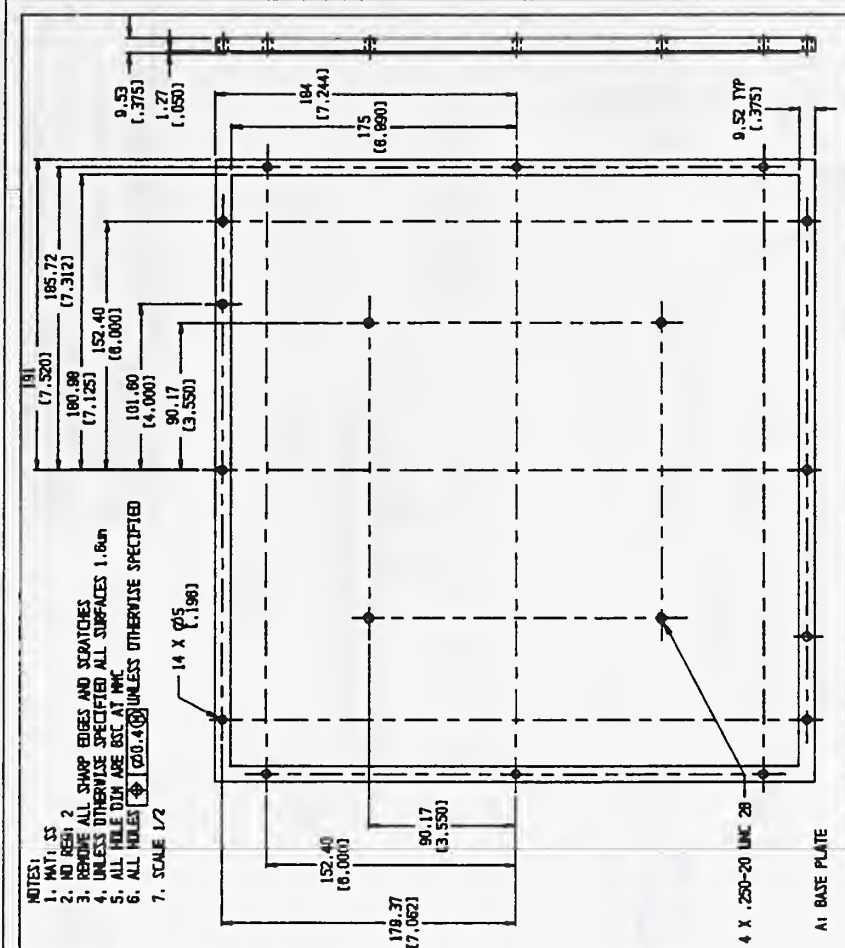


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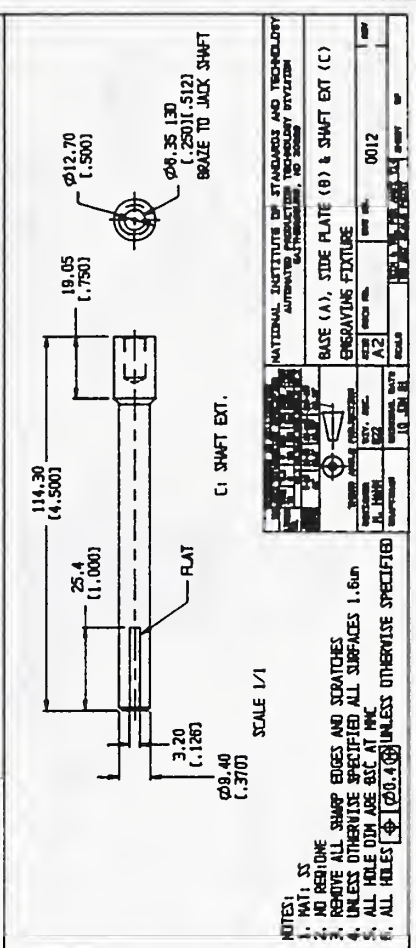
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 5. ALL HOLE DIM ARE BS1 AT MMC
 6. ALL HOLES $\text{Ø} (20.40)$ UNLESS OTHERWISE SPECIFIED
7. SCALE 1/2

- NOTES:
1. MAT: PLEXIGLASS 3.2 THK
 2. NO REQ: ONE
 3. REMOVE ALL SHARP EDGES AND SCRATCHES
 4. UNLESS OTHERWISE SPECIFIED ALL SURFACES 1.6um
 5. ALL HOLE DIM ARE BS1 AT MMC
 6. ALL HOLES $\text{Ø} (20.40)$ UNLESS OTHERWISE SPECIFIED
7. SCALE 1/2

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY		ARTWORK		DRAWING	
DATE	BY	NO.	REV.	DATE	BY
10/10/81
FRONT PLATE (A), REAR PLATE (B), COVER (C)			ENGRAVING FIXTURE		
DATE	BY	NO. <td>REV. <td>DATE</td> <td>BY</td> </td>	REV. <td>DATE</td> <td>BY</td>	DATE	BY
...
DRAWING NO. 0011			...		

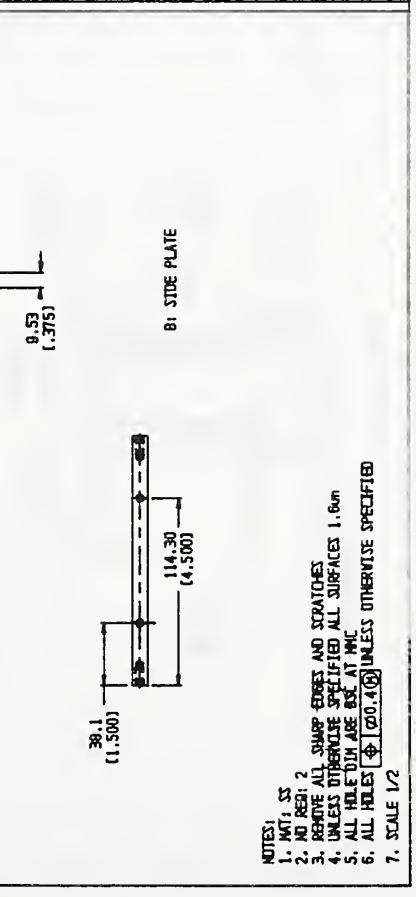
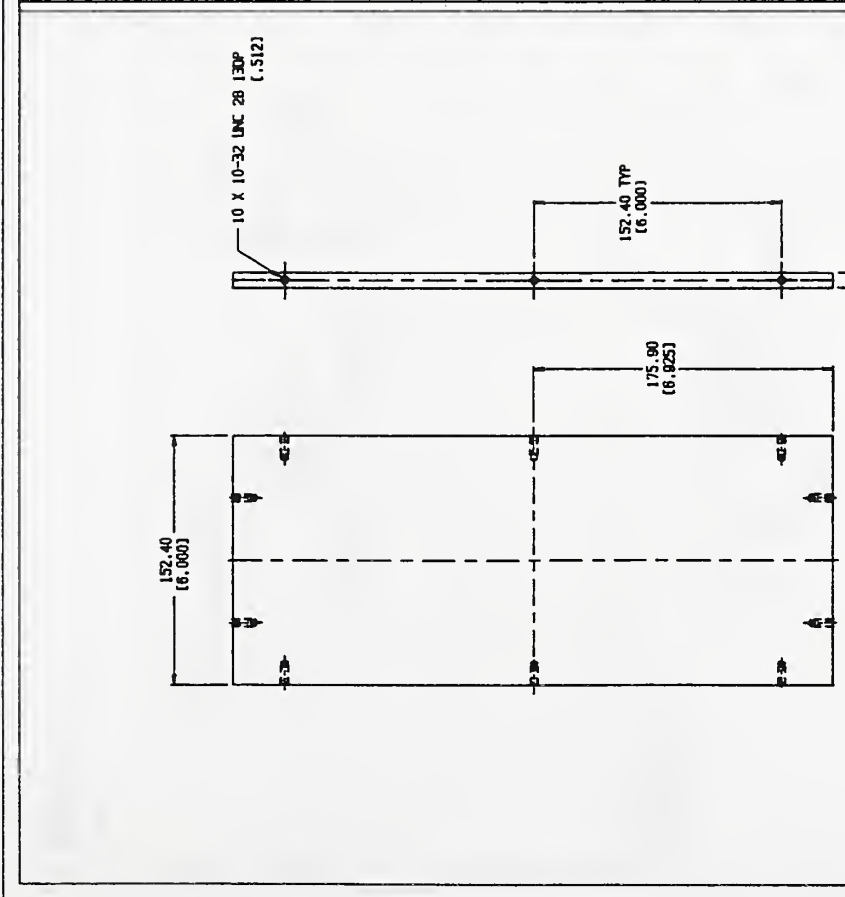


- NOTES:
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 5. ALL HOLE DIM ARE ESC AT MMC
 6. ALL HOLE DIM ARE ESC AT MMC
 7. SCALE 1/2



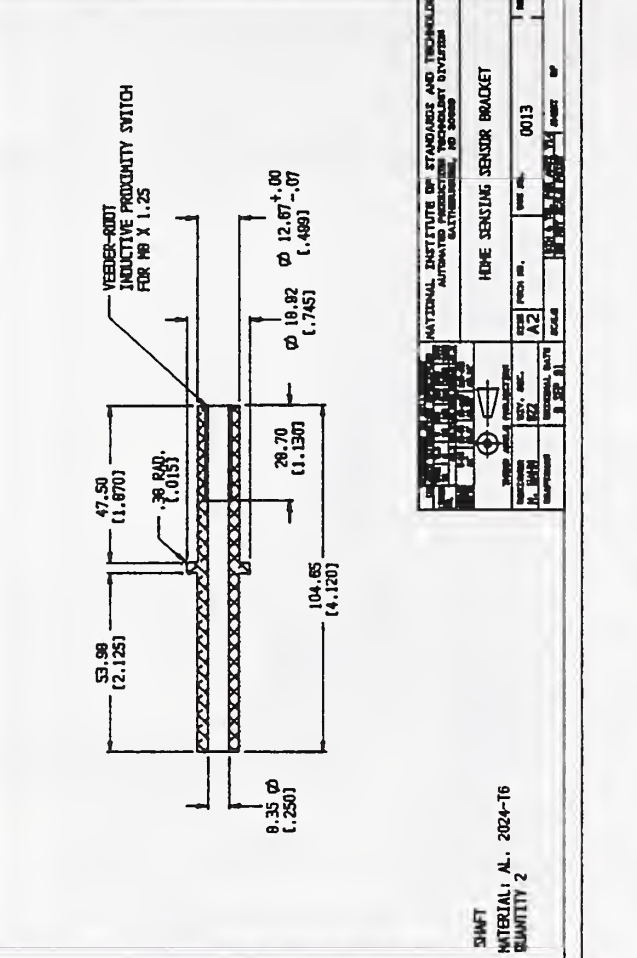
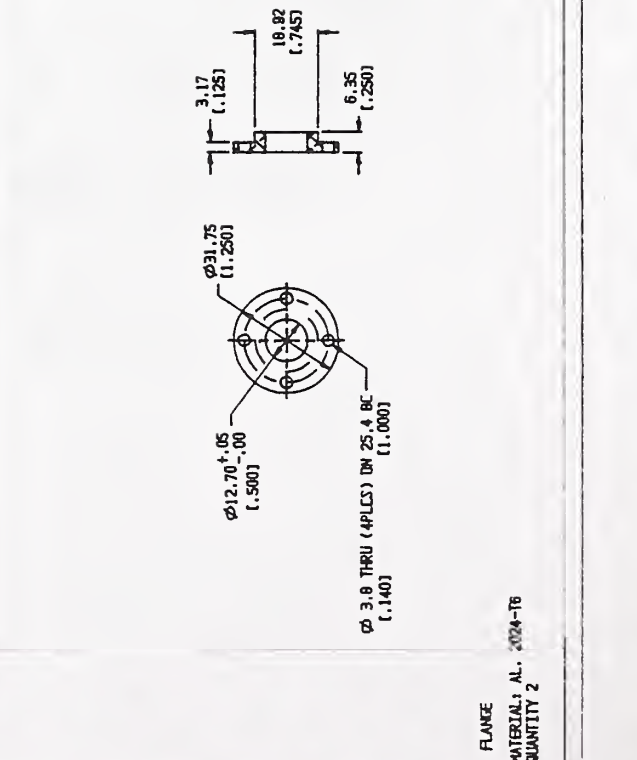
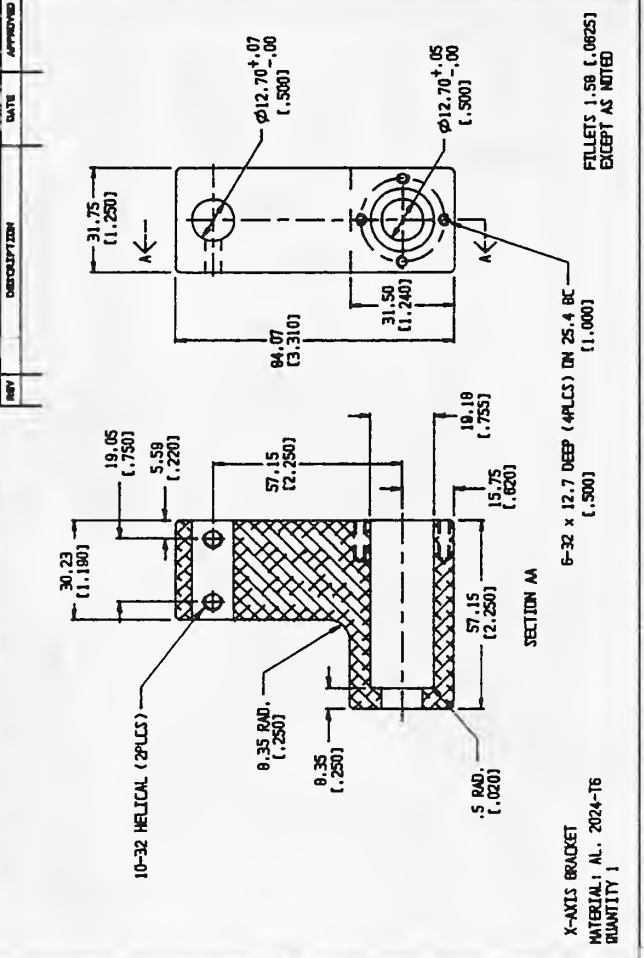
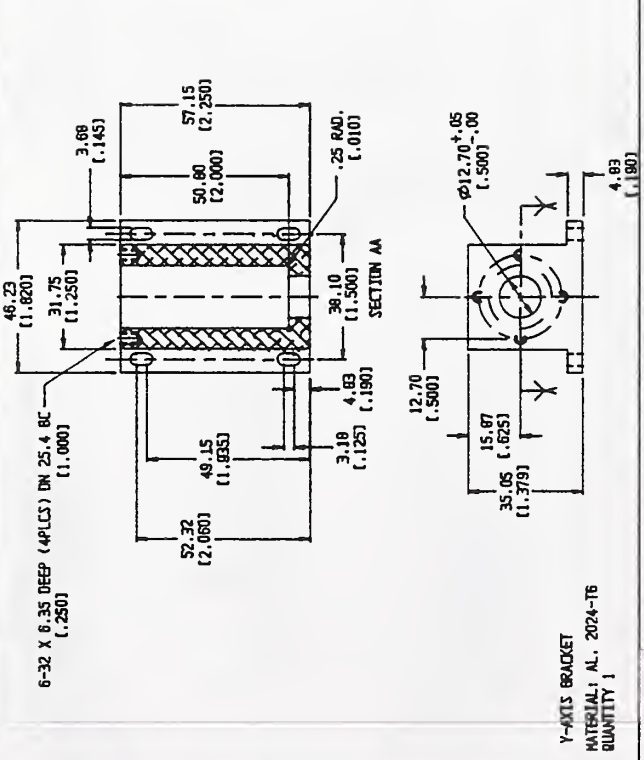
- NOTES:
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 4. ALL HOLE DIM ARE ESC AT MMC
 5. ALL HOLE DIM ARE ESC AT MMC
 6. ALL HOLE DIM ARE ESC AT MMC
 7. SCALE 1/2

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY	
AUTOMATIC TECHNOLOGY	
BASE (A), SIDE PLATE (B) & SHAFT EXT (C)	
EMBRACING FIXTURE	
DATE	REV
10/11/88	0012
BY	CHK
W. H. H. H.	J. J. J. J.
SCALE	10 0A 0B 0C 0D 0E 0F 0G 0H 0I 0J 0K 0L 0M 0N 0O 0P 0Q 0R 0S 0T 0U 0V 0W 0X 0Y 0Z



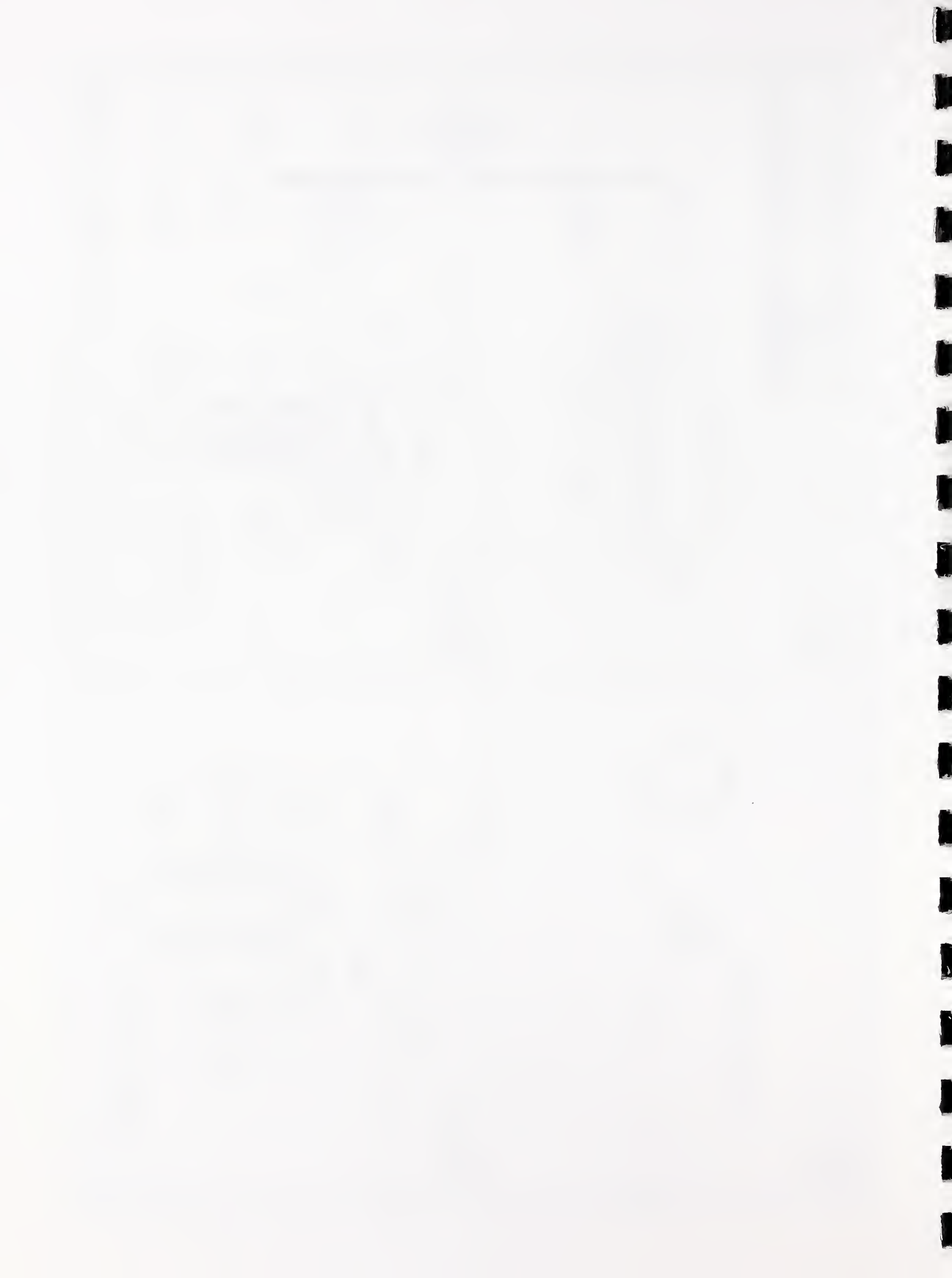
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 5. ALL HOLE DIM ARE ESC AT MMC
 6. ALL HOLE DIM ARE ESC AT MMC
 7. SCALE 1/2

REV	DESCRIPTION	DATE	APPROVED



NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY AUTOMATED PRODUCTION TECHNOLOGY DIVISION GAITHERSBURG, MD 20899	
DATE	0013
REV	0013
SCALE	AS SHOWN
PROJ. NO.	0013
WORK CENTER	0013
OPERATOR	0013
INSPECTOR	0013
APPROVED	0013

Appendix B
Operating Manual for the Engraving System



PORTSMOUTH
FASTENER
MANUFACTURING
WORKSTATION



FASTENER ENGRAVING SYSTEM
OPERATING MANUAL

February 1993

Michael Huff and Mahn Hee Hahn

Automated Production Technology Division
National Institute of Standards and Technology

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1. Introduction

This is an operating manual for the fastener engraving system, as a part of the Portsmouth Fastener Manufacturing Workstation. The engraving system consists of a Newing-Hall Model 300 engraving machine, controlled by a PC-based computer, and a custom designed mechanical fixturing/interface software system. This manual is separated into two main sections. The first section describes the procedures for the mechanical setup of the engraving fixture and rotary spindle(s). The second section describes the steps for running the software for engraving the fasteners with identification codes (manufacturer's symbol, lot number, material ID symbol).

Because this engraving system is custom designed for engraving fasteners, this operation manual is considered to be an extension of the Newing-Hall Model 300 User's Manual. This manual is written so that the operator may engrave fasteners without being required to learn the detailed Newing-Hall manual and computer operating system. However, to engrave items other than fasteners, the authors strongly recommend learning the basic operating procedures of the original Newing-Hall engraving system. For some detailed procedures, such as setting up a job file or changing fonts, the operator should refer to the Newing-Hall Model 300 User's Manual.

2. Mechanical Setup

The mechanical setup of the engraving system must be completed before the operator can run the control software at the computer. First, the engraving fixture must be set up for the correct type and size of fastener. Second, the rotary spindle(s) must be properly installed and referenced to the "home" position.

2.1 Setting Up the Engraving Fixture

The engraving fixture consists of a base plate with 42 clamping block positions in a six by seven array as shown in figure 1.1. Each block position holds a pair of inserts which, in turn, holds a fastener of a particular major diameter. Figure 1.2. shows the clamping blocks with a full array of inserts installed. The blocks are clamped by three inflatable gaskets that extend from the front to the back of the fixture. Each gasket, when inflated, will clamp two columns of fourteen positions. A cover plate having holes with a diameter matching the insert hole size rests on top of the fixture to keep out metal chips as shown in figure 1.3. A height-adjustable pin stop plate located under the fixture supports studs during the engraving as shown in figure 1.4.

Any number of fasteners can be engraved with a single software setup. Three types of fasteners can be engraved in this system: hex head cap screws, socket head cap screws, and studs. The fixture will hold hex head cap screws with a nominal major diameter from 1/4 in.

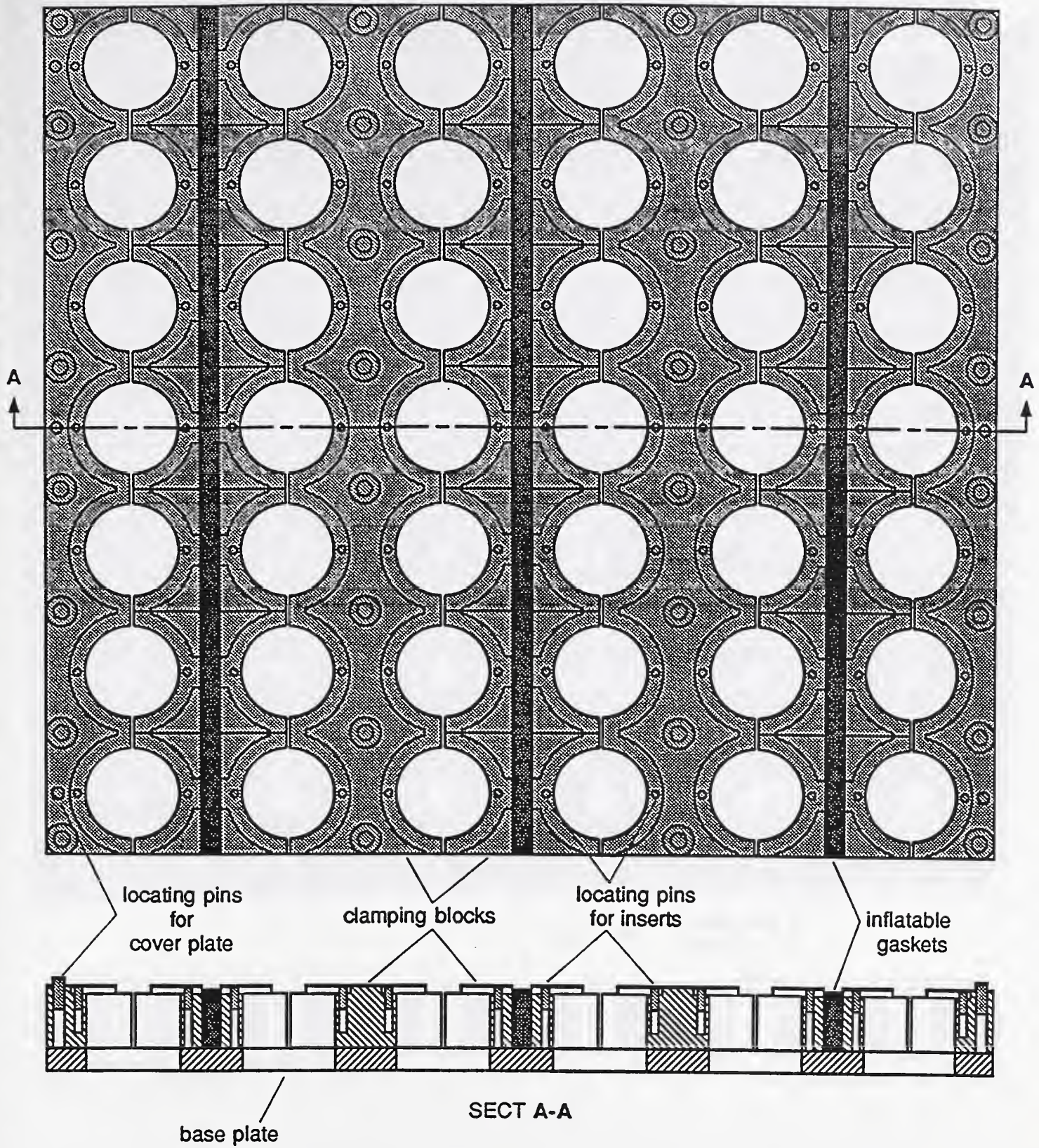


Figure 1.1 Clamping Blocks with Base Plate

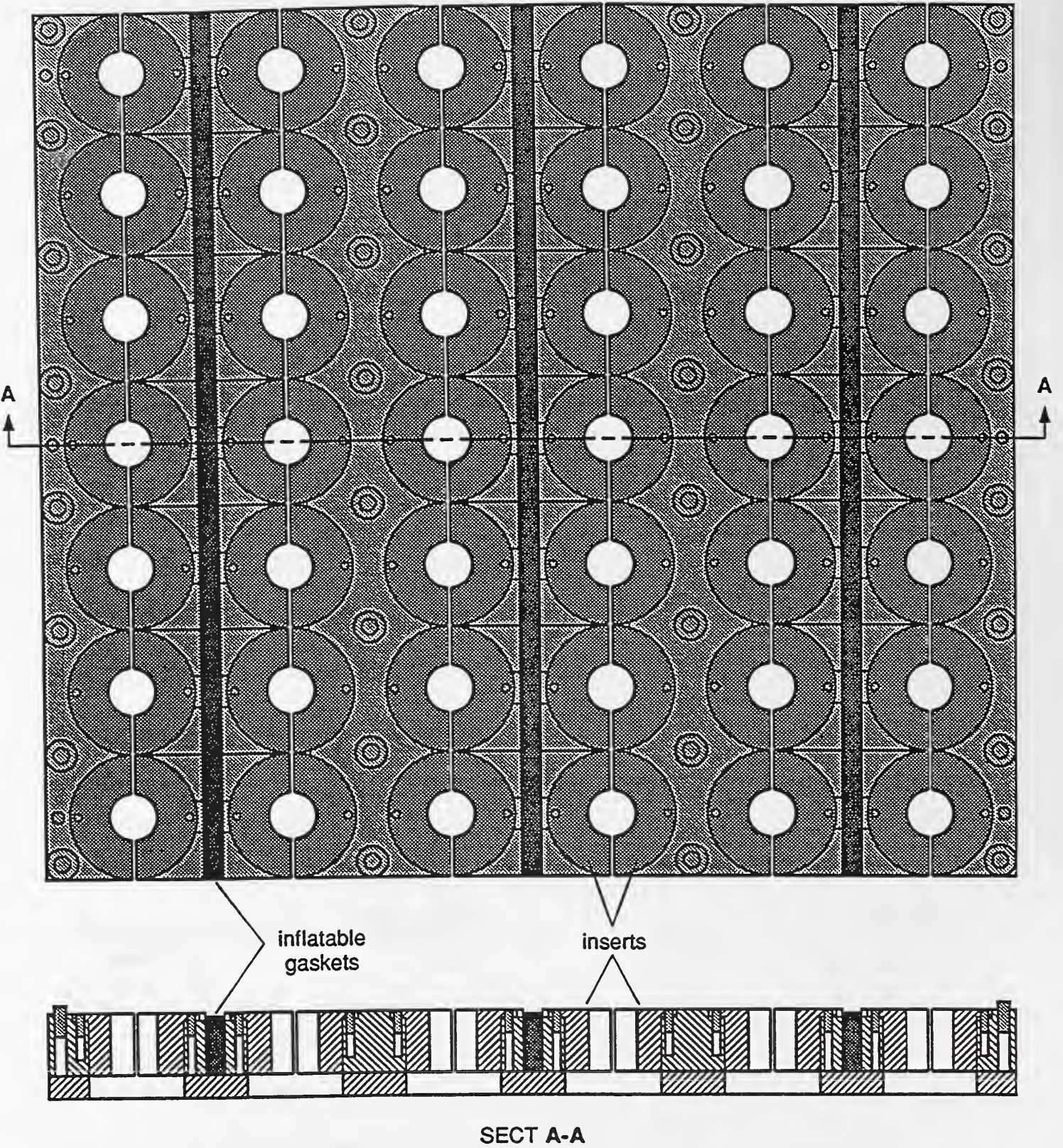
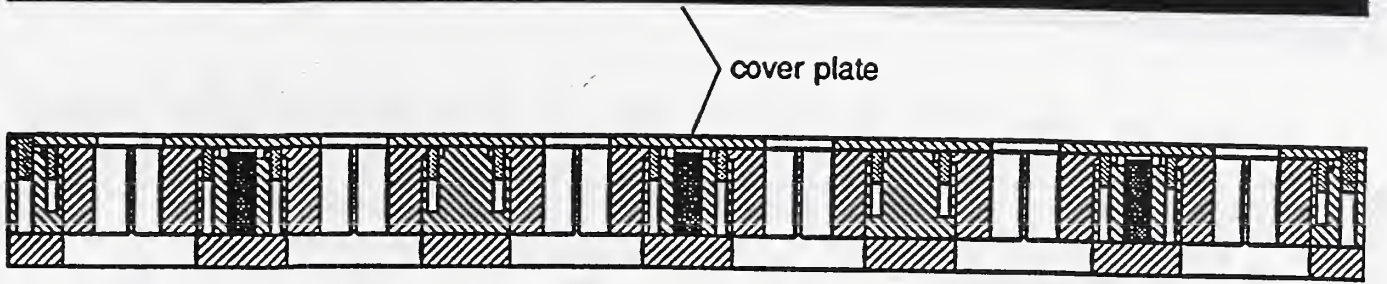
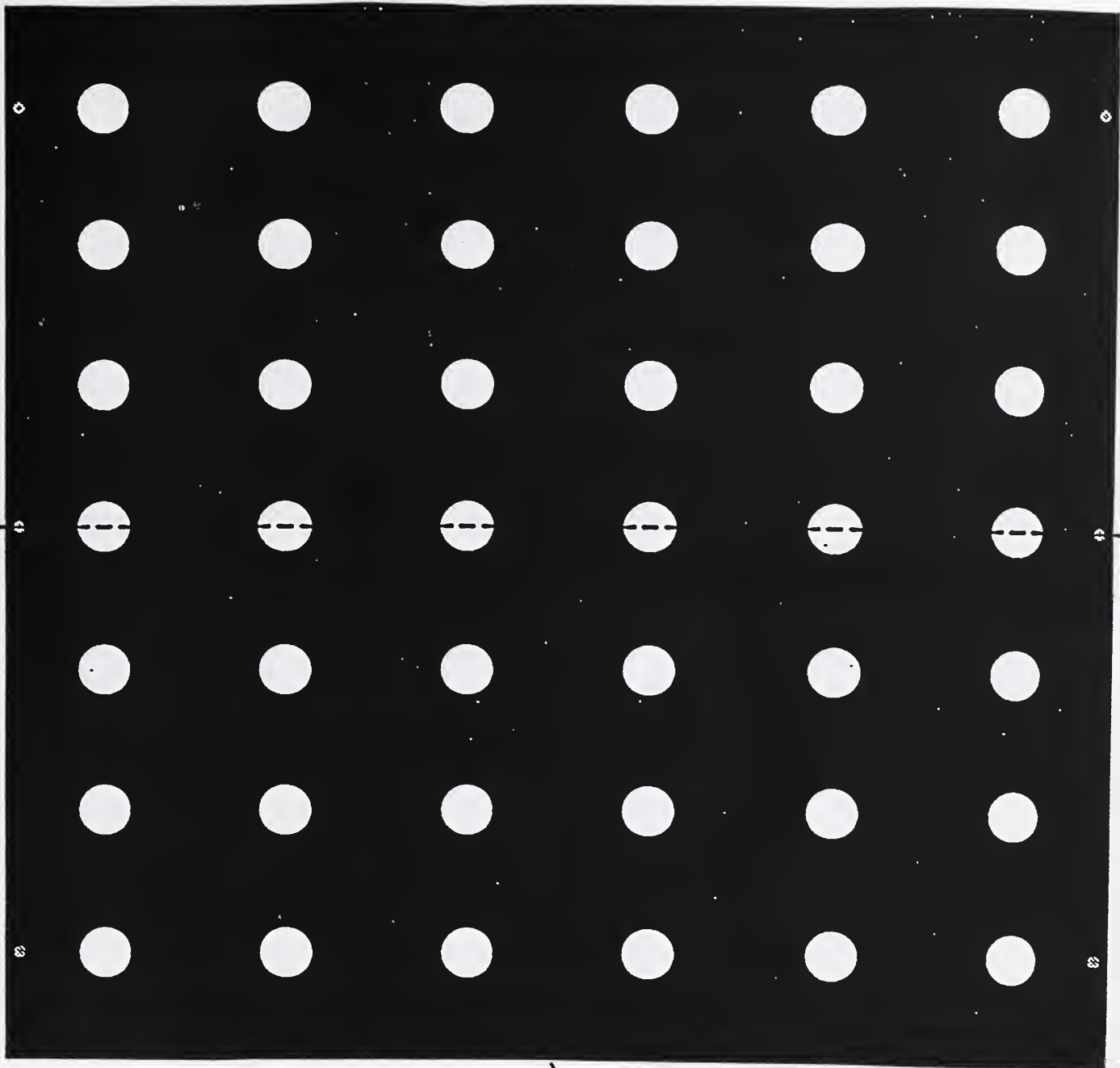


Figure 1.2 Inserts with Clamping Blocks



SECT A-A

Figure 1.3 Cover Plate with Engraving Fixture

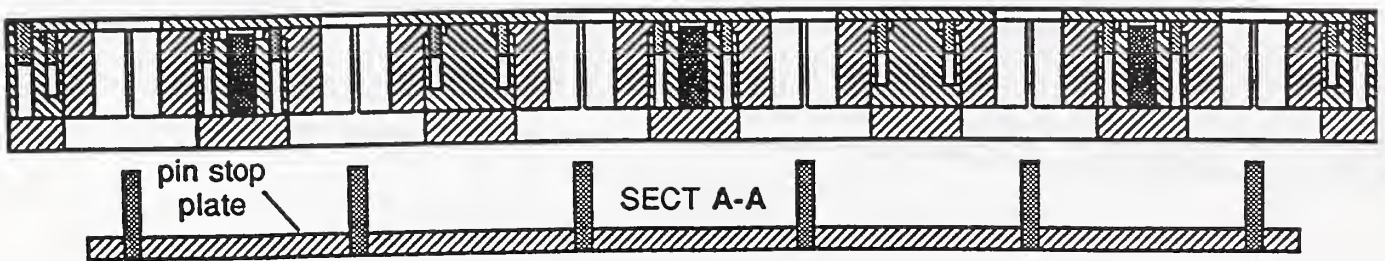
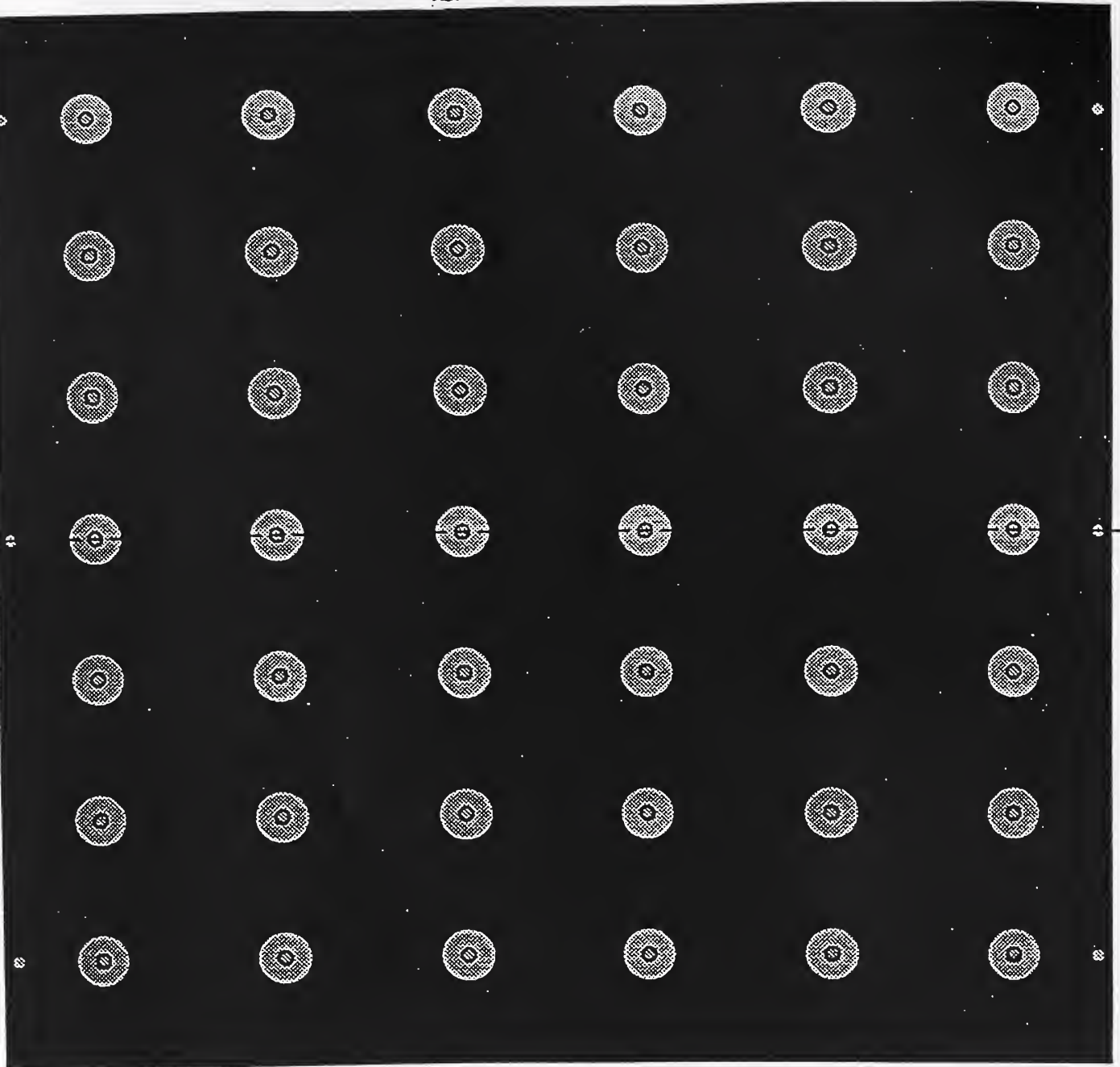


Figure 1.4 Complete Engraving Fixture with Pin Stop Plate

to 7/8 in., socket head cap screws from 1/4 in. to 1 in., and studs from 1/4 in. to 1 1/2 in..¹

2.1.1 Setting Up the Air Valves

Compressed air, with a minimum pressure of 552 kPa (80 lb/in²), is required for the engraving system. The main air line is branched to three lines, each with a shut-off valve. The left shut-off valve activates a vacuum pump. The vacuum hose is connected to the nose cone of each rotary spindle. The vacuum removes any fine engraving chips and collects them at a filter. A branch of the vacuum system is connected to a vacuum cup designed for picking up the inserts from the fixture. The middle shut-off valve and pressure regulator are used for controlling the downward force and speed of the rotary spindle(s). Set the pressure to 103 (+/-34) kPa (15 ((+/-5)) lb/in²). The right shut-off valve and regulator are used to actuate the inflatable gaskets. Three pneumatic toggle switches mounted on top of the pneumatic control box activate the inflatable gaskets. Set this pressure to 414 (+/-34) kPa (60 ((+/-5)) lb/in²).

2.1.2 Installing the Fixturing Inserts

The fixturing inserts are stored in trays inside the blue cabinet below the engraving workbench. Each tray holds a set of inserts for a major diameter size. The sizes range from 1/4 in. to 1 3/8 in. (studs with a major diameter of 1 1/2 in. do not use an insert). Each insert is made up of two symmetric halves. Each half fits into one of the two opposing clamping

¹The fasteners made in this workstation are nominal inch sizes, e.g. 1/4-20. Therefore, the fixtures are also nominal inch sizes.

blocks for each position on the fixture.

Before loading inserts into the fixture, any inserts already in the fixture from a previous job must be removed. Place the empty insert tray for the corresponding size of inserts in the fixture on top of the two aluminum bars mounted on the workbench. Make sure the inflatable gaskets are deactivated. Remove the inserts from the fixture and place them in the tray.

Inserts for major diameters of 1/2 in. or less are difficult to remove by hand. Use the vacuum cup to remove them. Turn on the vacuum pump valve mounted on the left rear of the workbench. Turn the pneumatic toggle switch "on" to activate the vacuum cup.

Place the cup on top of an insert in the fixture. Make sure that the two guide lines on the side of the cup align with the gap between the two insert halves. Press the button on the top of the cup and lift the insert pair out of the fixture as shown in figure 1.5. Lower the insert into a hole in the tray and release the button. Repeat the process for removing the remaining inserts in the fixture.

Store the insert tray in the cabinet and retrieve the tray of inserts for the next job. Place the tray on the workbench and load enough inserts into the fixture for the number of fasteners that will be engraved. Load the inserts from left to right and from the back row to the front. Fill the fixture completely for jobs of more than forty-two fasteners.

When all the inserts have been loaded, select the corresponding cover plate and place it over the four locating pins on the fixture. The vacuum cup may be used to load or unload cover plates for major diameters of 1/2 in. or less.

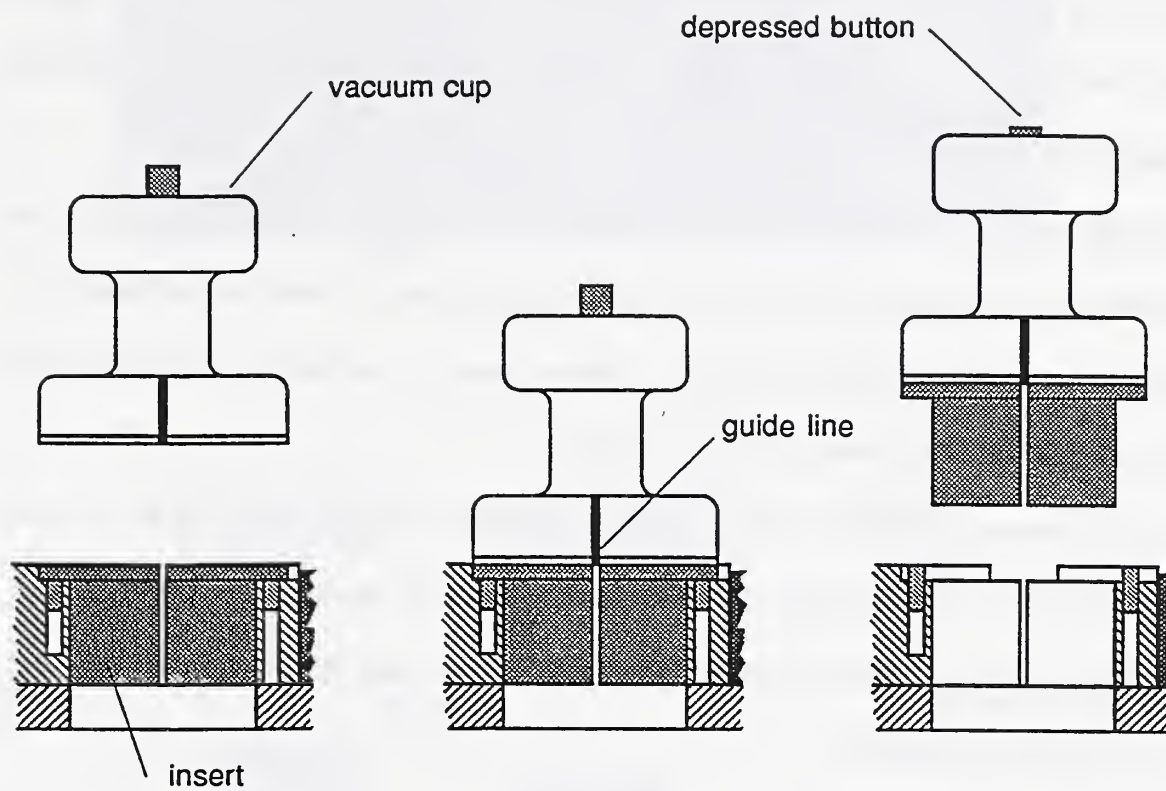


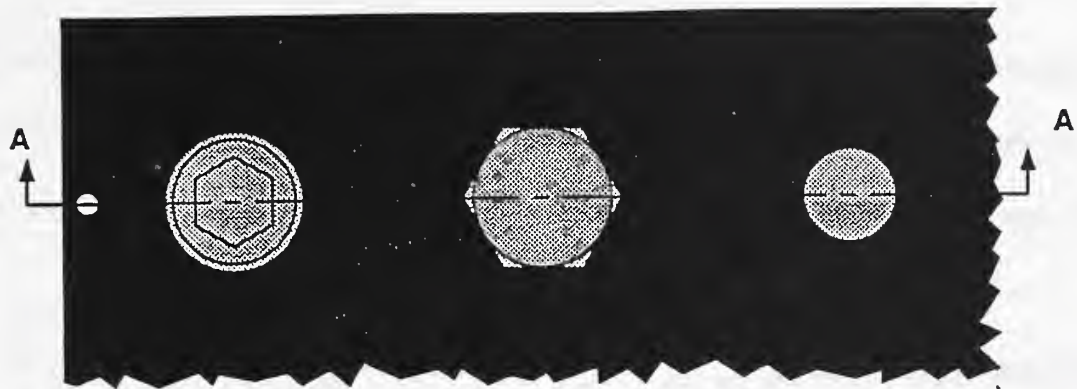
Figure 1.5 Removing an Insert from the Fixture with the Vacuum Cup

2.1.3 Loading the Fasteners

To load a hex head or socket head cap screw into the engraving fixture, move the stop plate all the way down and turn off the pneumatic switches. Slide the body of a screw into an insert until the head shoulder rests on the cover plate. The maximum length of fasteners that can be engraved is six inches.

To load studs, the stop plate must be set at the correct height to support them. Turn the height adjustment knob, located on the front of the stop plate housing under the workbench, to the corresponding length marked on the scale. Slide a stud into an insert. The stud should extend above the cover plate about 6.35 mm (1/4 in.).

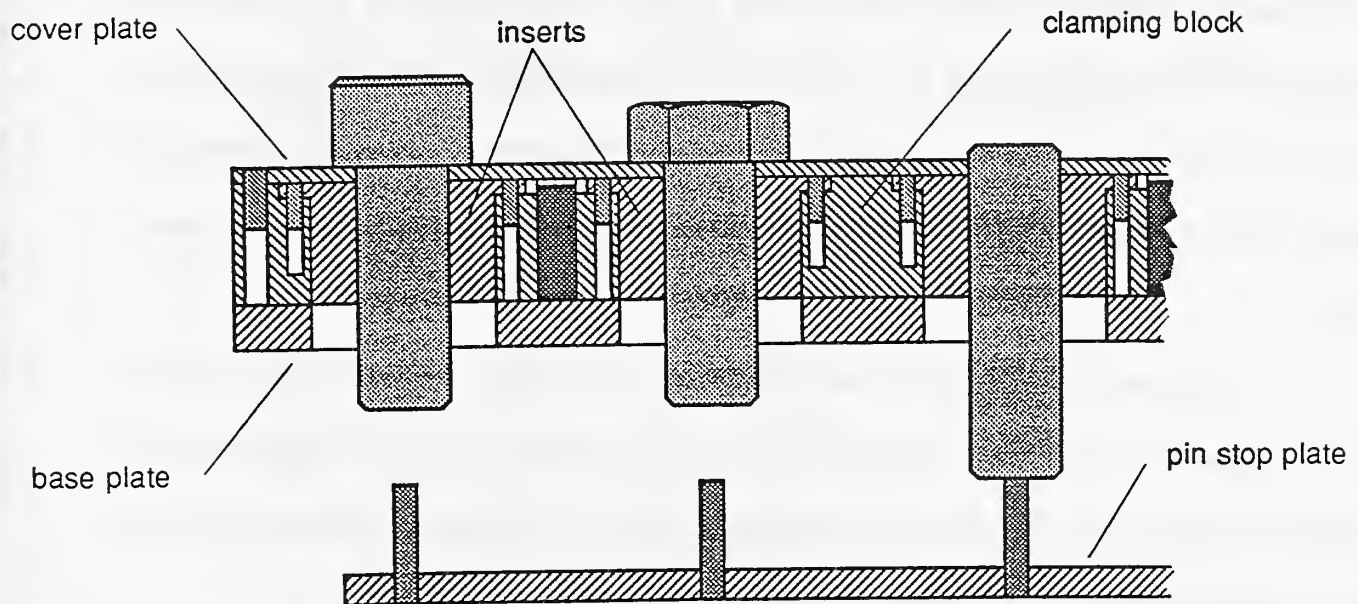
All the fasteners should be loaded in the same manner as the inserts: from left to right and from the back row to the front. After all the fasteners have been loaded, clamp them in place by turning on the pneumatic switches. Figure 1.6 shows each type of fastener properly loaded in the engraving fixture.



Socket Head
Cap Screw

Hex Head
Cap Screw

Stud



SECT A-A

Figure 1.6 The Three Types of Fasteners Supported in the Engraving Fixture

2.2 Setting Up the Rotary Spindle

The second part of the mechanical setup involves installing, referencing, and adjusting the rotary spindle assembly. The engraver can be set up to use either one or two rotary spindles. Figure 1.7 shows a side view of the rotary spindle with its various components.

2.2.1 Installing the Rotary Spindle

Slide the rotary spindle into one of the three horizontal t-slots on the black spindle carriage as shown in figure 1.8. Select a slot which will provide a clearance of approximately 12.7 mm (0.5 in.) between the spindle nose (see fig. 1.7) and head of the fastener. When installing one spindle, the distance between the left edge of the spindle housing and the left edge of the carriage should be approximately 38 mm (1.5 in.). When installing two spindles, the distance should be approximately 25.4 mm (1.0 in.). Tighten the two black securing knobs on the front of the spindle housing. Adjust the depth regulator sleeve and travel stop sleeve such that the spindle nose does not touch the cover plate when the spindle barrel is pushed all the way down.

To install the second spindle, slide the spindle into the same t-slot as the first spindle. Place a spacer or a rod with a diameter of 12.70 mm (0.500 in.) thickness between the two spindle housings and fix the second spindle against the first. The spacing between the axes of the two spindles should be 50.80 mm (2.000 in.).

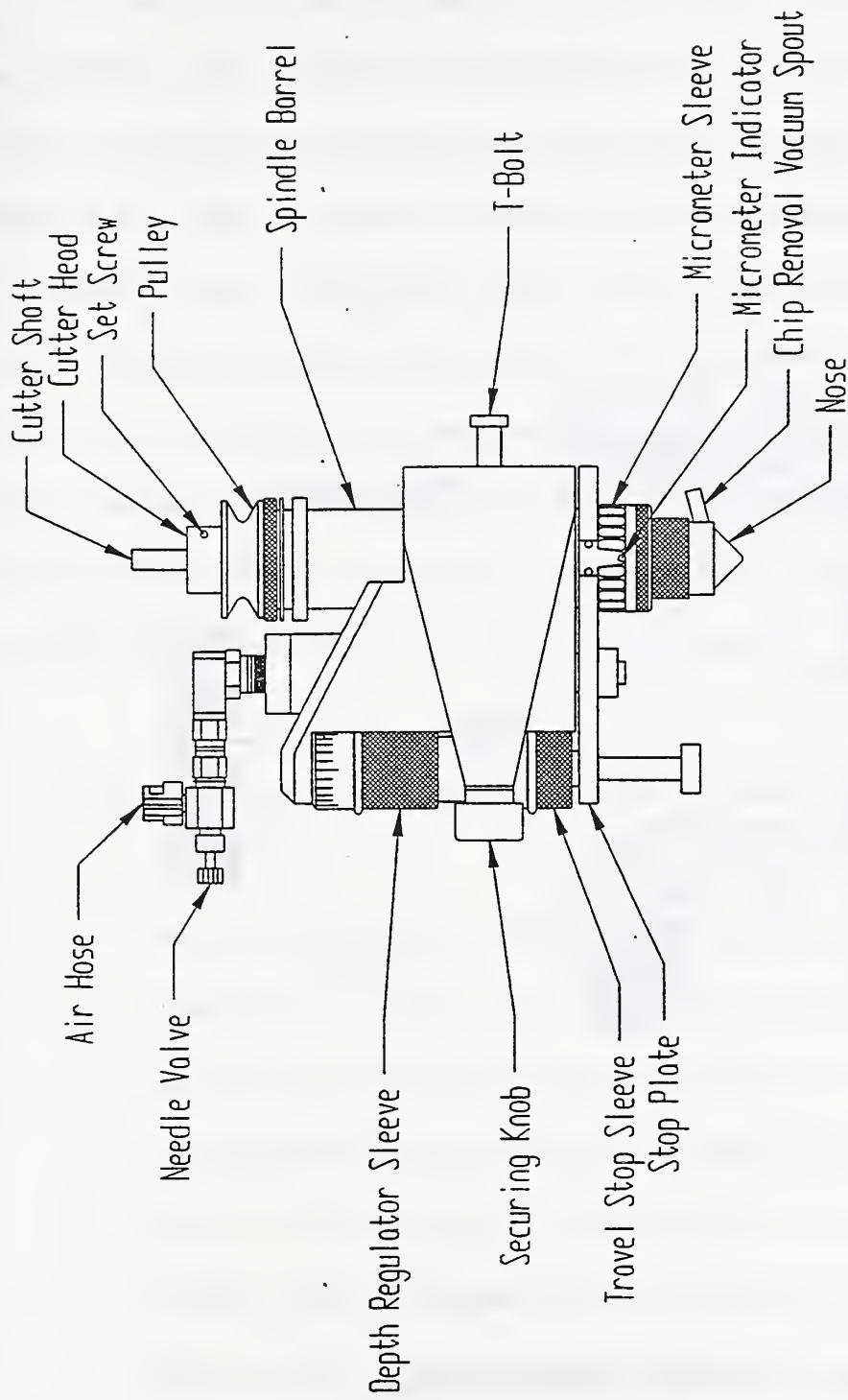


Figure 1.7 Rotary Spindle

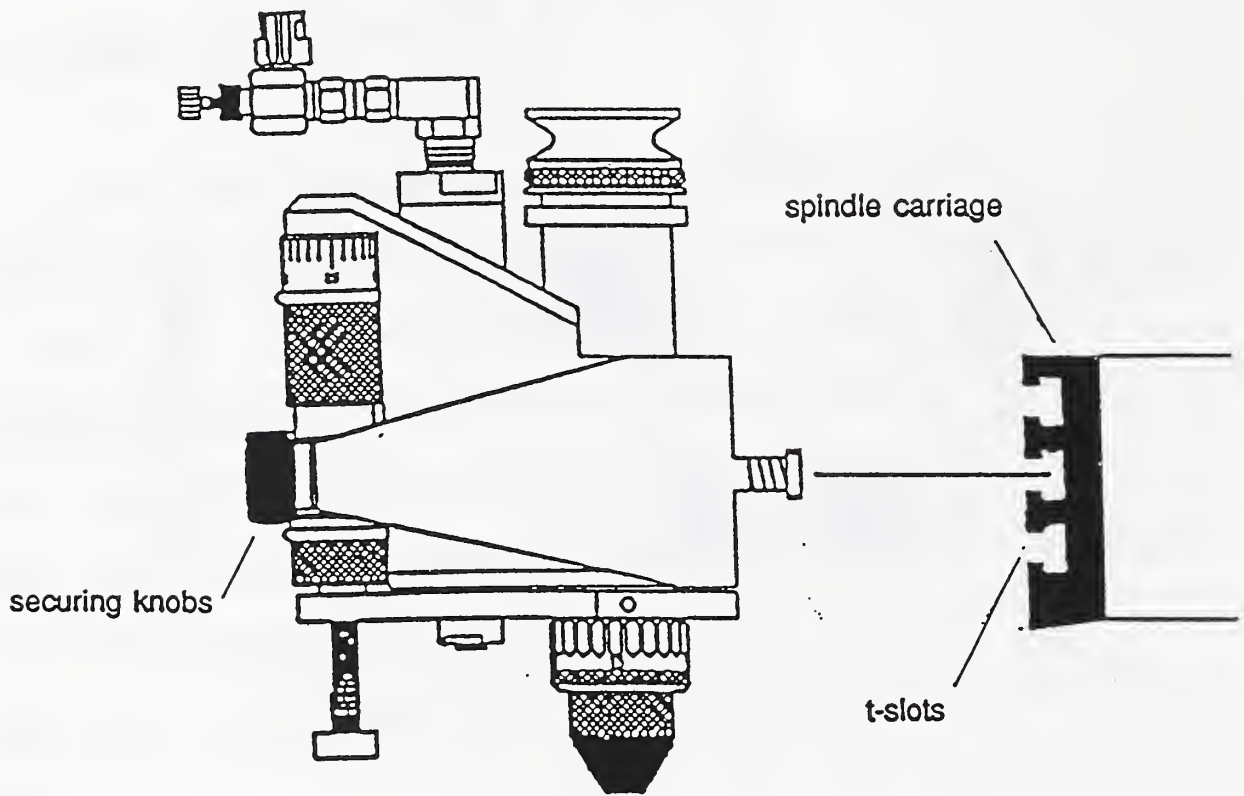


Figure 1.8 Rotary Spindle Installation

2.2.2 Homing the Rotary Spindle

The center of the rear left clamping block is the starting position for all engraving jobs and is referred to as the "HOME" reference position. The rotary spindle must be moved to the "HOME" reference position before the engraving process can begin. To verify the "HOME" position of the spindle, two inductive proximity sensors are mounted on the engraver. The x-axis proximity sensor is mounted on the left end of the horizontal guide rod of the spindle carriage. The left surface of the spindle housing is the x-axis sensing target. The y-axis sensor is mounted on the base plate of the engraver behind the "HOME" position. The y-axis sensing target is mounted on the axis bridge. Two LED's (Light Emitting Diode) labeled X-AXIS and Y-AXIS are installed on the control panel. The sensing range or repeatability of the sensors is well within 0.05 mm (0.002 in.).

To move the spindle to the "HOME" position:

1. Press **STOP/MANUAL MODE** on the Newing-Hall control panel.
2. Manipulate the joystick to move the spindle near the "HOME" position. The sensing targets should not touch the proximity sensors. Even though the sensors are spring-loaded, do not jog the spindle at full speed into them.
3. Move the x-axis manually to the left where the sensing target just touches the sensor by turning the manual adjustment wheel located at the right end of the x-axis lead screw. The x-axis LED will light up.

4. Very slowly move the spindle back and forth along the x-axis until the LED goes off and on again. Stop when the LED lights up. This location is the x-axis "HOME" position.
5. Repeat steps #3 and #4 to move the spindle along the y-axis by turning the manual adjustment wheel located at the front end of the y-axis lead screw. The wheel's protective clip can be removed for easier access.

When both LED's are lit, the center of the spindle should be aligned with the "HOME" position within 0.05 mm (0.002 in.). Draw a line at each manual adjustment wheel to be used as a point of reference for the "HOME" position of later jobs. To verify the alignment of the "HOME" position, follow the procedures described in 2.2.3. Install the cutter(s) in the spindle(s) as described in 2.2.5. Final adjustments are described in 2.2.6.

2.2.3 Aligning the Home Position and Spacing the Second Spindle

The alignment of the spindle to the "HOME" position and the spacing of the second spindle can be checked by using the solid brass reference inserts supplied with the system. The reference insert has a center hole that is 0.05 mm (0.002 in.) larger than the diameter of a cutter shaft. If only one spindle is used, omit steps #9 and #10:

1. Move the spindle(s) away from the "HOME" position towards the right to clear the first and second insert positions.

2. Replace the regular insert in the first position with a reference insert and clamp it in place. If the second spindle is used, replace the insert in the second position with a reference insert as well.
3. Remove the cutter from each spindle by unthreading the cutter head clockwise (left-hand thread). Remove the nose from each spindle.
4. Move the first spindle to the "HOME" position as described in 2.2.2.
5. Install a blank cutter (flat end) of full length into each spindle. If a blank cutter is not available, invert a full length regular cutter.
6. Loosen the set screw in the cutter head of each spindle and lower each cutter until the flat end is about 6.35 mm (0.25 in.) above its reference insert. Retighten the set screw.
7. Slowly push down the first spindle while watching the flat end of the cutter. If the spindle is correctly aligned, the cutter shaft will slide smoothly into the hole without any binding. If the spindle is aligned, proceed to section 2.2.5. If the spindle is out of alignment, continue to step #8. If two spindles are being used, and the first spindle is aligned, proceed to step #9.
8. If the cutter shaft does not slide into the hole or it binds, the spindle must be realigned with the "HOME" position. Push the spindle down and hold it in place just before the end of the cutter touches the reference insert. While watching the alignment of the cutter shaft with the hole, move the spindle along the x-axis and y-axis by turning their respective manual adjustment wheels until the cutter shaft slides into the hole. The spindle is realigned with the "HOME" position, but the

proximity sensors must be repositioned as described in section 2.2.4. If two spindles are being used, and the sensors have been repositioned, continue to step #9 to check the spacing of the second spindle.

9. To check the spacing of the second spindle, the first spindle must be at the "HOME" position. Push down the second spindle and check the alignment of the cutter end with the hole in the second reference insert.
10. If the second spindle does not slide into the second insert, adjust the spacing between the two spindles. **DO NOT MOVE THE FIRST SPINDLE!** Loosen the two securing knobs on the second spindle housing. Gently tap the side of the spindle housing until the cutter shaft slides into the hole. Retighten the knobs and check the spacing again. If the spindle housing needs to be adjusted in the y-axis direction, either shim the spindle housing or swap spindle positions.

When the spindles are correctly aligned, proceed to section 2.2.5 Installing the Cutter.

Checking the alignment of the "HOME" position is not needed for every engraving batch, however, checking the alignment at least once a day or each shift is necessary to maintain the high quality and aesthetic appearance of the engraving.

2.2.4 Positioning the Proximity Sensors

The proximity sensors do not normally need to be repositioned unless the sensor housings have been shifted as a result of a crash by the spindle housing or removal for maintenance is

required. Whenever a realignment of the "HOME" position is done as described in section 2.2.3, the proximity sensors must be repositioned.

1. Align the "HOME" position as described in section 2.2.3.
2. Loosen the two set screws that hold the x-axis sensor housing to the guide rod.
3. While keeping the sensor housing level with the guide rod, gently tap it to the left until the x-axis LED goes off.
4. Gently tap the sensor housing back to the right until the x-axis LED turns on.
5. Tighten the set screws.
6. Loosen the four mounting screws that fix the y-axis sensor housing to the base plate.
7. Reposition the y-axis sensor following the guidelines of steps #3 through #5.
8. Verify the correct positioning of the sensors by repeating the homing and alignment of the "HOME" position procedures described in sections 2.2.2 and 2.2.3.

2.2.5 Installing the Cutter and Adjusting the Depth of Cut

The engraving specifications are described in Ref. [1] (PROCESS INST 9200-942-500H CH1). Section 2.7.1.2.4 Type VII, engrave marking specifies "Engraved characters shall be restricted to the following dimensional limitations: maximum depth - 0.010 inch, minimum depth - 0.004 inch and minimum root radius - 0.005 inch." The width of the cutter tip should

be selected by the user based on the character height. Various cutter tip sizes are available from commercial sources.

Before installing the cutter, the micrometer sleeve (see figure 1.7) of the rotary spindle should be properly set.

1. To reset the micrometer sleeve, remove any cutter from the spindle.
2. Turn the sleeve counter-clockwise all the way until it stops, then turn it back four times.
3. Set the sleeve to zero.
4. Place a flat piece of aluminum plate (about 40 x 40 x 3 mm) under the spindle for setting the cutter tip flush with the nose cone. If a flat plate is not available, use the fastener head surface.
5. Select a proper tip size for the job. The tip size is marked on the cutter head.
6. Install the cutter with the head (left-hand thread) in the spindle until hand tight. If the cutter tip protrudes out of the nose cone, loosen the set screw in the cutter head and raise the cutter.
7. Push the spindle down until the nose cone touches the flat plate and hold it in place.
8. Loosen the set screw and gently slide the cutter down until it touches the flat plate. Do not drop the cutter down the spindle or press the shaft too hard. The cutter tip is very brittle and sharp. Tighten the set screw. The cutter tip should be flush with the nose cone, and the depth of cut should be zero. A simple engraving test is recommended at this point to insure that the spindle does not

engrave any surface at this setting.

9. Turn the micrometer sleeve clockwise to set the depth of cut. Each notch on the sleeve is equivalent to a depth of cut of 0.025 mm (0.001 in.).

2.2.6 Final Adjustments

Before running the engraving software, the following final adjustments should be made:

A. Spindle Drive

The rotary spindles are driven by a single motor mounted on the back of the engraver and are connected with a single belt and spring-loaded yoke. The yoke should be mounted on the retaining groove of the first spindle pulley. To run both spindles, stretch the belt and engage it to the pulley of the second spindle. CAUTION: The belt is tensioned by a spring inserted in the connecting tube. If the belt is not removed carefully, the spring will pop out. While removing the belt, hold the yoke and connecting tube firmly. Slowly release the yoke to relax the spring. Follow the reverse order for installing the belt.

B. Adjustment of the Needle Valve

The needle valve on the spindle air cylinder controls the speed of the spindle's downward movement. If the speed is too fast, the cutter tip will break or leave heavy indentation marks on every down stroke of the spindle. If the speed is too slow, part of the engraving at the end of the down stroke will be skipped, and the cuts will be shallower than the set depth of cut. The

speed of the spindle's downward movement, the feed rate, and the dwell time between strokes should be synchronized to engrave correctly.

1. Place the aluminum plate used for the spindle alignment under the spindle(s).
2. Press the **STOP/MANUAL MODE** button.
3. Press the **TEST SPINDLE LEFT** and/or **TEST SPINDLE RIGHT** buttons to move the spindle(s) down. While watching the speed of the spindle's movement, adjust the needle valve.
4. Adjust both spindles to the same speed.

C. Adjustments of the Spindle Speed, RPM (Revolutions Per Minute)

The spindle RPM is controlled by the **PERCENT SPINDLE SPEED** knob on the control panel. The conversion of percent spindle speed to the actual RPM is shown in Table 1. The settings for spindle speeds for commonly used materials and cutter sizes are shown in Table 2.

D. Adjustment of Spindle Feed Rate and Dwell Time

Under normal conditions, set the feed rate and dwell time at mid-range. Depending on the material and spindle RPM, make adjustments to obtain the best results. Record all settings and adjustments for later use.

Table 1

**Newing-Hall Model 300
Rotary Spindle Speed
(No Load)**

PERCENT SPEED	SPINDLE RPM
ON	2,000
10%	3,500
20%	5,000
30%	7,300
30%	11,000
50%	14,000
60%	18,500
70%	22,000
80%	24,500
90%	26,500
100%	28,000

Table 2 *

Suggested Spindle Speed Settings For Commonly Used Materials And Cutter Sizes

CUTTER TIP SIZE	STANDARD ENGRAVING STOCK AND MICROSURFACES	ACRYLICS AND MODIFIED ACRYLICS	ANODIZED AND COLORED ALUMINUM BRASS	PHENOLIC	STAINLESS STEEL
0.010	100%	100%	70% TO 80%	100%	35% TO 55%
0.020					
0.030					
0.040					
0.050	55% TO 85%	60% TO 75%	55% TO 80%	60% TO 70%	15% TO 25%
0.060				50% TO 60%	
0.090				40% TO 50%	
0.125				30% TO 40%	
0.171	30% TO 40%	30% TO 40%	40% TO 45%	20% TO 30%	

* (Adapted from Newing-Hall Model 300 Engraving System Manual)

E. Final Test

Before engraving the production fasteners, perform a test run on a sample fastener to ensure that all settings and adjustments are correct. Make corrections if needed.

3. Running the Software

Once the mechanical setup is completed, the computer with the operator-to-engraver interface software controls and runs the engraving jobs. This software allows the operator to enter all the necessary data at the computer keyboard for engraving the fasteners. The software configures keyboard input into a text file and an engraving job file. The text file contains the engraving characters and symbols, and the job file contains the layout pattern for the text. The two files are downloaded from the computer to the engraver, and the engraving process begins.

Making sure that the computer is prompted at Drive C:, start the software. If only one rotary spindle is being used, type **ENGRAVE1** and enter. If both spindles are being used, enter **ENGRAVE2**. The operator will be prompted to enter information or select from a menu of options throughout the program. If, at any time, the operator wishes to change a response already entered, simply press **CTRL-C** to exit the program. Begin again by entering **ENGRAVE1** or **ENGRAVE2** and reentering all requested information.

The first instruction prompts the operator to select the appropriate symbol for identifying Portsmouth Naval Shipyard as the manufacturer of the fasteners:

**Select the manufacturer's symbol to be engraved.
Enter a 1, 2 or 3.**

- 1 A**
- 2 PNS**
- 3 No manufacturer's symbol is used**

Both A and PNS are acceptable Portsmouth identifiers, but each symbol indicates a different

destination for that batch of fasteners. Refer to the shop work instruction for the appropriate marking. The monitor will display the operator's choice as it is entered and will return with a statement indicating that choice. If, for example, the operator chooses the symbol A, the monitor will read:

1

Manufacturer's symbol is A.

Next, the operator is prompted for the lot number:

**Enter the lot number of the batch of fasteners to be engraved.
The number of characters must be limited to 5; e.g., "D2568".**

At the time that this instruction manual is being written, the total number of characters in the lot number is four. When the four character series ends, a five character series will start. Refer to the shop work instruction. Make sure that any letters entered are in upper case mode:

Acceptable: **R759**

Not Acceptable: **r759**

As stated earlier, this engraving system is limited to marking hex head cap screws (referred to as "bolts" in this manufacturing workstation), studs, and socket head cap screws.

The operator is prompted to select the type of part to be engraved:

Select the type of fastener to be engraved.

Enter a 1, 2, or 3.

- 1 Bolt**
- 2 Stud**
- 3 Socket Head Cap Screw**

Fasteners with nominal diameters of 6.35 mm to 38.1 mm (1/4 in. to 1 1/2 in.) can be engraved in this system:

Select the nominal diameter of the fastener to be engraved.

Enter one number between 1 and 14.

- | | |
|-----------------|------------------|
| 1 0.2500 | 8 0.7500 |
| 2 0.3125 | 9 0.8750 |
| 3 0.3750 | 10 1.0000 |
| 4 0.4375 | 11 1.1250 |
| 5 0.5000 | 12 1.2500 |
| 6 0.5625 | 13 1.3750 |
| 7 0.6250 | 14 1.5000 |

Some nominal diameter sizes do not apply to certain fastener types in this system. Table 3 shows the fastener types with their available nominal diameters:

Table 3

Fastener Types and Sizes for the Portsmouth Fastener Manufacturing Workstation

Major Diameter (inches)	Bolts	Studs	Socket Head Cap Screws
0.2500	✓	✓	✓
0.3125	✓	✓	✓
0.3750	✓	✓	✓
0.4375	✓	✓	✓
0.5000	✓	✓	✓
0.5625	✓	✓	
0.6250	✓	✓	✓
0.7500	✓	✓	✓
0.8750	✓	✓	✓
1.0000		✓	✓
1.1250		✓	
1.2500		✓	
1.3750		✓	
1.5000		✓	

If, for example, a socket head cap screw is selected as the fastener type, and the operator selects 0.5625 inches for the nominal diameter, the program will accept the selection but will not be

able to execute the engraving process. No such job file has been created for a 9/16 inch diameter socket head cap screw. When the computer attempts to download the necessary job file to the engraver, the monitor will display an error message.

An identification symbol indicating the material that the fastener is made of is required:

**Enter the material ID symbol to be engraved on the fasteners.
Limit the number of characters to 4; "*K*" (K-monel),
"NC" (Nickel Copper), etc.**

Some bolts and socket head cap screws will require nylock inserts in their usage. If the fasteners will be using nylon inserts, they must be marked with six equally spaced dots on the head of each fastener:

**Will nylon inserts be used in the fastener(s)?
Enter a "y" or "n".**

The operator is prompted for the total number of fasteners that will be engraved in the batch:

Enter the number of pieces you wish to engrave.

For studs, the stop plate under the engraving fixture will have to be adjusted to the correct height to support the pieces securely. The operator is asked to select the appropriate stud

length and is instructed to set the plate for that length:

**Select the length of the stud to be engraved.
Enter one number between 1 and 19.**

1	1	8	2 3/4	15	4 1/2
2	1 1/4	9	3	16	4 3/4
3	1 1/2	10	3 1/4	17	5
4	1 3/4	11	3 1/2	18	5 1/2
5	2	12	3 3/4	19	6
6	2 1/4	13	4		
7	2 1/2	14	4 1/4		

Finally, the operator is instructed to load the engraving fixture with the fasteners. If more than forty-two pieces are in the batch, the operator loads the fixture to full capacity:

**Load engraving fixture to capacity with 42 pieces.
When ready to engrave, press "Enter".**

The computer downloads the proper text and job files to the engraver and starts the engraving process. The operator is notified when the engraving is complete:

**When job has finished, unload the fasteners
and press "Enter".**

The operator is prompted to load the next forty-two pieces or any remaining and hit the "Enter" key. When the engraving is complete, he is instructed to remove the fasteners. After the entire

batch has been engraved, the operator can press **CTRL-C** to set up the software for the next operation.

4. List of References

- [1] PROCESS INSTRUCTION 9200-924-500H, Enclosure (1.3) Receipt Inspection and Marking, 2.7.1.2.4 Type VII, engrave marking, (1987), p. 5.



