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Adaptation of a Commercial Robot for Genome Library Replication

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Lawrence Berkeley Laboratory
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Engineering Division

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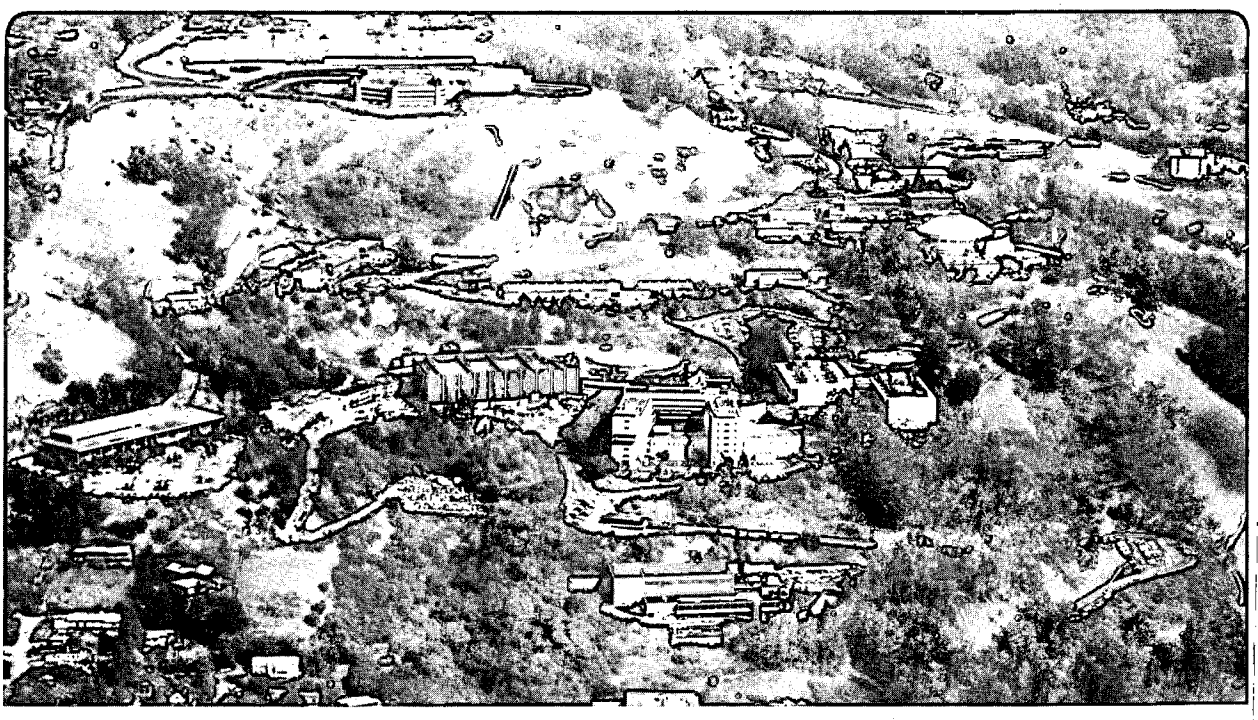
D.C. Uber and W.L. Searles

January 1994



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Adaptation of a Commercial Robot for Genome Library Replication

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Abstract

This report describes tools and fixtures developed at the Human Genome Center at Lawrence Berkeley Laboratory for the Hewlett–Packard ORCA™ (Optimized Robot for Chemical Analysis) to replicate large genome libraries. Photographs and engineering drawings of the various custom–designed components are included.

Introduction

The Human Genome Program is a fifteen year project, funded by the U.S. Department of Energy and National Institutes of Health, to map and sequence the human genome. Similar programs are underway to map and sequence the DNA of other plant and animal species. Current sequencing technology requires that the DNA of the target organism be cut into fragments of a few hundred base pairs. To facilitate its manipulation, each fragment is introduced into a bacteria or yeast cell, which replicates this foreign DNA as well as its own when it divides. The DNA of a single human may consist of as many as two hundred thousand such colonies arrayed in microtiter plates, which are plastic dishes with grids of wells in standard formats of 96 or 384 wells each. Such a collection of plates is known as a genome library.

It is frequently necessary to make copies of a library so that several researchers may collaborate on the mapping and sequencing of the same organism. The original material, which took much effort to produce, can then be safely kept in cold storage. While the copies may be made with a hand replicating tool, it is a very tedious job for a library of several hundred plates. Fortunately, the task is automatable on a general purpose robot such as the ORCA.

The ORCA is a benchtop machine designed by Hewlett–Packard primarily for preparing samples and transporting them among analytical laboratory instruments (1). It has a rail–mounted arm with six degrees of freedom, giving it a great deal of dexterity. Its open hardware and software architecture permit it to be adapted to a wide variety of tasks. We chose library replication as the first task to implement on an ORCA at the LBL Human Genome Center.

Custom Hardware

Hewlett–Packard supplies the ORCA with a flexible software development system, and expects third party developers and technically sophisticated end users to develop the necessary hardware and programs for specific applications. Consequently, all the plate replication tools, fixtures, and software were developed at LBL. However, we were able to take advantage of our experience in customizing an earlier model Hewlett–Packard Microassay System robot for the same job (2), and refined those ideas for the ORCA.

We now describe each of the various custom hardware components in detail. Figure 1 shows the layout of the components on the ORCA table. Engineering drawings are found in the Appendixes.

Gripper Fingers

The stainless steel gripper fingers (Fig. 2) enable the ORCA to pick up microtiter plates, move them around the workspace, and remove their lids. They mate to the ORCA hand by means of standard adapters supplied by Hewlett–Packard that allow the robot to exchange tools during a procedure.

Microplate Hotel

The source microtiter plates during a replication run are stored in a Lucite "hotel" consisting of three columns of twelve shelves each, for a total of thirty–six plates. Cutouts at the rear of each shelf permit easy loading by hand. The robot can reach in with its gripper fingers and remove or replace the plates in any order. We use the hotel rather than a stacker because the source plates frequently come with sealing tape under the lids. Once the tape is removed by hand, the sticky residue prevents the robot from removing the lids, so the plates must be individually stored without lids on the shelves of the hotel. The library replication program has the option of removing source plate lids, so source plates without sealing tape may be stored in the hotel with their lids on.

The bottom level of the hotel has countersunk holes so that it may be screwed to the 25 mm grid of tapped holes on the ORCA table. The holes have minimal clearance so that the hotel is precisely located. This is also true for other fixtures such as the stackers, workstations, etc.

The front surfaces of the hotel are beveled to guide the plate into place when being replaced by the robot. We use this technique on all the fixtures where the robot must insert an object into a space with small clearance. This makes the system tolerant of small variations between similar workstations or of imprecisely taught motions, and prevents crashes that would occur if the robot tried to force an object against a blunt surface.

Microplate Stacker

The blank copy microtiter plates for a replication run are stored with lids in Lucite stackers (Fig. 2) that ORCA accesses sequentially. While the stackers can store up to twenty–five plates each, the robot arm can only reach twenty at the distance from the rail we mount the stackers. Lines are scribed on the back of the stackers to indicate stack heights for both standard 96–well and LLNL 384–well plates, which are slightly taller.

To optimize use of the workspace, stackers may be placed 10 cm apart. This spacing allows just enough room for the gripper fingers between adjacent stacks.

Microplate Workstation

The Lucite workstations (Fig. 2) provide temporary storage for microtiter plates and their lids during actual replication. They have the same 10 cm by 15 cm footprint as the stackers, so that they can be packed tightly together on the table.

Multipin Replicating Tools

The ORCA replicates plates with either a 96–pin or 384-pin tool (Fig. 3), depending on the type of plates being used. Replication from one plate size to the other is possible, as well as between like sizes. In addition, the tools may be used to make high density filters. Each tool contains stainless steel captive pins that can slide vertically in holes in a Delrin™ baseplate. An internal stripper plate pushes down on the heads of the pins, so that they do not get hung up in the holes. An aluminum heat shield on the bottom keeps the Delrin base from warping when the tool is heated in the sterilizing station.

Each tool has a polyethylene upper layer that supports two aluminum gripper bars (Fig. 4). Each bar has a centered square hole that mates with a pin on one of the gripper fingers. Both the pins and holes are beveled to assure positive mating. The pins are located on the support bar of the fingers, so that the multipin tool is very stably supported directly beneath the centerline of the ORCA hand.

Since the same gripper fingers are used to hold the multipin tools as well as to move microtiter plates, the robot does not have to waste time changing fingers.

Multipin Tool Park

Two simple Lucite parking stations hold the multipin tools between replication runs. These stations resemble raised microplate workstations with a large cutout so that the pins in the tools can hang freely.

Multipin Tool Sterilizer

The multipin tool in use must be cleaned between source plates, so that the organisms from one source plate do not contaminate the next. We have built a sterilizer (Fig. 4) that consists of two parts: a sonic bath and an electric heater. Under control of the library replication program, the ORCA places the multipin tool on top of the sonic bath, so that the pins are immersed in a sterilizing fluid, such as 70% ethanol, that is toxic to the organisms being replicated. The robot's control computer turns on a sonicator that agitates the fluid and helps knock contaminants off the pins. During this time the ORCA puts finished plates back into hotels and stackers. The computer turns off the sonicator after a programmed delay of several seconds. The ORCA then moves the tool to the electric heater, which the program switches on to evaporate the fluid from the pins. During the heating, the robot gets new plates ready for the next round of replication. The computer switches the heater off after it has been at operating temperature for several seconds.

The sonic bath is kept at a constant level by pumping fluid from an external reservoir. When the fluid in the bath reaches the top of an adjustable dam, the overflow returns the fluid to the reservoir. Level sensors in the bath and reservoir allow the computer to wait while the bath fills, and to alert the operator if insufficient liquid is present. At the end of a replication run, the computer turns off the pump, allowing the liquid to drain from the bath to the enclosed reservoir, to reduce evaporation.

The electric heater contains an electric heating element whose temperature is maintained by a commercial controller, using a thermocouple near the heating wire for feedback. The controller also tells the computer when the heater has reached operating temperature. An over–temp safety switch automatically shuts down the heater if the controller fails. Another safety switch prevents the heater from turning on unless the multipin tool is present, to reduce shock hazard. The computer monitors these switches and shuts down the system if a failure occurs.

Dispensing Station

New copy plates may optionally be filled with growth medium during a replication run. For this purpose, we took Hewlett–Packard G1243A syringe pump drives from the older Microassay System, and interfaced them to a COM port on the ORCA control computer via an RS232 to RS485 converter. The dispensing station and 16–channel head were also taken from the Microassay System and mounted on the ORCA table with a simple Lucite adapter plate. A vacuum pump connected through a trap vessel suctions fluid from a catch basin underneath the dispense head when the dispenser system is being primed.

Input/Output Control

Digital control of external devices such as the vacuum pump and the sterilizer sonicator, temperature control, and reservoir pump, is accomplished by means of a Hewlett–Packard HP3488A Switch/Control Unit with a 44474A 16–bit digital i/o card. The 3488A is controlled by the ORCA computer via the IEEE 488 bus. Eight bits of the i/o card are connected to a control box of our own design that provides latched 115 vac outputs and allows the same eight bits to be used as inputs via tri–state gates. The control box also provides a 5 vdc supply for external circuitry such as the heater temperature control and sonicator level sensor.

Performance

The number of new copy plates that the system can generate per hour is shown in Fig. 5. The throughput increases as more copies of each source plate are made, because the overhead of fetching and storing the source plate and cleaning the replication tool is spread over all the copy plates. The 384–well plates are copied more slowly than 96–well simply because of the longer time needed to dispense growth medium into the larger number of wells. For comparison, the older Microassay System (polar arm) is also shown.

In terms of volume, the ORCA can generate up to 180 new copy plates (e.g., five copies of thirty-six source plates) in a single unattended run using the workspace on only one side of the rail. The Microassay System can generate a maximum of eighty new plates per run.

Conclusions

The custom hardware described above, together with appropriate software, provides a good example of how a commercially available, general purpose robot can be successfully adapted to replicate large genomic libraries. In developing such a system, we have found it essential to have access to a high quality machine shop that can provide rapid turnaround as new ideas are tried. Almost all the items described went through several iterations before reaching final form.

Acknowledgments

We thank Arnold Haus, Steven Rothway, and Donald Thewlis for expert machining and construction of the custom hardware, Joseph Katz and Michael Press for design and construction of the I/O control box, Davey Hudson for design and construction of the sonic bath level sensor, and Michael Osofsky and John Home for preparing CAD drawings.

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Reference to a company or product name does not imply approval or recommendation of the product by the University of California or the U.S. Department of Energy to the exclusion of others that may be suitable.

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1. G.B.Gordon, J.C.Roark, A.,Schleifer, "ORCA: Optimized Robot for Chemical Analysis," *Hewlett–Packard Journal,* (June 1993): 6-19.

2. J.M. Jaklevic, A.D.A. Hansen, E.H. Theil, D.C. Uber, "Application of Robotics and Automation in a Genomic Laboratory," Laboratory Robotics and Automation, Vol. 3, 161-168 (1991).

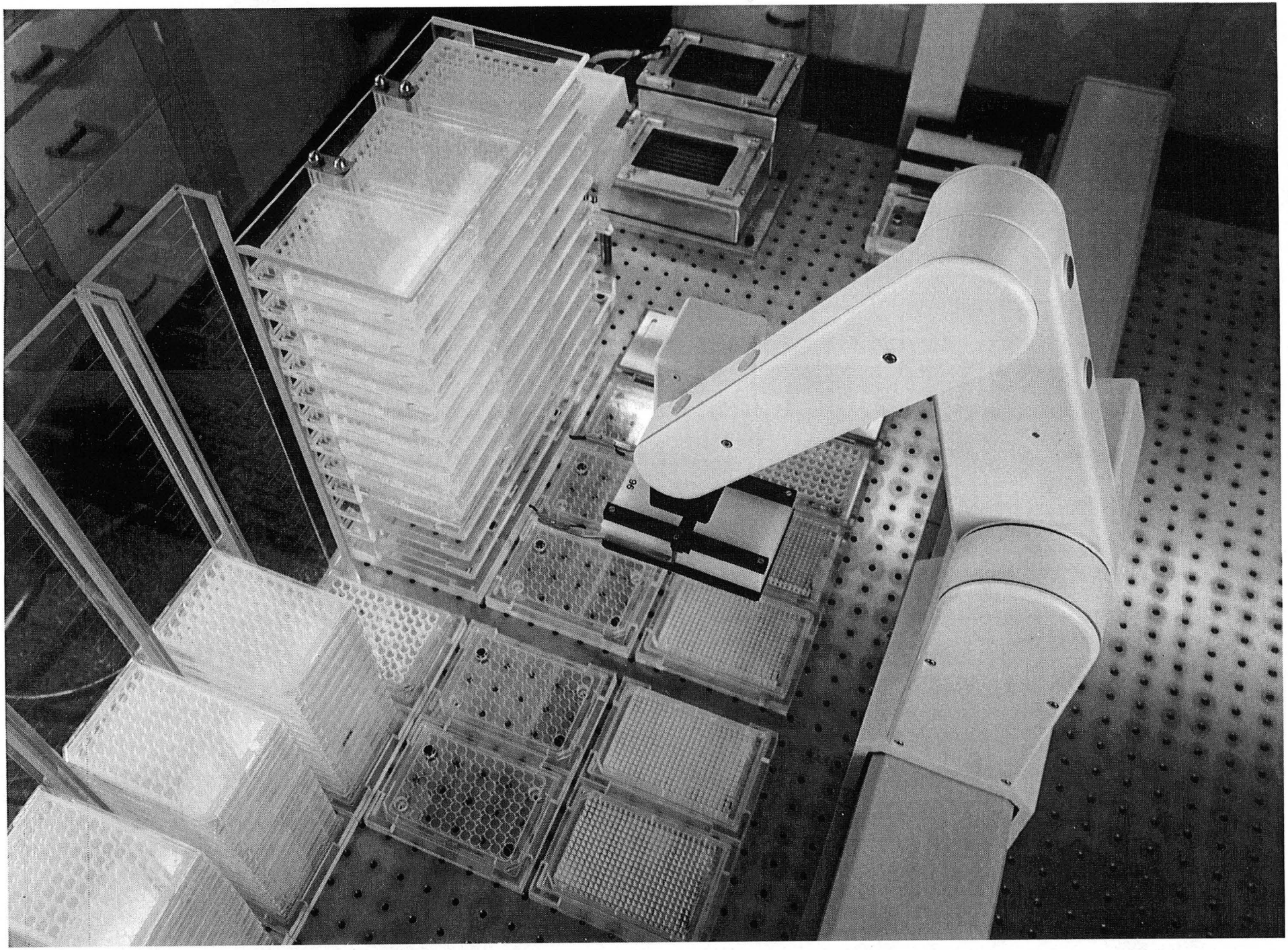


Figure 1. Overview of automated library replication system. The ORCA arm and rail are at right. The ORCA is holding a multipin replicating tool over workstations containing microtiter plates and lids. Furthest from the rail, starting at lower left, are stackers with copy plates, the hotel with source plates, the dispensing station (partially hidden), the sterilizer heater, and sterilizer bath.

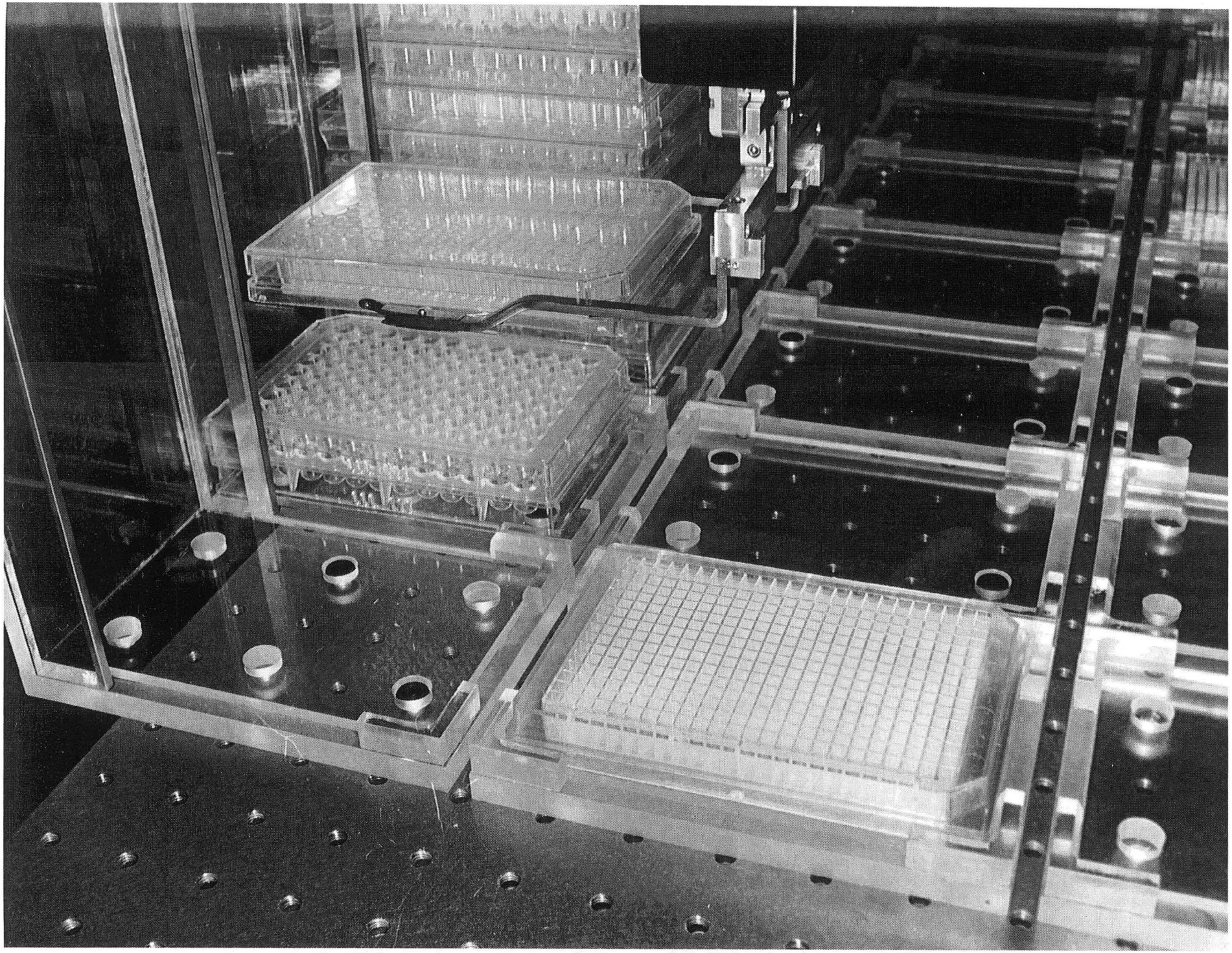


Figure 2. Close–up of gripper fingers lifting a microplate from a stacker. A 384–well plate sits on a workstation in the foreground.

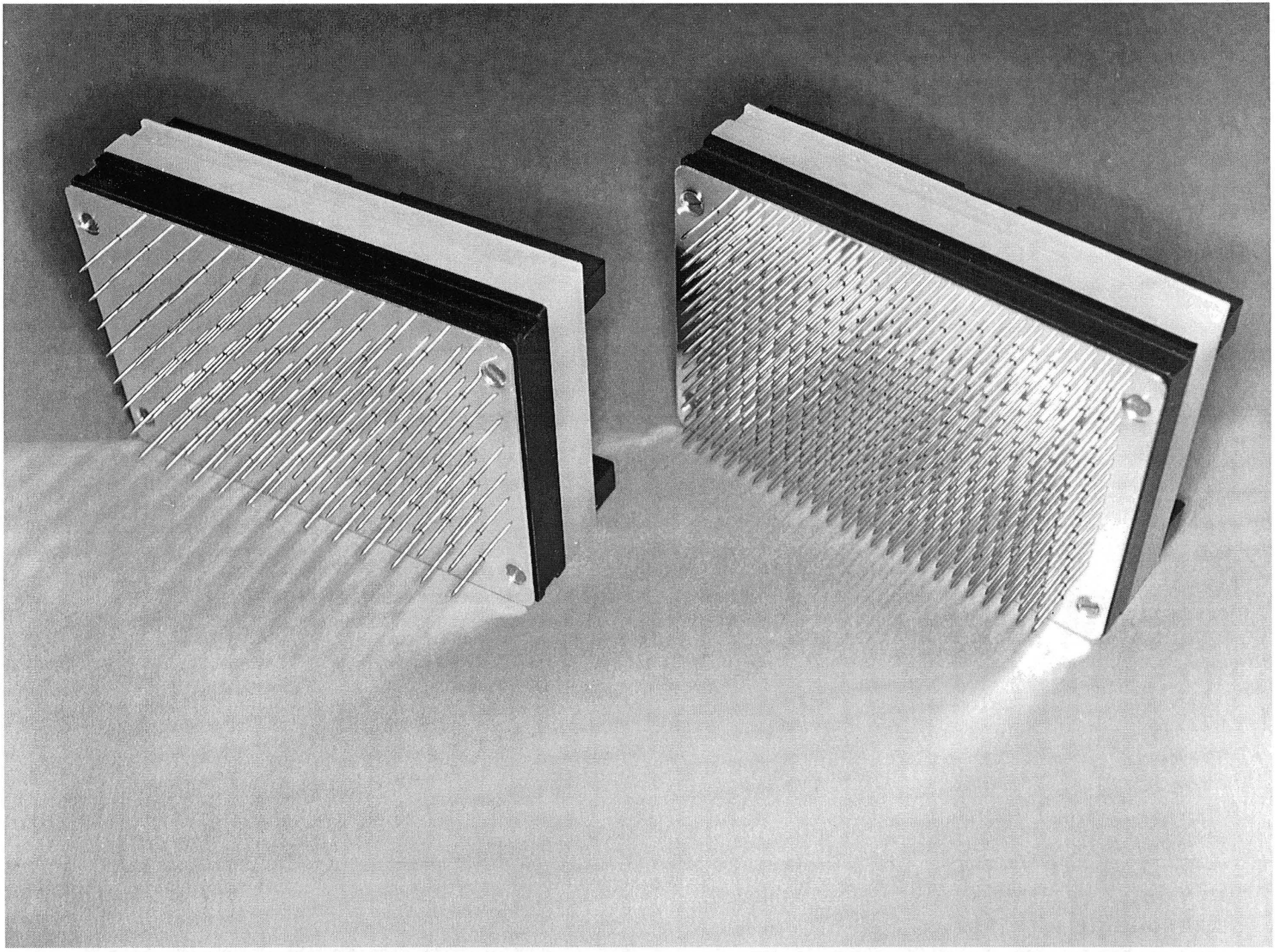


Figure 3. The 96 and 384–pin replicating tools. The captive pins slide in holes in the black Delrin baseplate. An aluminum heat shield keeps the Delrin from warping in the sterilizer heater.

Figure 4. The sterilizing station. The ORCA gripper is holding a multipin tool above the sonic bath. The electric heater is at left; its temperature controller at right. The ethanol reservoir is out of sight beneath the table.

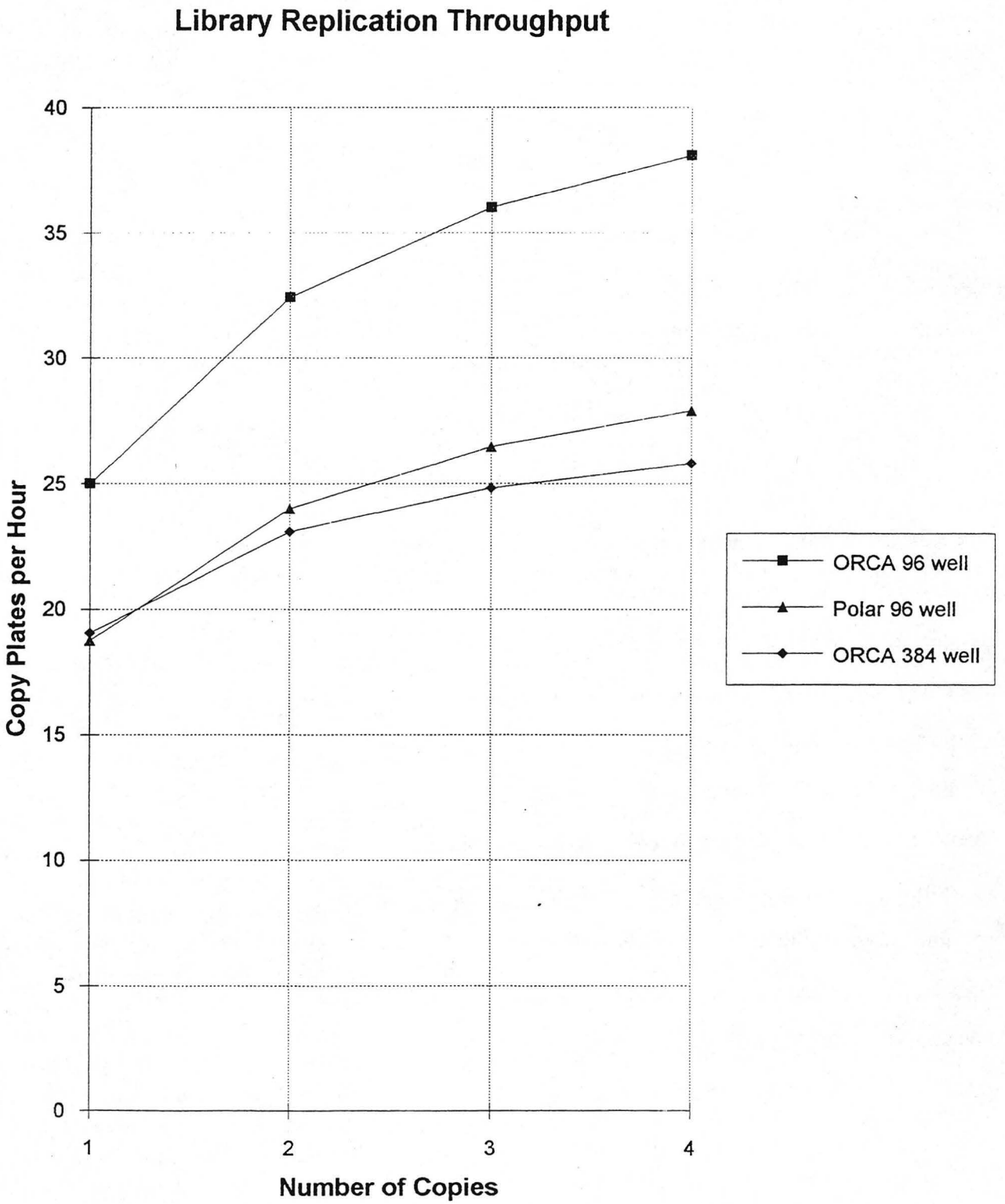


Figure 5. System throughput for the ORCA and Microassay System (polar) robots.

APPENDIXES

Engineering Drawings

Appendix A: Gripper Fingers

Appendix B: Microplate Hotel
- B(1): Assembly, Common Details, & Blanks
- B(2): Auxilary Pieces
- B(3): Base I/Hotel 5/8 Blank 11.80 X 5.630
- B(4): Roof 1/Hotel 1/4 Blank 11.800 X 5.630
- B(5): Floor II/Hotel 1/4 Blank 11.800 X 5.630

Appendix C: Microplate Stacker

Appendix D: Microplate Workstation

Appendix E: 96–Pin Replicating Tool

Appendix F: 384–Pin Replication Tool

Appendix G: Multipin Tool Parking Station

Appendix H: Multipin Tool Sterilizer Bath

Appendix I: Multipin Tool Sterilizer Bath Level Sensor

Appendix J: Multipin Tool Sterilizer Bath Sonicator Driver

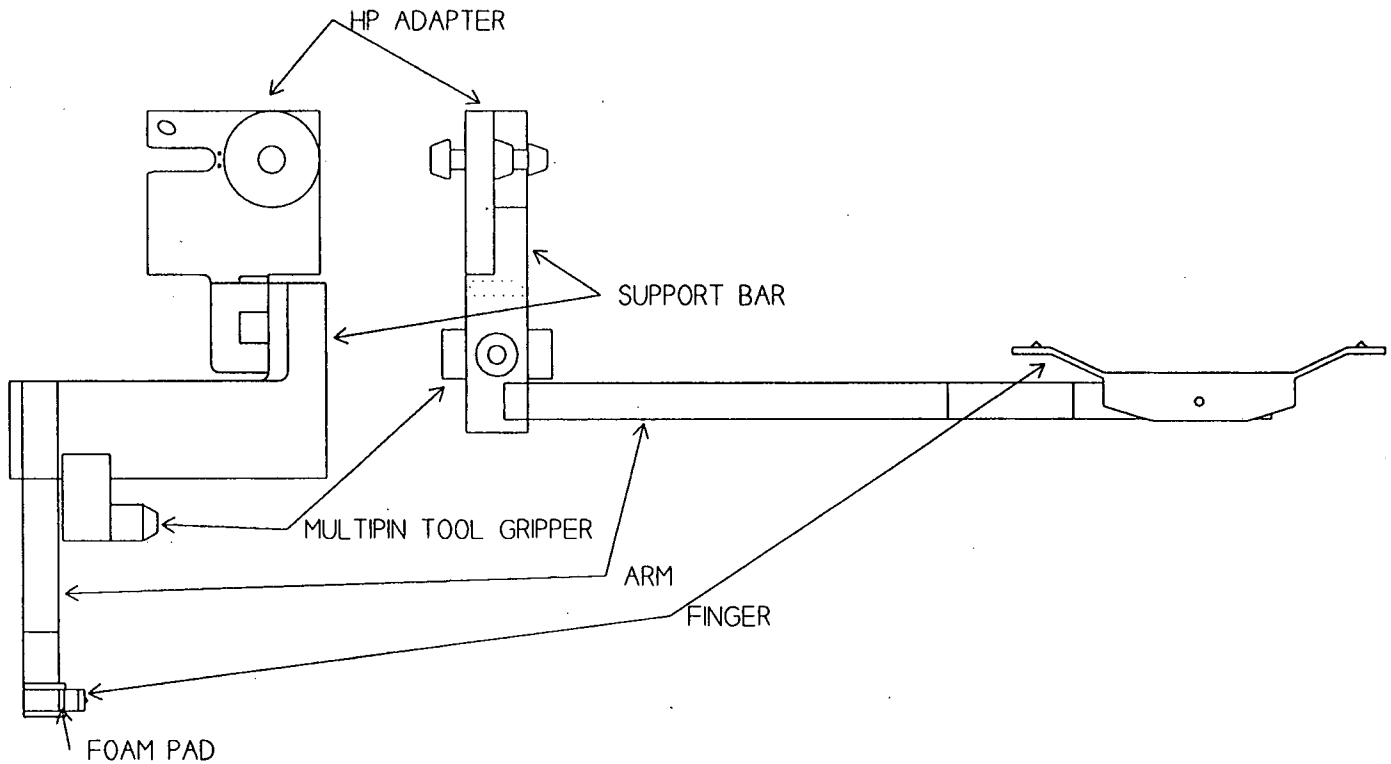
Appendix K: Multipin Tool Sterilizer Reservoir

Appendix L: Multipin Tool Sterilizer Heater

Appendix M: Multipin Tool Sterilizer Heater Control

Appendix N: I/O Control Box (1 Of 8 Bits)

Appendix A: Gripper Fingers



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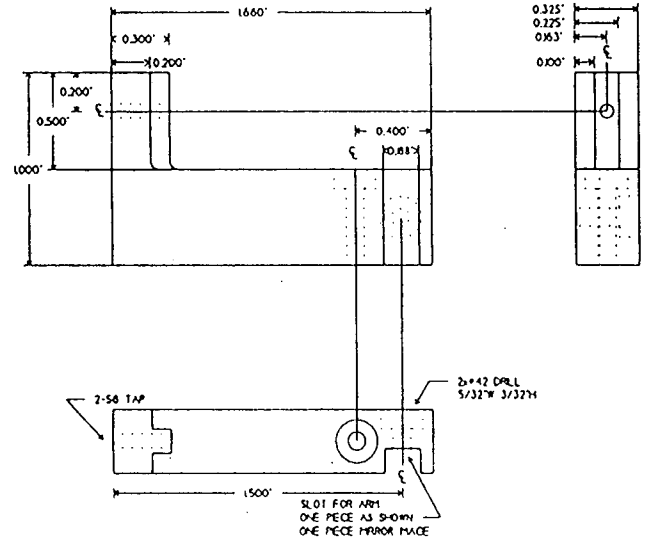

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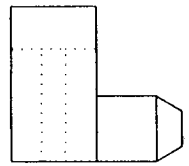

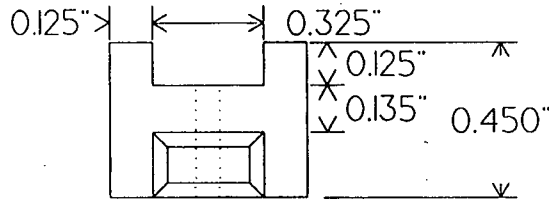

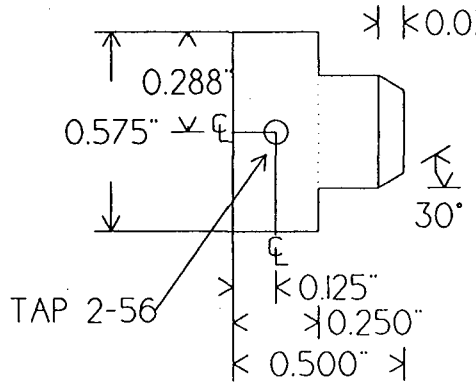

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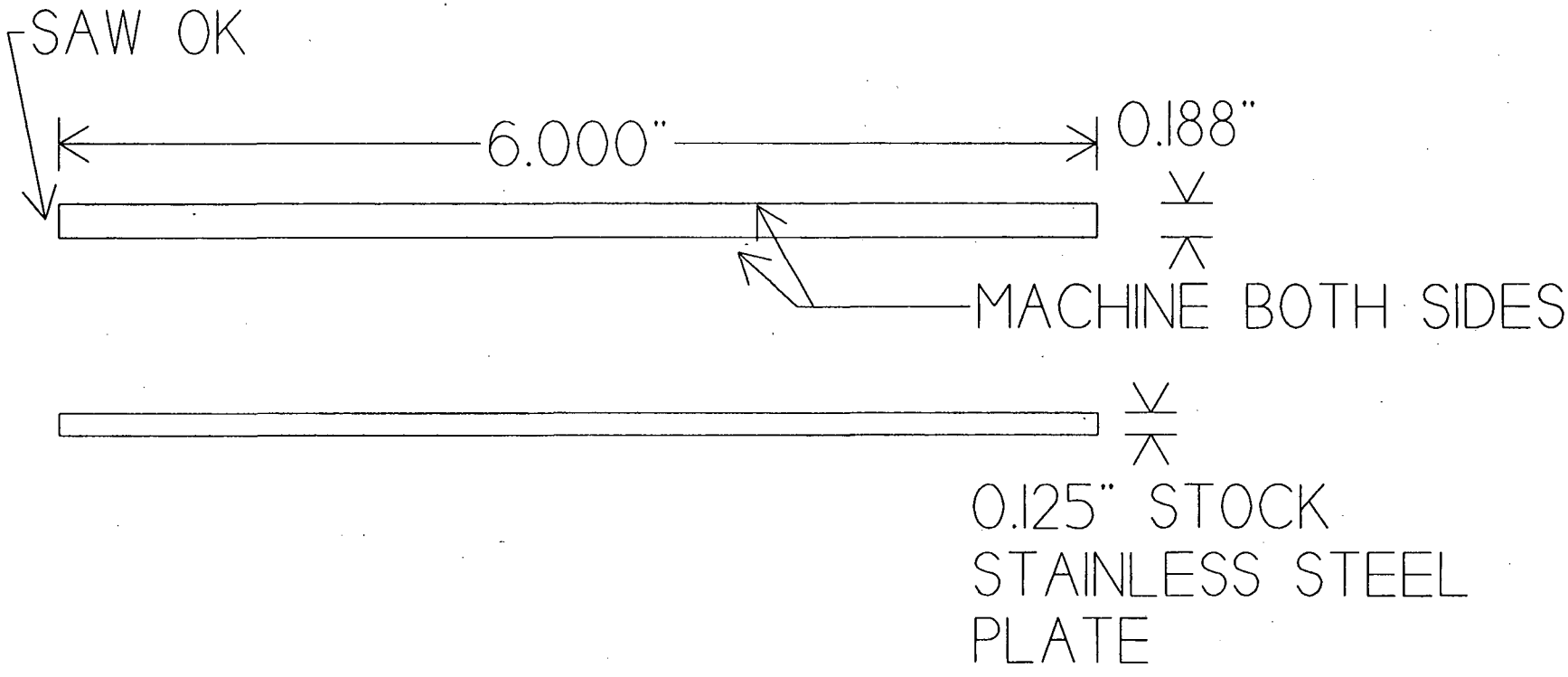

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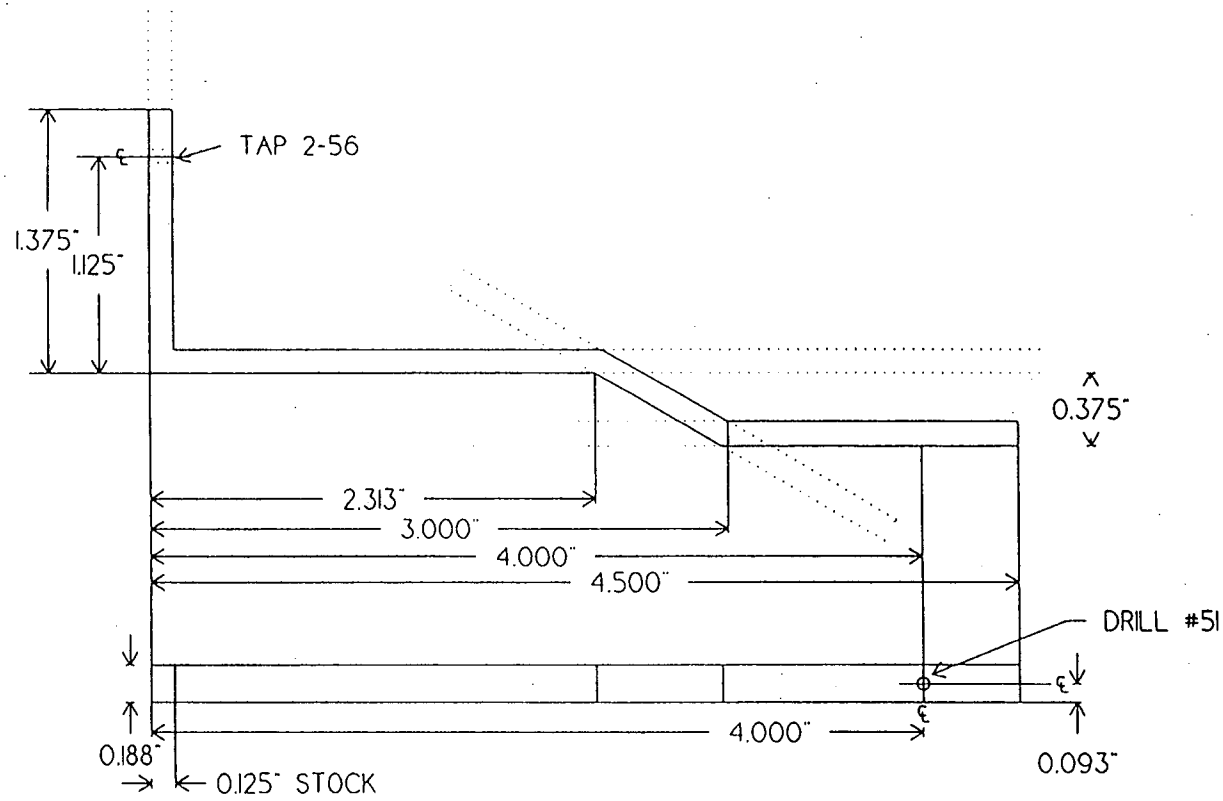

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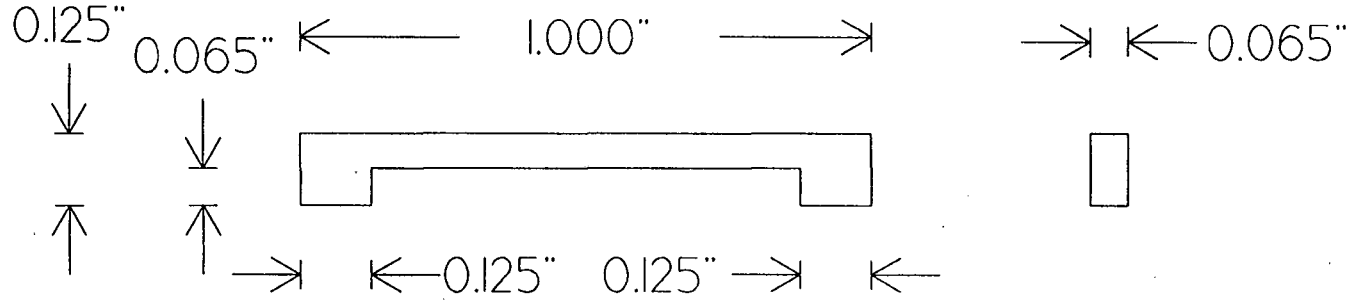

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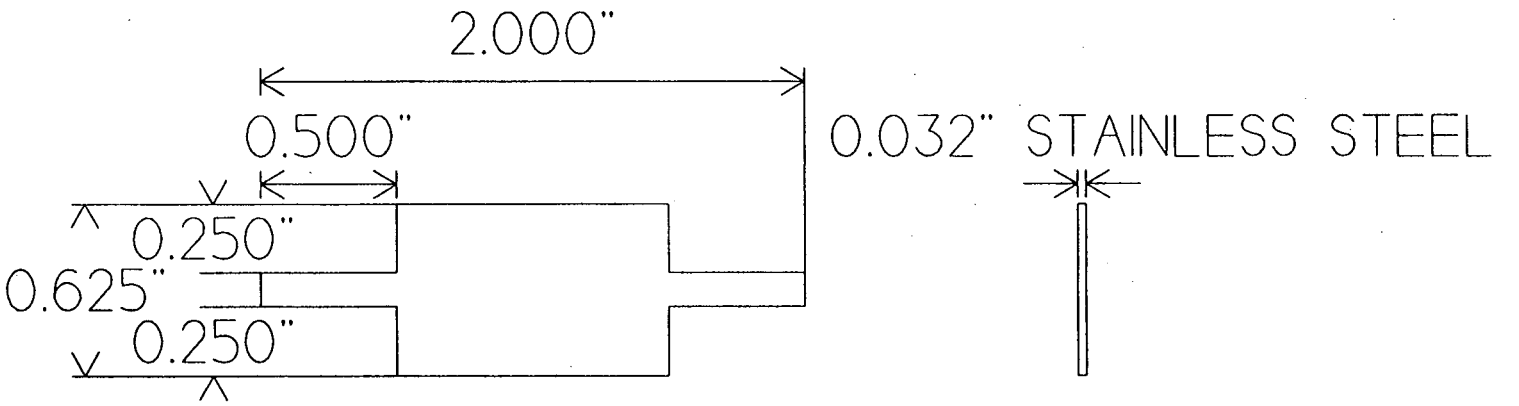

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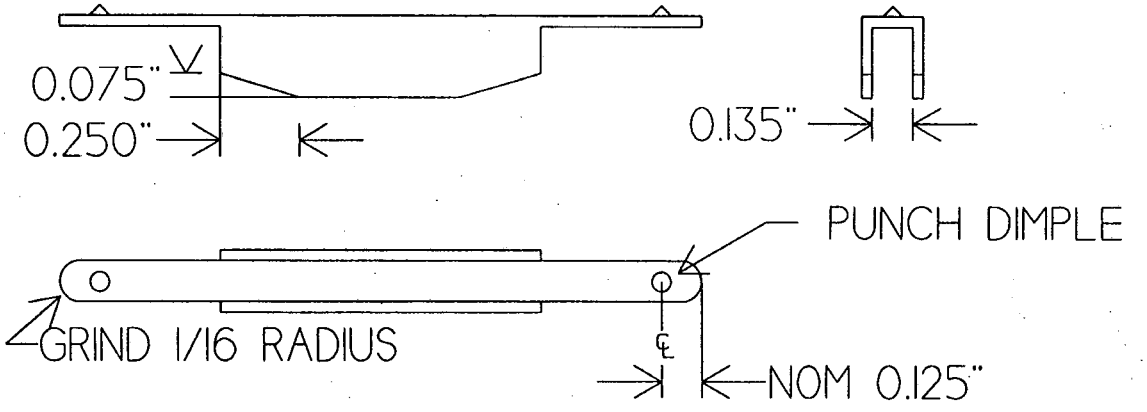

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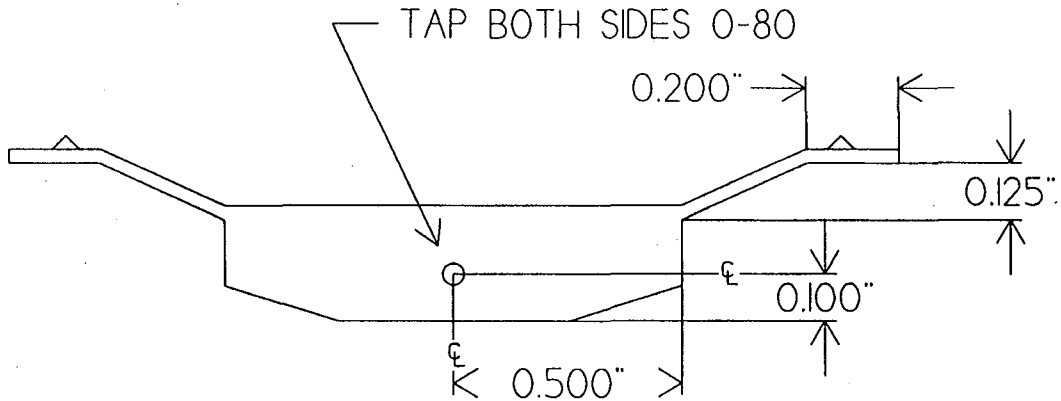

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Appendix B: Microplate Hotel

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Appendix B(1): Assembly, Common Details, & Blanks

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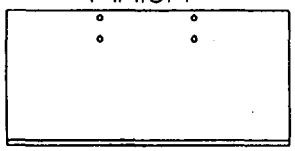

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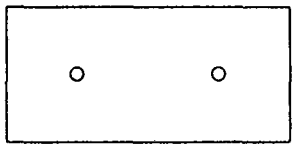

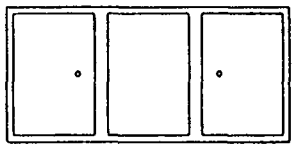

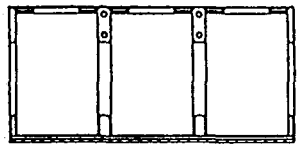

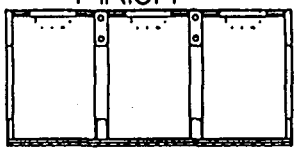

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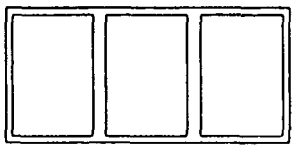

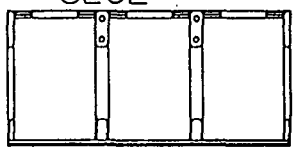

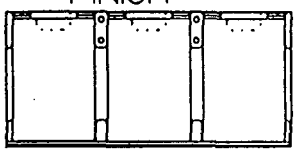

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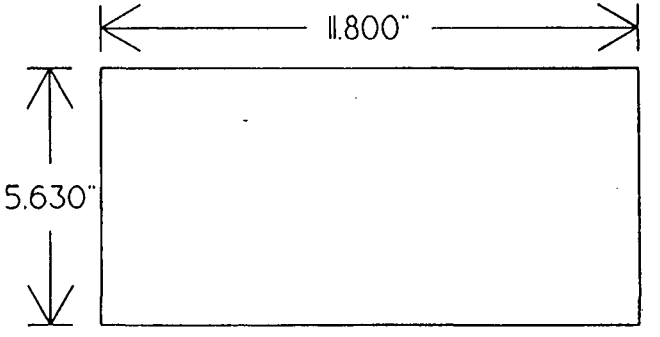
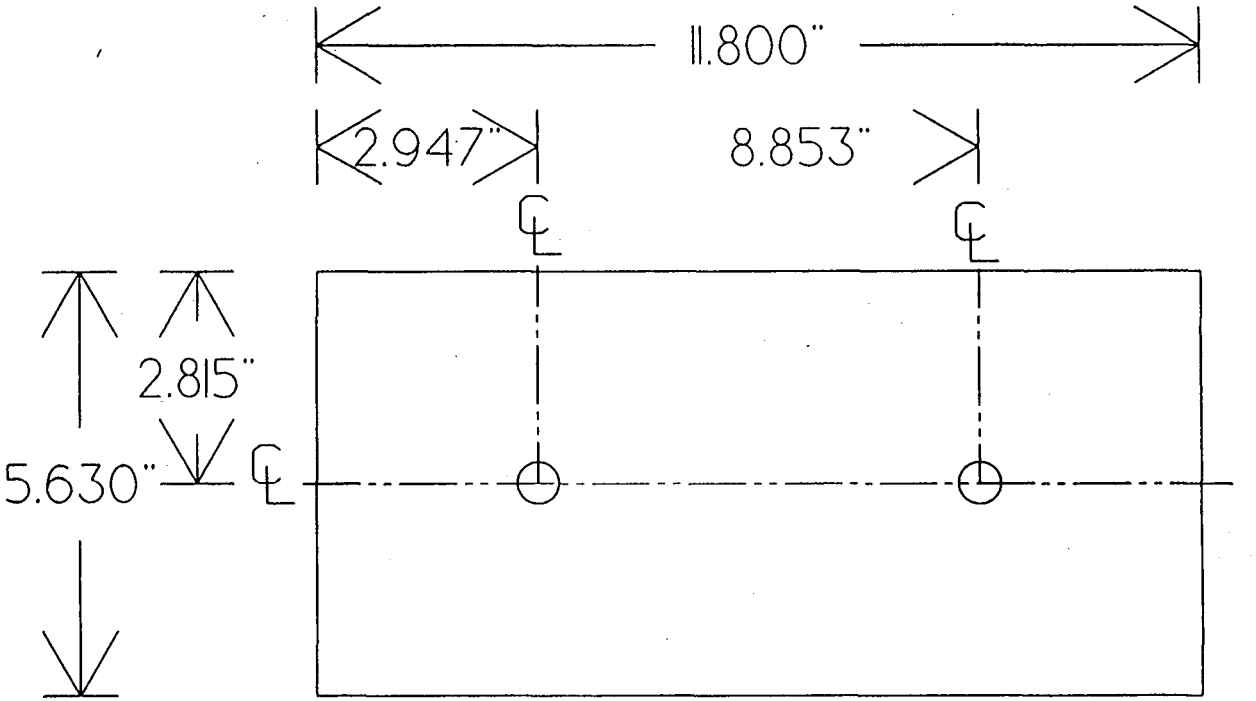
CHK BY: WILLIAM SEARLES	FILE NAME: ORCA\HOTEL\ASSORDER	



1 ROOF/HOTEL 1/4 LUCITE
11 FLOOR/HOTEL 1/4 LUCITE
1 BASE/HOTEL 5/8 LUCITE

LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP			
PART OF: HOLIDAY INNS			
COMPONENT NAME: ROOF/FLOOR BASE			
DWG. TYPE: BLANK	ORIGINAL DATE: 1-22-93	REV. DATE:	
DWG. BY: MICHAEL J. OSOFSKY			
CHK BY: WILLIAM SEARLES	FILE NAME: ORCA\HOTEL\ROFLBLNK		



LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP			
PART OF: HOLIDAY INNS			
COMPONENT NAME: 1/4 FLOOR			
DWG. TYPE: BLANK	ORIGINAL DATE: 1-22-93	REV. DATE:	
DWG. BY: MICHAEL J. OSOFSKY			
CHK. BY: WILLIAM SEARLES	FILE NAME: ORCA\HOTEL\FLORBLNK		

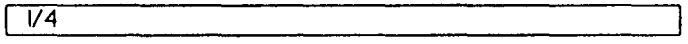
REAR END 3/HOTEL LUCITE

ABOUT 12" BY 1.5

REAR SPACER 3/HOTEL LUCITE

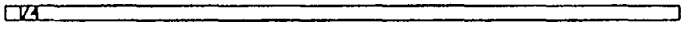
ABOUT 12" BY 1.5

FRONT SPACER 2/HOTEL LUCITE



ABOUT 12" BY .535

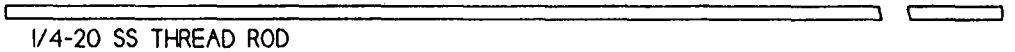
STOPS 20/HOTEL LUCITE



ABOUT 12" BY .25

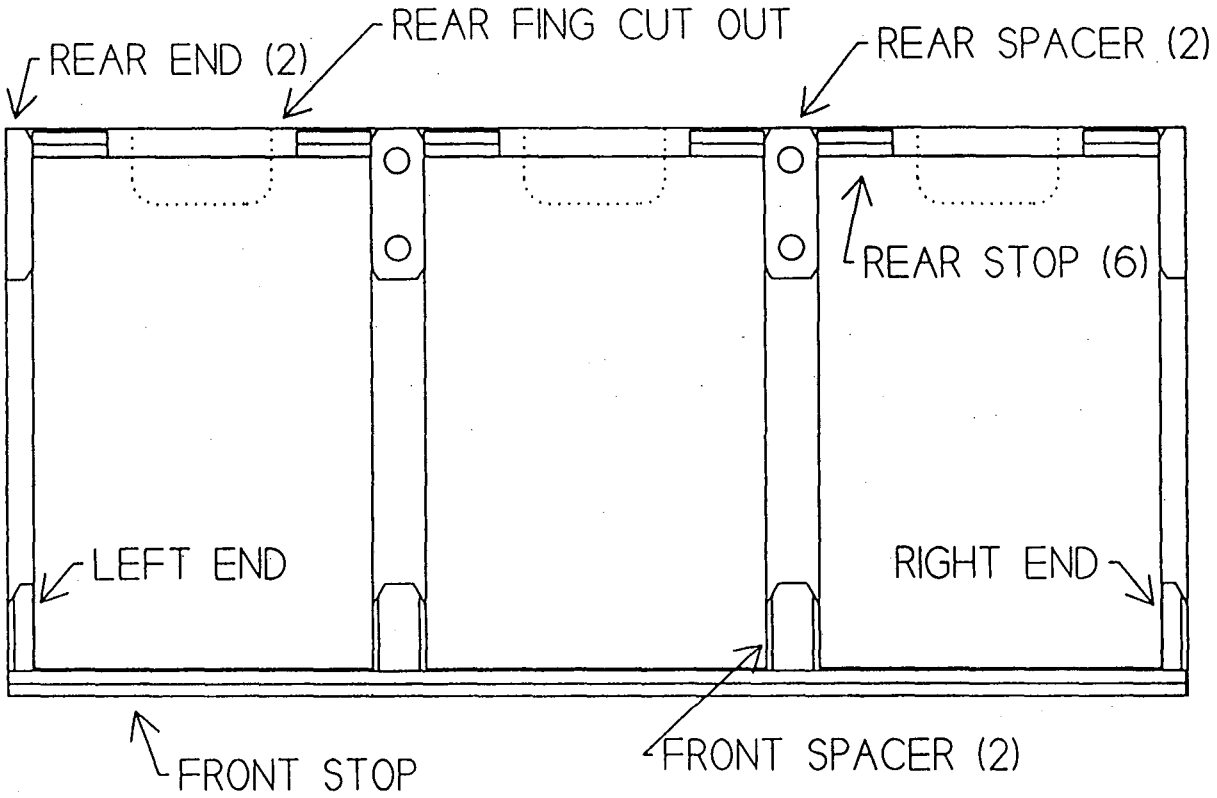
TIE ROD 2/HOTEL

36" STOCK

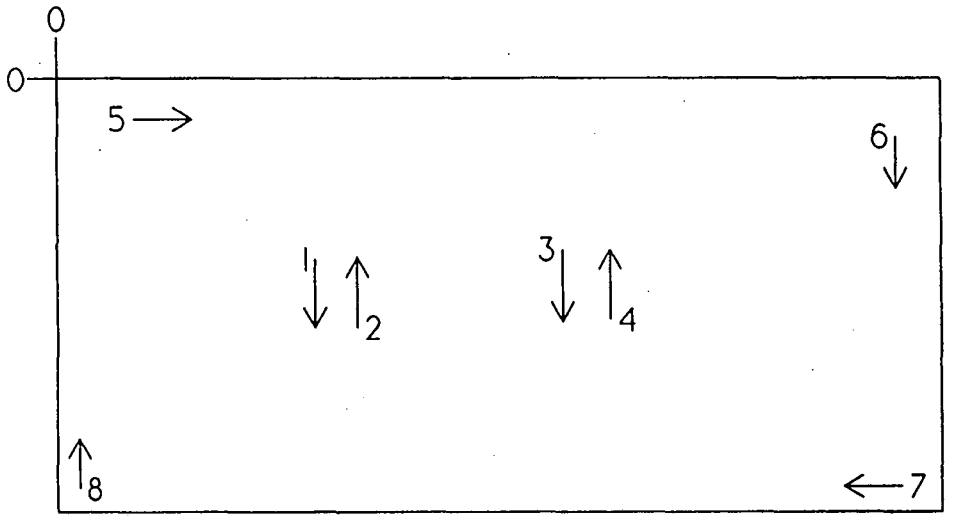


1/4-20 SS THREAD ROD

LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: HOLIDAY INNS		
COMPONENT NAME: AUX PIECE		
DWG. TYPE: BLANK	ORIGINAL DATE: 1-22-93	REV. DATE:
DWG BY: MICHAEL J. OSOFSKY		
CHK BY: WILLIAM SEARLES	FILE NAME: ORCA\HOTEL\AUXBLNK	



LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP			
PART OF: HOLIDAY INNS			
COMPONENT NAME: ASSEMBLY			
CHG. TYPE: DETAIL	ORIGINAL DATE: 1-22-93	REV. DATE:	
CHG. BY: MICHAEL J. OSOFSKY			
CHK. BY: WILLIAM SEARLES	FILE NAME: ORCA\HOTEL\ASSDET		

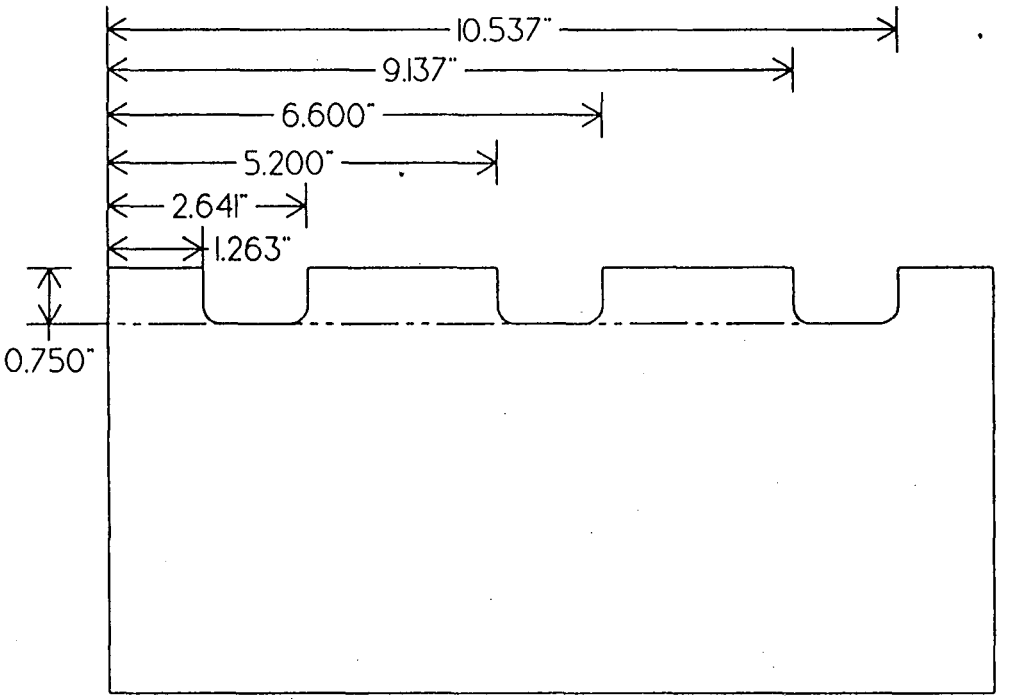


	X-AXIS	Y-AXIS
1	X 3.913 FIXED	Y -.300 -> 6.000
2	X 3.950 FIXED	Y 6.000 -> -.300
3	X 7.850 FIXED	Y -.300 -> 6.000
4	X 7.887 FIXED	Y 6.000 -> -.300
5	X -.300 -> 12.100	Y -.027 FIXED
6	X 11.787 FIXED	Y -.027 -> 5.602
7	X 11.787 -> .013	Y 5.602 FIXED
8	X .013 FIXED	Y 5.602 -> .300

TOOL PATH 1/2 DIA END BILL
GROOVE .090 BELOW SURFACE
BASE AND FLOOR

LAWRENCE BERKELEY LABORATORY
ENGINEERING DIVISION
HUMAN GENOME INSTRUMENTATION GROUP

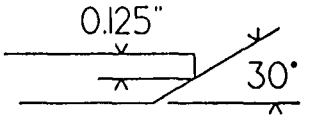
PART OF: HOLIDAY INNS		
COMPONENT NAME: GROOVES		
DWG. TYPE: DETAIL	ORIGINAL DATE: 1-22-93	REV. DATE:
DWG. BY: MICHAEL J. OSOFSKY		
CHK. BY: WILLIAM SEARLES	FILE NAME: ORCA\HOTEL\GRUVDET	



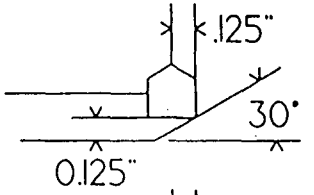
TOOL PATH 1/2 DIA
END MILL

LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: HOLIDAY INNS		
COMPONENT NAME: FINGER CUTOUTS		
DWG. TYPE: DETAIL	ORIGINAL DATE: 1-22-93	REV. DATE:
DWG. BY: MICHAEL J. OSOFSKY		
CHK. BY: WILLIAM SEARLES	FILE NAME: ORCA\HOTEL\FINGROUT	

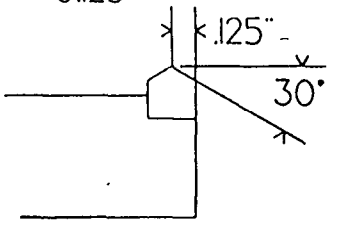
ROOF



FLOOR

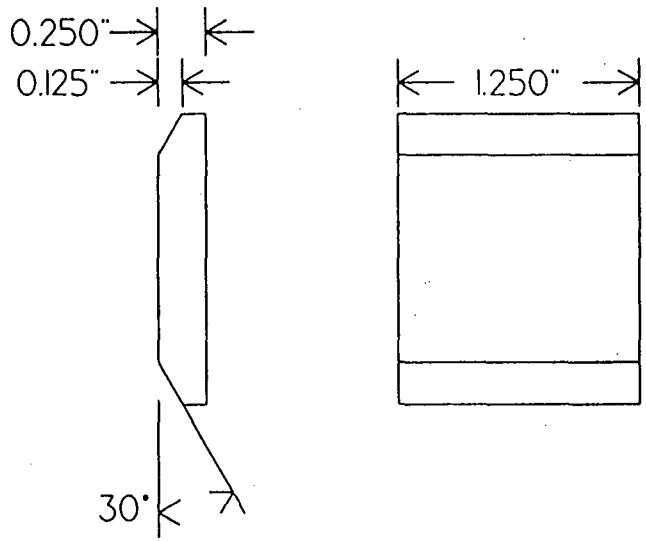


BASE



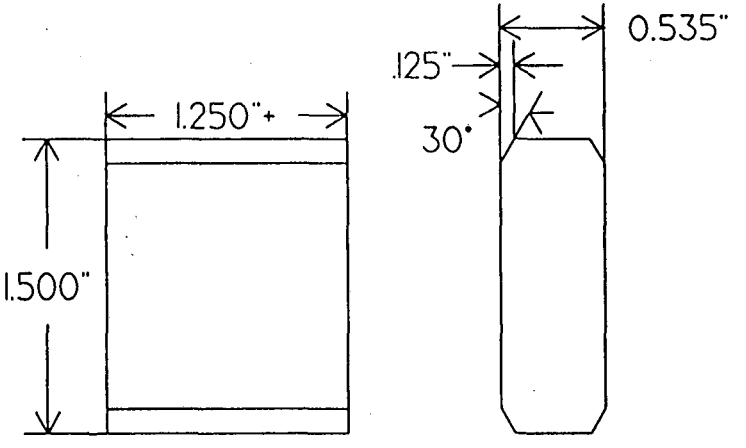
LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP			
PART OF: HOLIDAY INNS			
COMPONENT NAME: FRONT BEVEL			
DWG. TYPE: DETAIL	ORIGINAL DATE: 1-22-93	REV. DATE:	
DWG. BY: MICHAEL J. OSOFSKY			
CHK. BY: WILLIAM SEARLES	FILE NAME: ORCA\HOTEL\FRBEVDET		

Appendix B(2): Auxilary Pieces

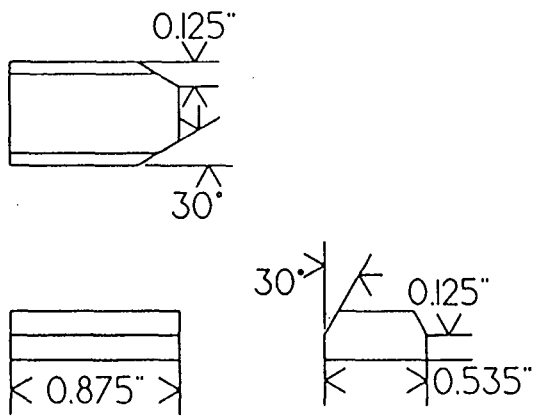


LAWRENCE BERKELEY LABORATORY
ENGINEERING DIVISION
HUMAN GENOME INSTRUMENTATION GROUP

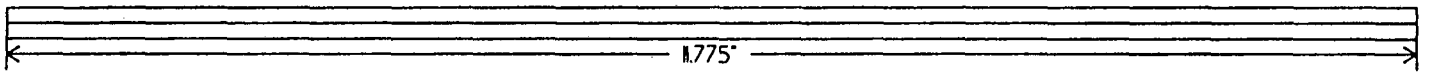
PART OF: HOLIDAY INNS		
COMPONENT NAME: AUXILARY REAR END		
DWG. TYPE: DETAIL	ORIGINAL DATE: 1-22-93	REV. DATE:
DWG BY: MICHAEL J. OSOFSKY		
CHK BY: WILLIAM SEARLES	FILE NAME: ORCA\HOTEL\AUXRE	

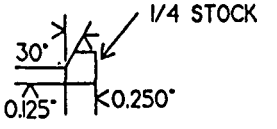


LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP			
PART OF: HOLIDAY INNS			
COMPONENT NAME: AUXILARY REAR SPACER			
DWG. TYPE: DETAIL	ORIGINAL DATE: 1-22-93	REV. DATE:	
DWG BY: MICHAEL J. OSOFSKY			
CHK BY: WILLIAM SEARLES	FILE NAME: ORCA\HOTEL\AUXRSP		



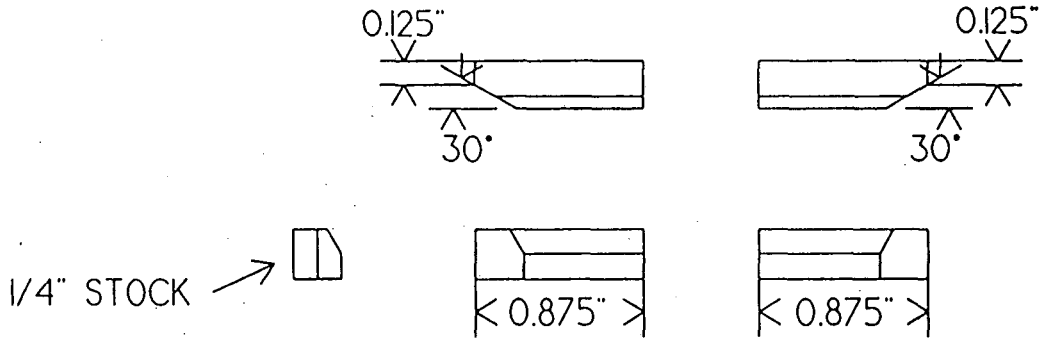
LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP			
PART OF: HOLIDAY INNS			
COMPONENT NAME: AUXILARY FRONT SPACER			
DWG. TYPE: DETAIL	ORIGINAL DATE: 1-22-93	REV. DATE:	
DWG. BY: MICHAEL J. OSOFSKY			
CHK. BY: WILLIAM SEARLES	FILE NAME: ORCA\HOTEL\AUXFSP		



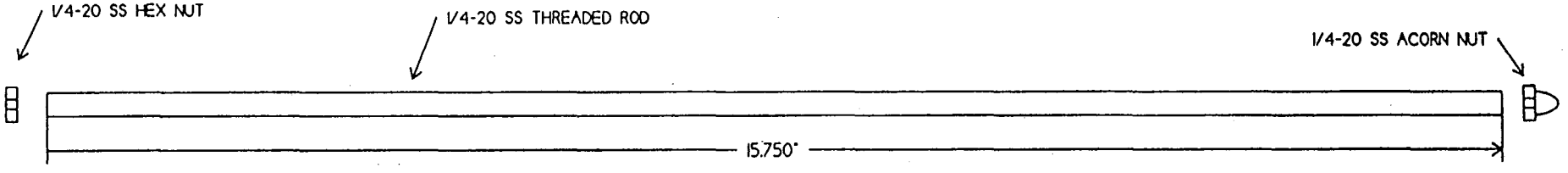


LAWRENCE BERKELEY LABORATORY
ENGINEERING DIVISION
HUMAN GENOME INSTRUMENTATION GROUP

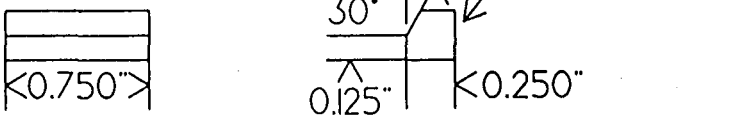
PART OF: HOLIDAY INNS / FRONT			
COMPONENT NAME: AUXILARY STOP			
DWG. TYPE: DETAIL	ORIGINAL DATE: 1-22-93	REV. DATE:	
DWG. BY: MICHAEL J. OSOFSKY			
D-K BY: WILLIAM SEARLES	FILE NAME: ORCA\HOTEL\AUXFS		



LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP			
PART OF: HOLIDAY INNS			
COMPONENT NAME: AUXILARY LEFT/RIGHT STOPS			
DWG. TYPE: FIN. DETAIL	ORIGINAL DATE: 1-22-93	REV. DATE:	
DWG. BY: MICHAEL J. OSOFSKY			
CHK BY: WILLIAM SEARLES	FILE NAME: ORCA\HOTEL\AUXLRSFD		

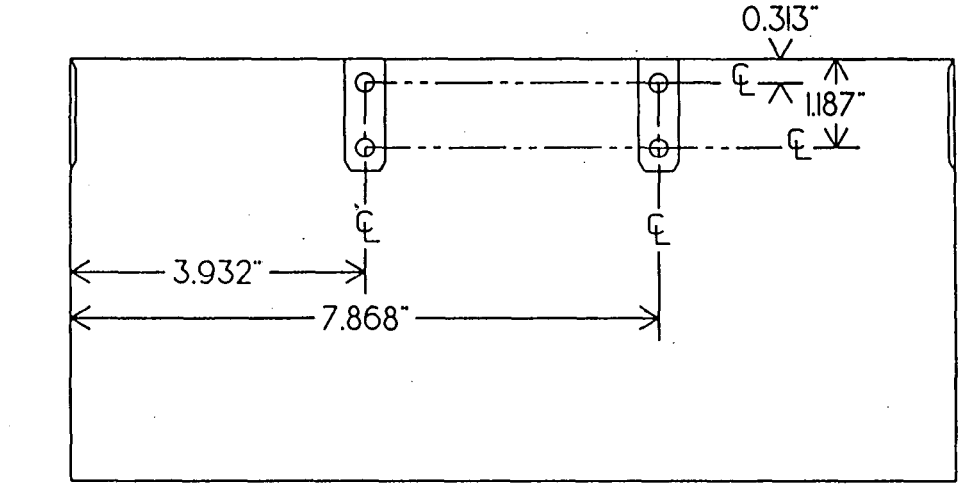


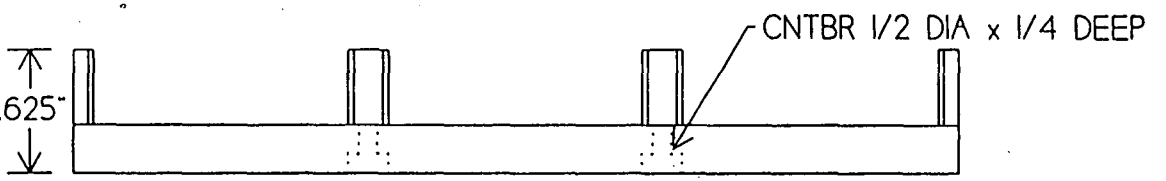
LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP	
PART OF: HOLIDAY INNS	
COMPONENT NAME: AUXILARY TIE ROD	
DWG. TYPE: DETAIL	ORIGINAL DATE: 1-22-93 / REV. DATE:
DWG. BY: MICHAEL J. OSOFSKY	
CHK. BY: WILLIAM SEARLES	FILE NAME: ORCA\HOTEL\AUXTIE



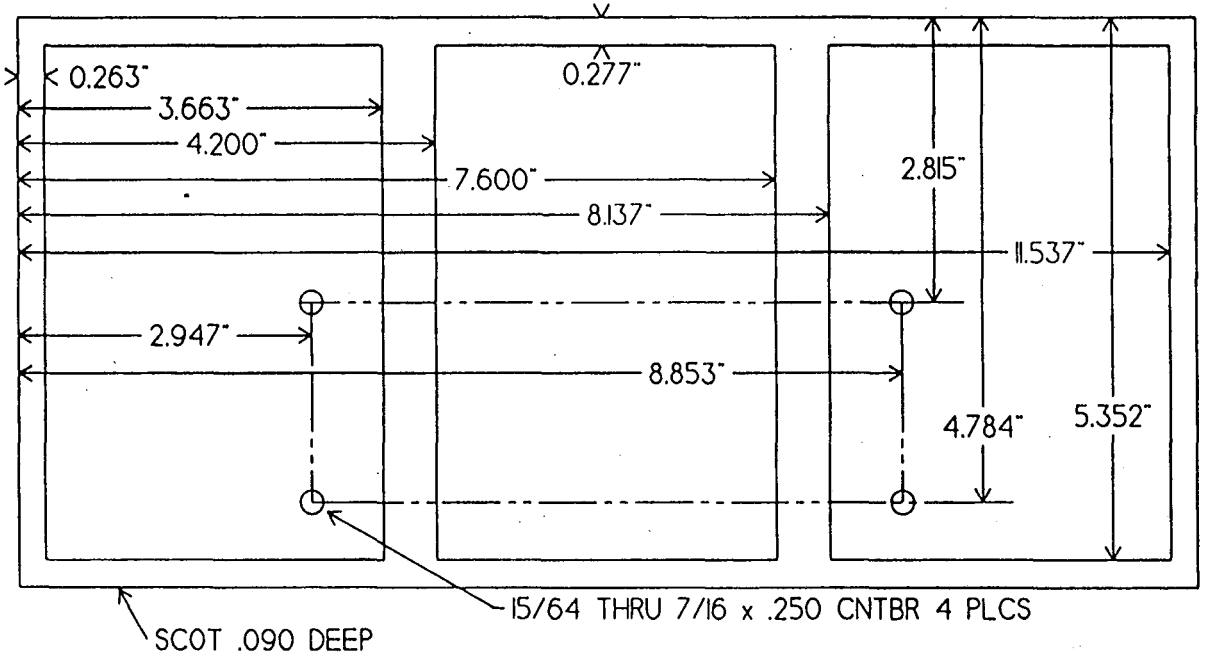
LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: HOLIDAY INNS		
COMPONENT NAME: AUXILARY REAR STOP		
DWG. TYPE: DETAIL	ORIGINAL DATE: 1-22-93	REV. DATE:
DWG BY: MICHAEL J. OSOFSKY		
CHK BY: WILLIAM SEARLES	FILE NAME: ORCA\HOTEL\AUXRS	

Appendix B(3): Base I/Hotel 5/8 Blank 11.80 X 5.630



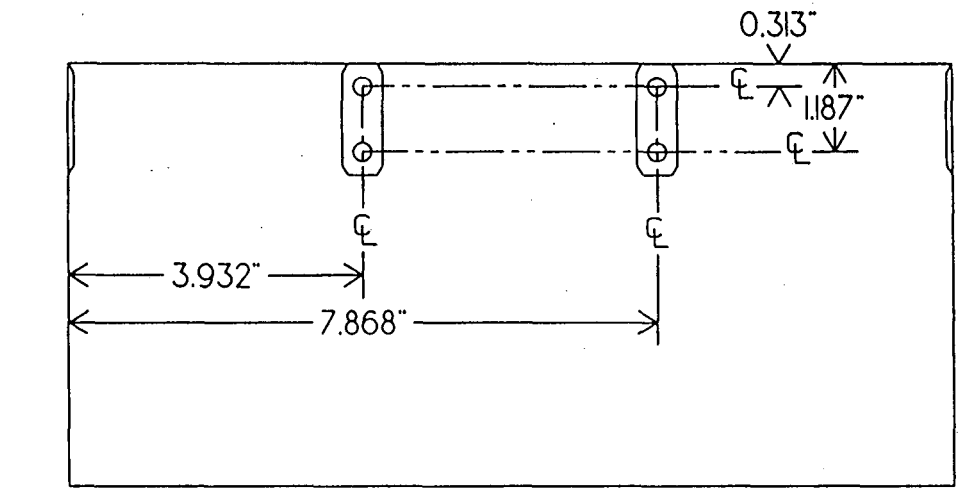


LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP			
PART OF: HOLIDAY INNS			
COMPONENT NAME: BASE			
DWG. TYPE: DETAIL	ORIGINAL DATE: 1-22-93	REV. DATE:	
DWG. BY: MICHAEL J. OSOFSKY			
CHK. BY: WILLIAM SEARLES	FILE NAME: ORCA\HOTEL\BFDET		



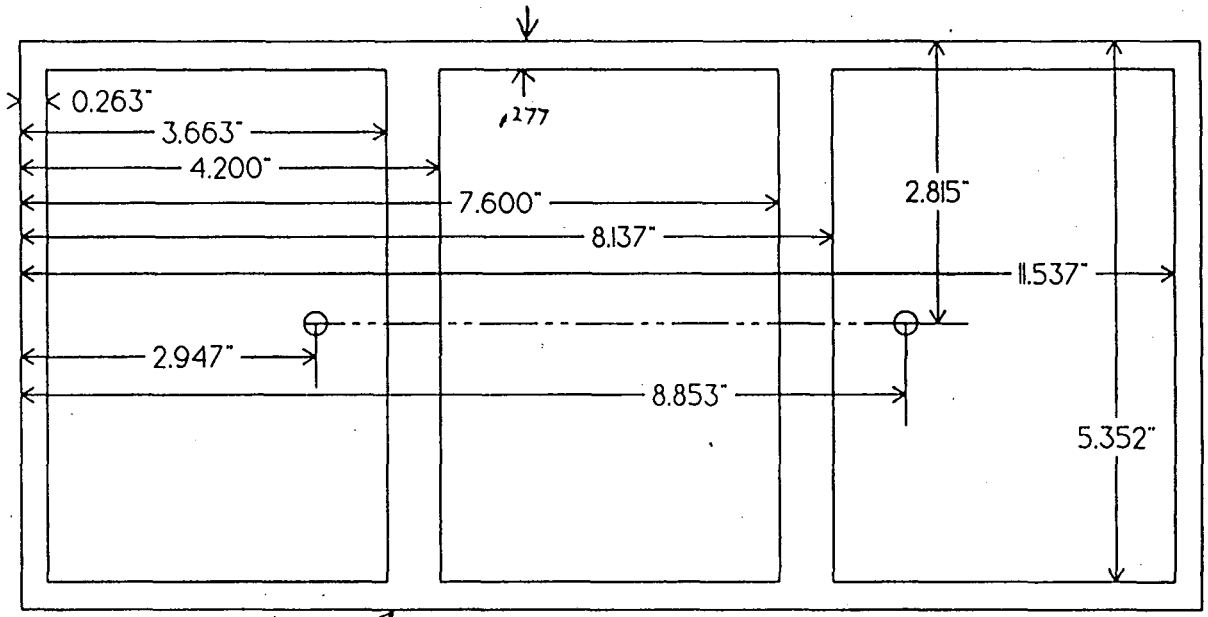
LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP			
PART OF: HOLIDAY INNS			
COMPONENT NAME: BASE			
DWG. TYPE: DETAIL2	ORIGINAL DATE: 1-22-93	REV. DATE:	
DWG. BY: MICHAEL J. OSOFSKY			
CHK. BY: WILLIAM SEARLES	FILE NAME: ORCA\HOTEL\BFDET2		

Appendix B(4): Roof 1/Hotel 1/4 Blank 11.800 X 5.630



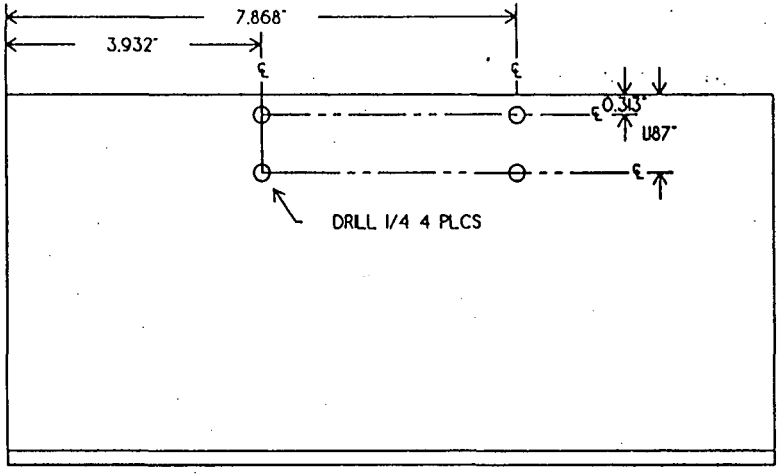
LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: HOLIDAY INNS		
COMPONENT NAME: 1/4 FLOOR		
DWG. TYPE: DETAIL1	ORIGINAL DATE: 1-22-93	REV. DATE:
DWG. BY: MICHAEL J. OSOFSKY		
CHK BY: WILLIAM SEARLES	FILE NAME: ORCA\HOTEL\FLORDET1	

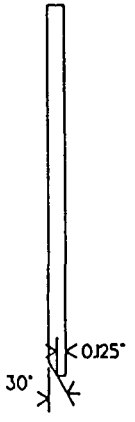
Appendix B(5): Floor II/Hotel 1/4 Blank 11.800 X 5.630



SCOT .090 DEEP
FINISH 1/2 AND 1/4 PLATES
TO SIZE BUT ONLY
FINISH 1/4 PLATE

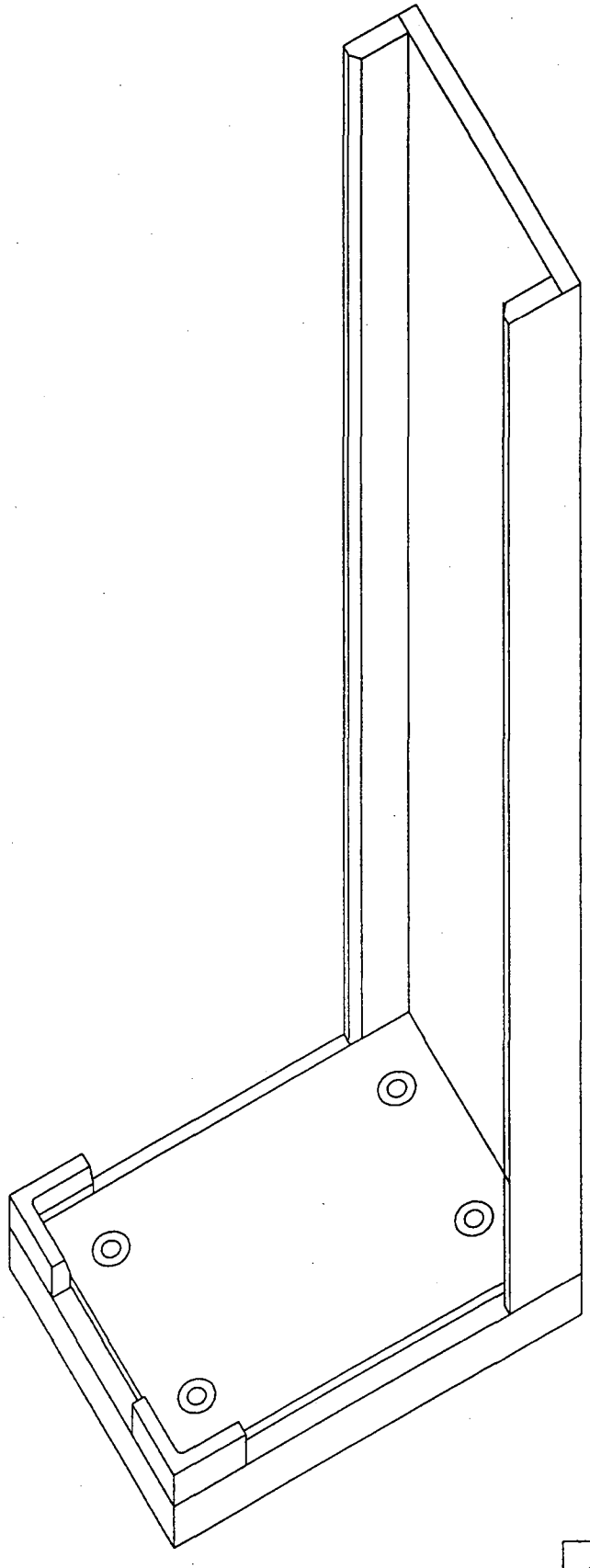
LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP			
PART OF: HOLIDAY INNS			
COMPONENT NAME: 1/4 FLOOR			
DWG. TYPE: DETAIL2	ORIGINAL DATE: 1-22-93	REV. DATE:	
DWG. BY: MICHAEL J. OSOFSKY			
CHK. BY: WILLIAM SEARLES	FILE NAME: ORCA\HOTEL\FLORDET2		





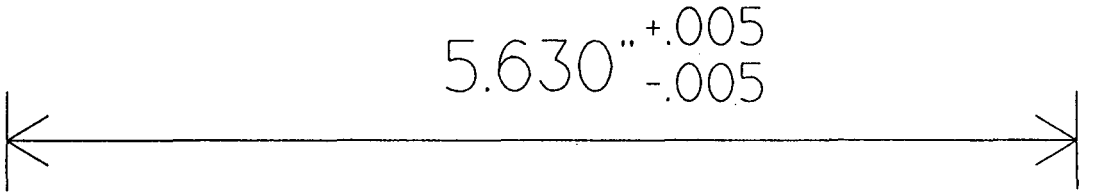
LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: HOLIDAY INNS		
COMPONENT NAME: ROOF		
DWG. TYPE: DETAIL	ORIGINAL DATE: 1-22-93	REV. DATE:
DWG. BY: MICHAEL J. OSOFSKY		
CHK. BY: WILLIAM SEARLES	FILE NAME: ORCA\HOTEL\ROOFDET	

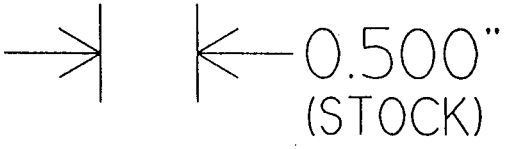
Appendix C: Microplate Stacker

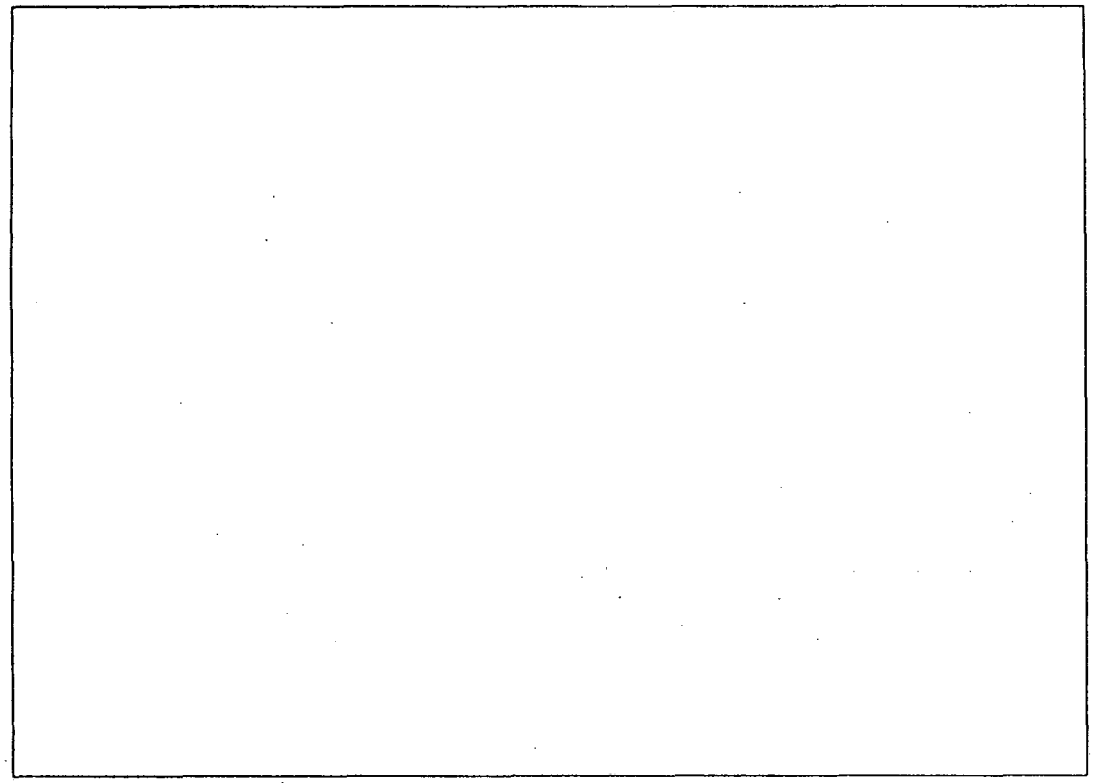


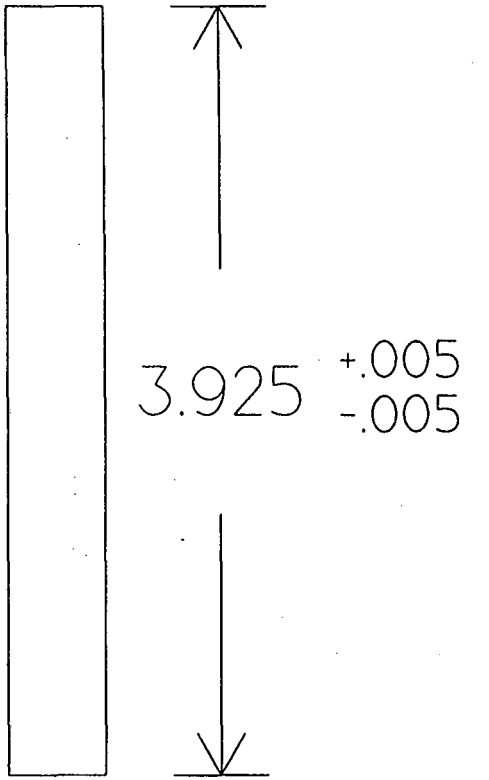
LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP	
PART OF: MICROPLATE STACKER 25 HIGH	
DWG TYPE: ORTHO 2	ORIGINAL DATE: 12-1-92 / REV. DATE: 4-28-93
BY: MICHAEL J. OSOFSKY	
BY: WILLIAM SEARLES	FILE NAME: ORCA\WORKSTAT\ORTHO2

C. 1.

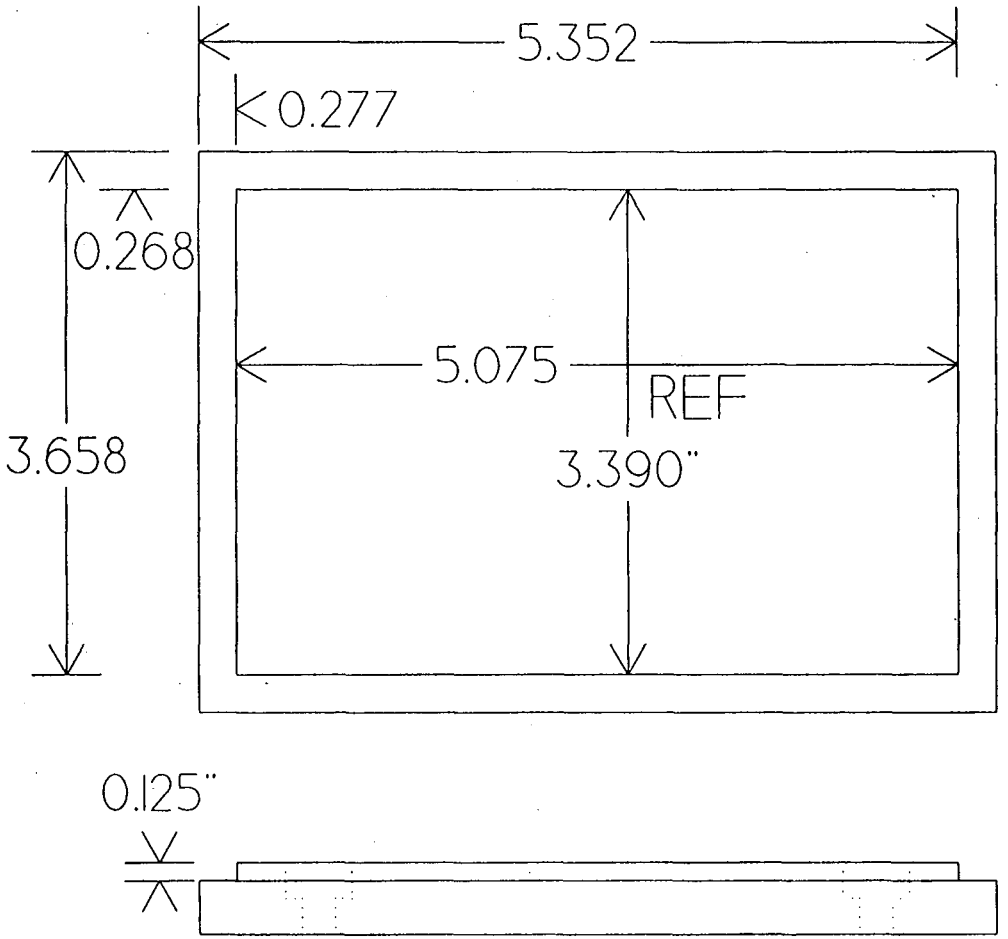




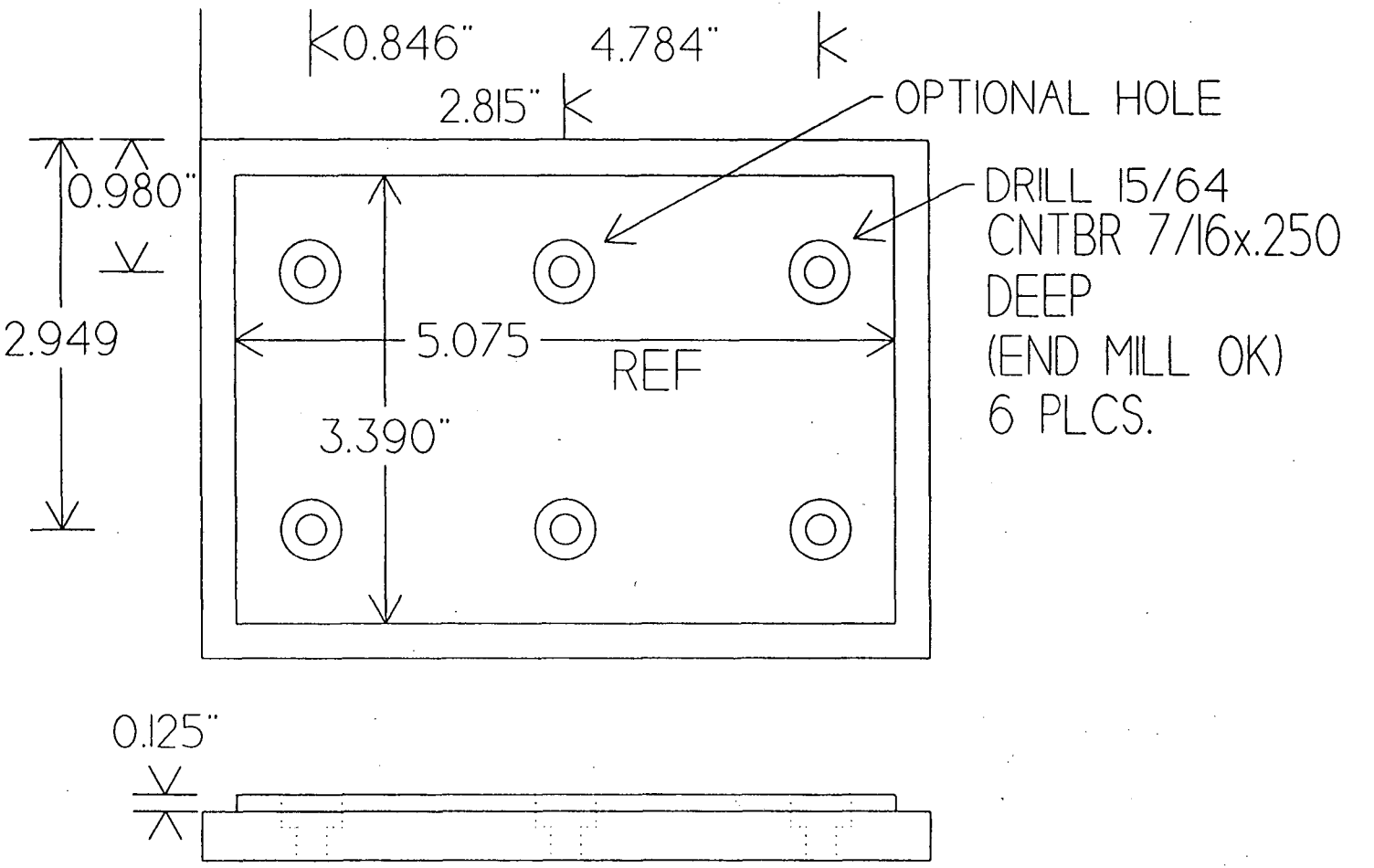




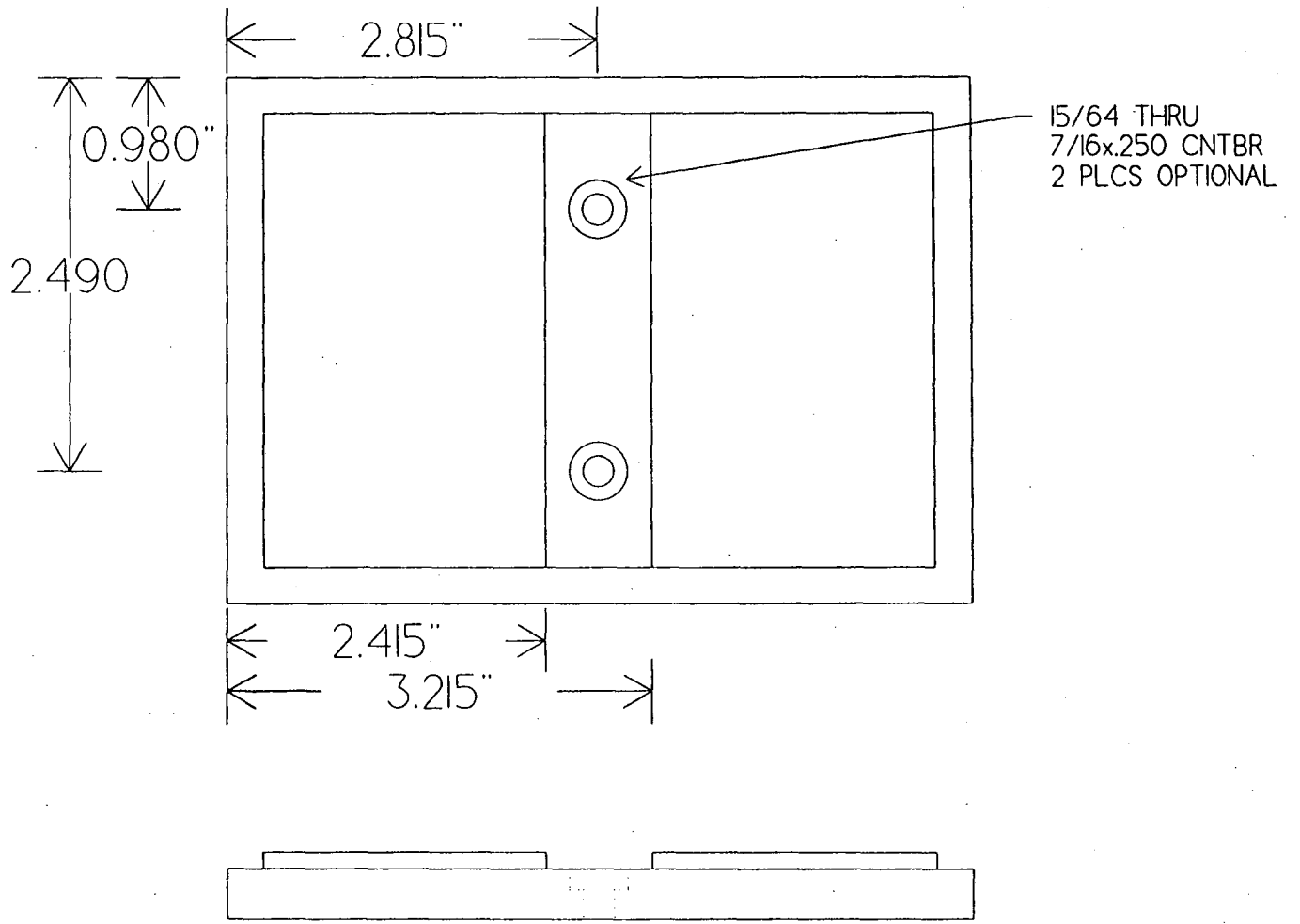
LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: MICROPLATE WORKSTATION		
COMPONENT NAME: BASE PLATE		
DWG. TYPE: BLANK	ORIGINAL DATE: 12-1-92	REV. DATE: 4-21-93
DWG. BY: MICHAEL J. OSOFSKY		
CHK. BY: WILLIAM SEARLES	FILE NAME: ORCAWORKSTATWKSTBS1	



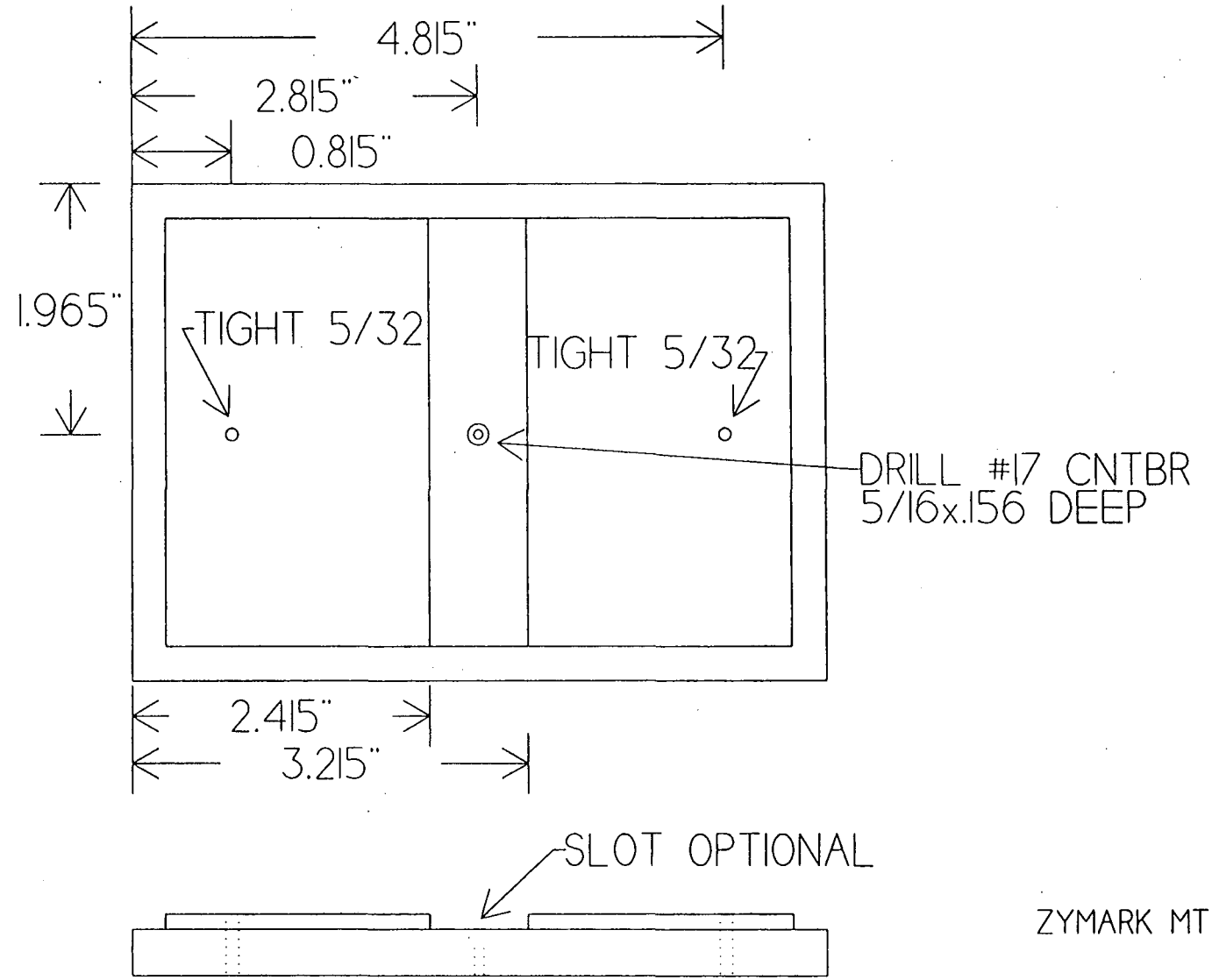
LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: MICROPLATE WORKSTATION		
COMPONENT NAME: BASE PLATE EDGE		
DWG. TYPE: DETAIL	ORIGINAL DATE: 4-20-93	REV. DATE: 4-21-93
DWG. BY: MICHAEL J. OSOFSKY		
CHK BY: WILLIAM SEARLES	FILE NAME: ORCA\WORKSTAT\BSPLATI	



LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: MICROPLATE WORKSTATION		
COMPONENT NAME: BASE PLATE HOLES		
DWG. TYPE: DETAIL	ORIGINAL DATE: 12-1-92	REV. DATE: 4-29-93
DWG. BY: MICHAEL J. OSOFSKY		
CHK. BY: WILLIAM SEARLES	FILE NAME: ORCAWORKSTATBSPLAT2	

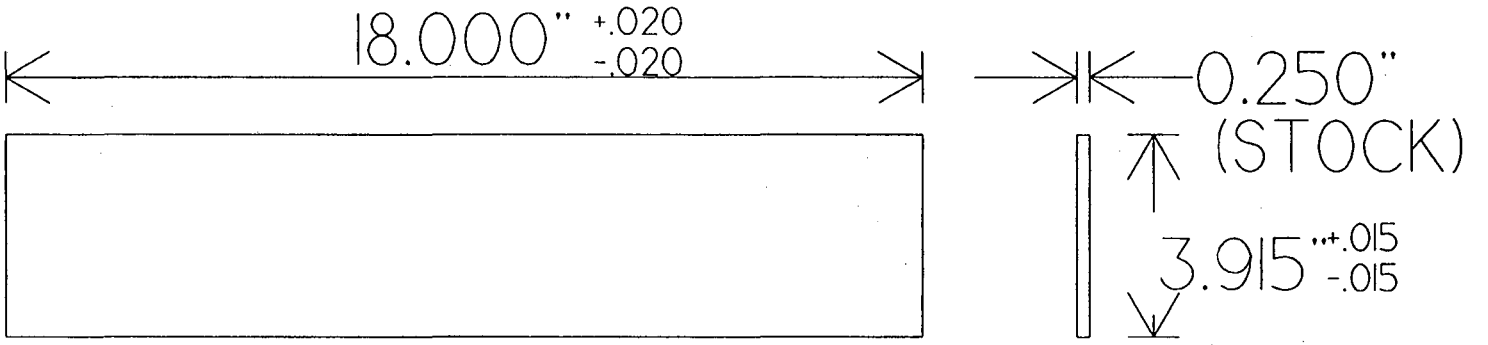


LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: MICROPLATE WORKSTATION		
COMPONENT NAME: BASE PLATE & OPTIONAL TAPE SLOT		
DWG. TYPE: DETAIL	ORIGINAL DATE: 12-1-92	REV. DATE: 4-28-93
DWG. BY: MICHAEL J. OSOFSKY		
CHK. BY: WILLIAM SEARLES	FILE NAME: ORCA\WORKSTAT\WKSTBS6	

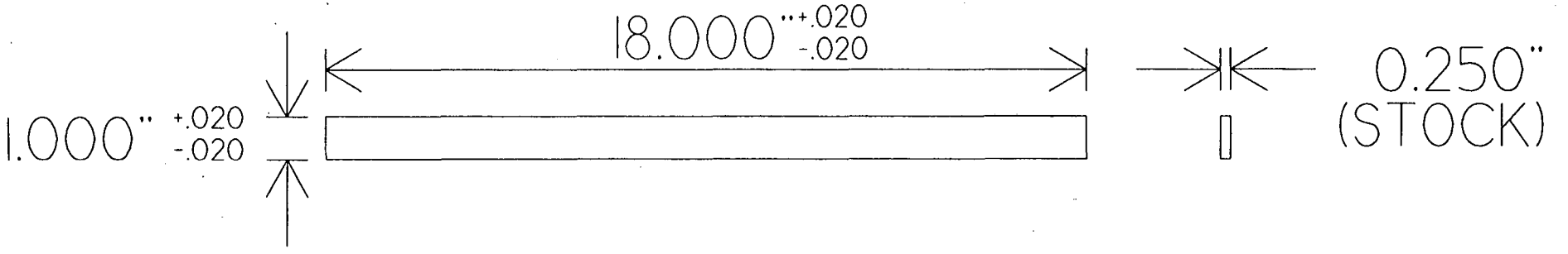


ZYMARK MTG OPTION

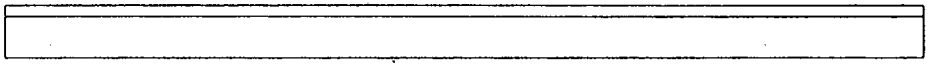
LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP	
PART OF: MICROPLATE WORKSTATION	
COMPONENT NAME: BASE PLATE & OPTIONAL TAPE SLOT	
DWG. TYPE: DETAIL	ORIGINAL DATE: 12-1-92 / REV. DATE: 4-21-93
DWG BY: MICHAEL J. OSOFSKY	
CHK BY: WILLIAM SEARLES	FILE NAME: ORCA\WORKSTAT\WKSTBS5

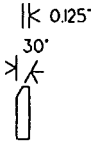


LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP			
PART OF: MICROPLATE STACKER 25 HIGH			
COMPONENT NAME: STACKER BACKS			
DWG. TYPE: BLANK	ORIGINAL DATE: 12-1-92	REV. DATE: 7-15-93	
DWG. BY: MICHAEL J. OSOFSKY			
CHK. BY: WILLIAM SEARLES	FILE NAME: ORCA\WORKSTAT\WKSTBS4		

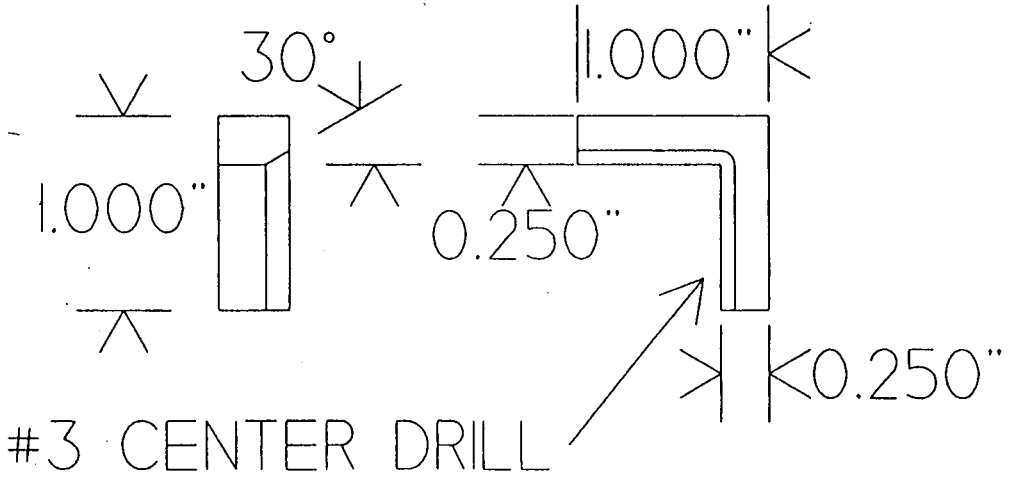


LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: MICROPLATE STACKER 25 HIGH		
COMPONENT NAME: STACKER SIDES		
DWG. TYPE: BLANK	ORIGINAL DATE: 12-1-92	REV. DATE: 7-15-93
DWG. BY: MICHAEL J. OSOFSKY		
CHK. BY: WILLIAM SEARLES	FILE NAME: ORCA\WORKSTAT\WKSTBS3	



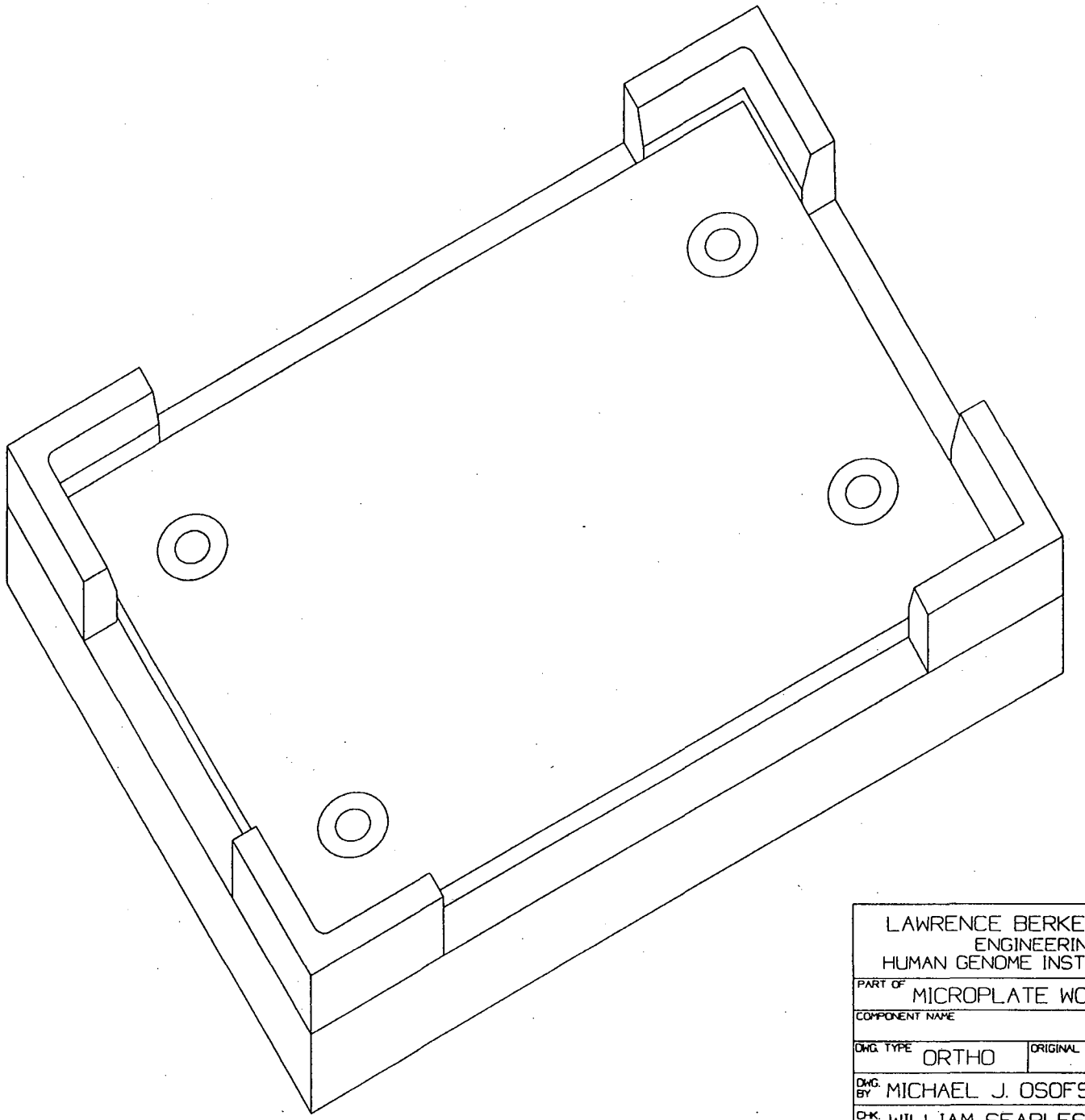


LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: MICROPLATE STACKER 25 HIGH		
COMPONENT NAME: STACKER SIDES		
DWG. TYPE: DETAIL	ORIGINAL DATE: 12-1-92	REV. DATE: 7-22-93
DWG. BY: MICHAEL J. OSOFSKY		
CHK. BY: WILLIAM SEARLES	FILE NAME: ORCA\WORKSTAT\WKSTBS3D	



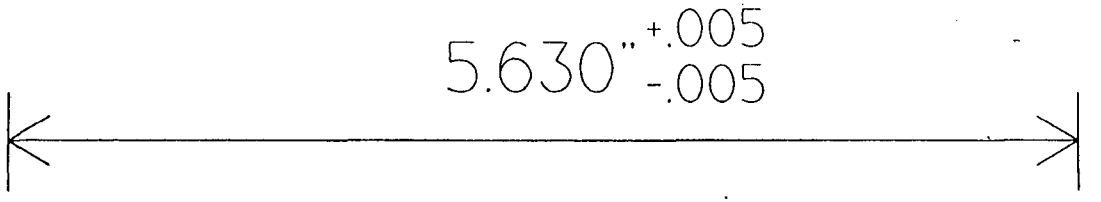
LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: MICROPLATE WORKSTATION		
COMPONENT NAME: GUIDE		
DWG. TYPE: DETAIL	ORIGINAL DATE: 12-1-92	REV. DATE: 4-20-93
DWG. BY: MICHAEL J. OSOFSKY		
CHK. BY: WILLIAM SEARLES	FILE NAME: ORCA\WORKSTAT\GUIDE	

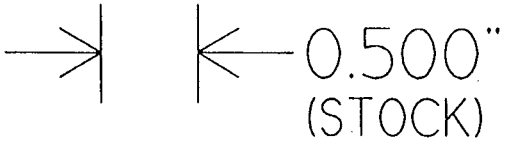
Appendix D: Microplate Workstation

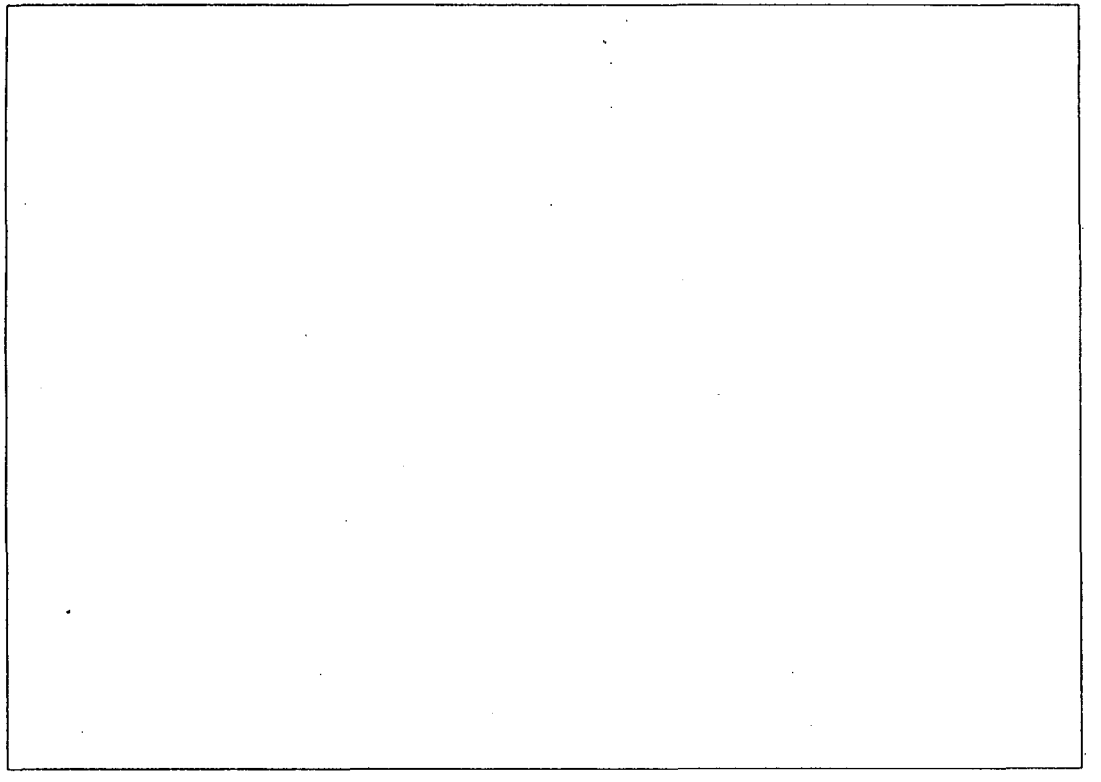


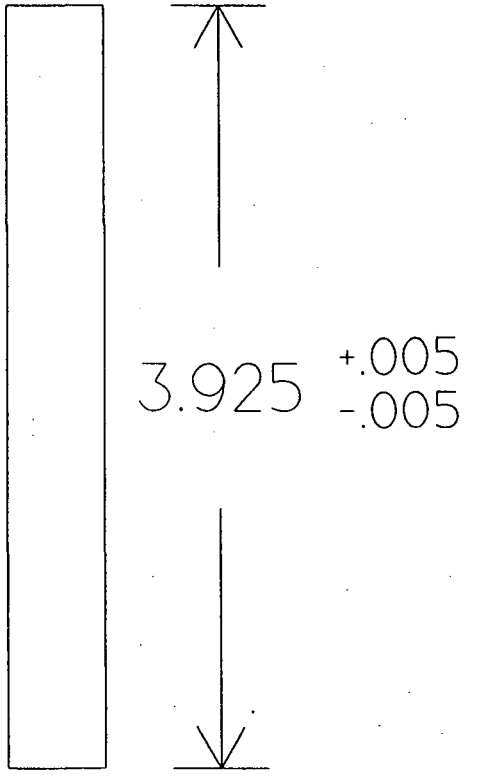
LAWRENCE BERKELEY LABORATORY
ENGINEERING DIVISION
HUMAN GENOME INSTRUMENTATION GROUP

PART OF: MICROPLATE WORKSTATION			
COMPONENT NAME:			
DWG. TYPE: ORTHO	ORIGINAL DATE: 12-1-92	REV. DATE: 4-20-93	
DWG. BY: MICHAEL J. OSOFSKY			
CHK. BY: WILLIAM SEARLES	FILE NAME: ORCA\WORKSTAT\ORTHOG1		

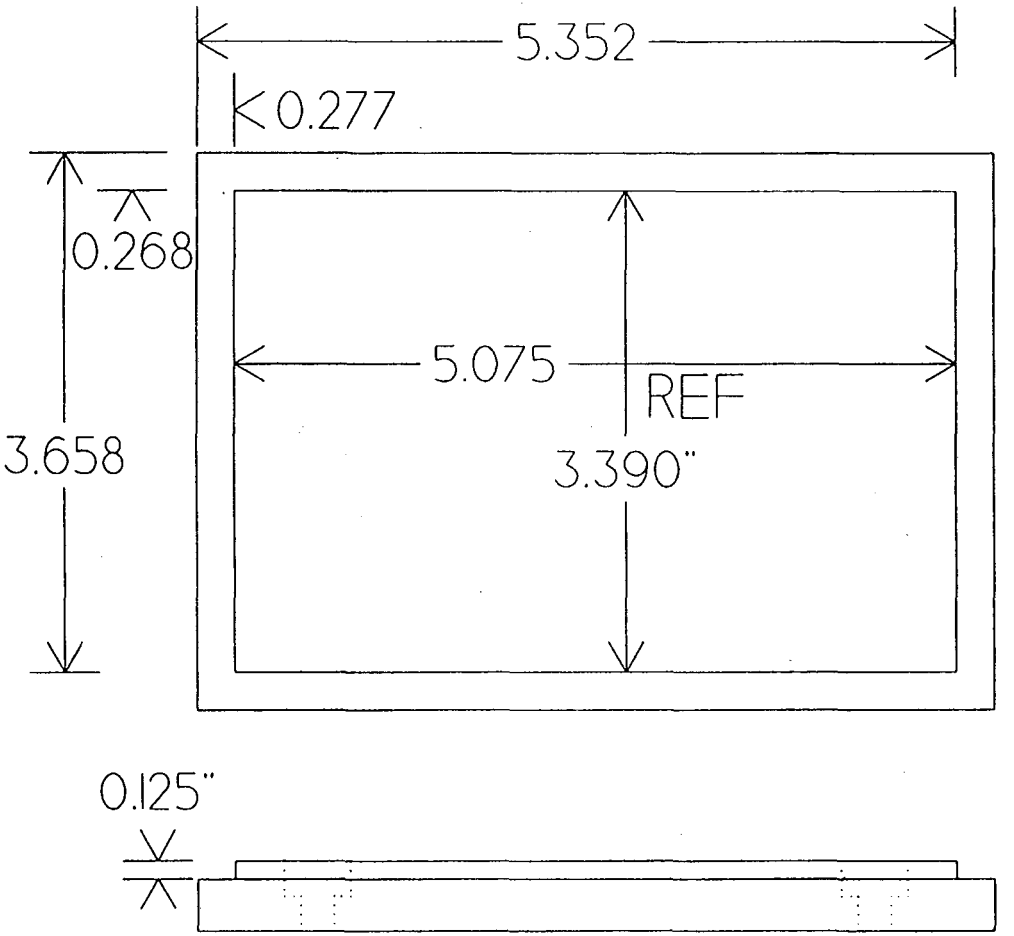




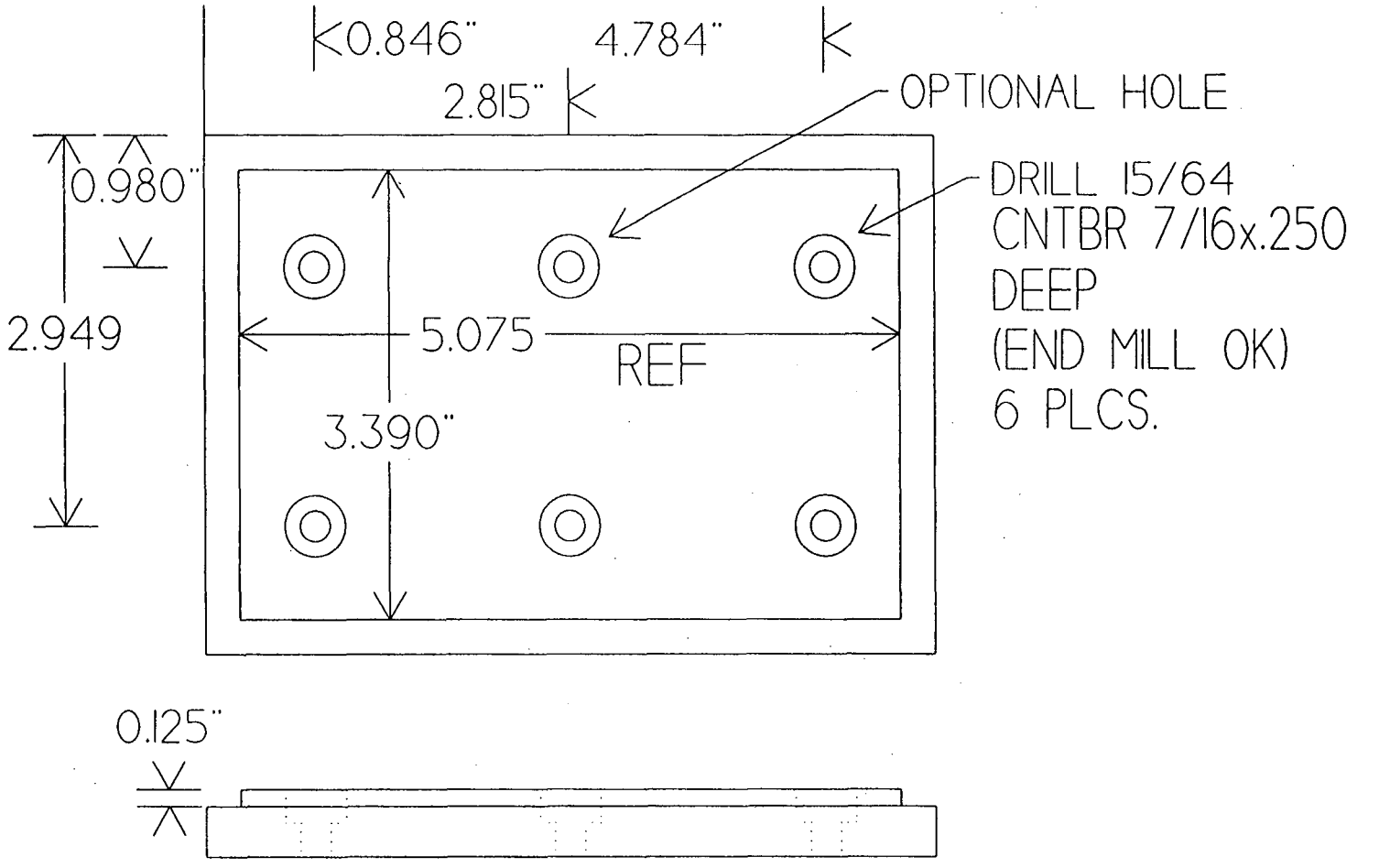




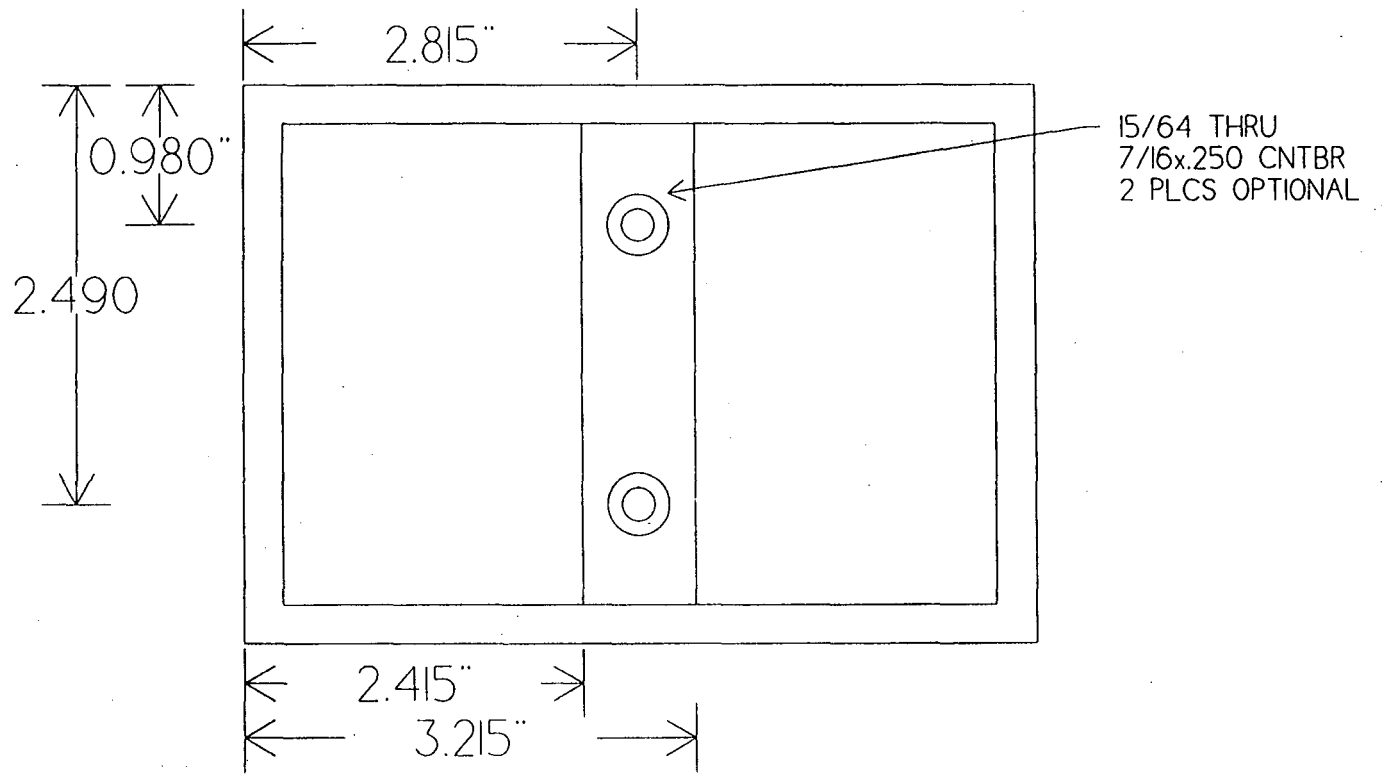
LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: MICROPLATE WORKSTATION		
COMPONENT NAME: BASE PLATE		
DWG. TYPE: BLANK	ORIGINAL DATE: 12-1-92	REV. DATE: 4-21-93
DWG. BY: MICHAEL J. OSOFSKY		
CHK. BY: WILLIAM SEARLES	FILE NAME: ORCAWORKSTATWKSTBS1	



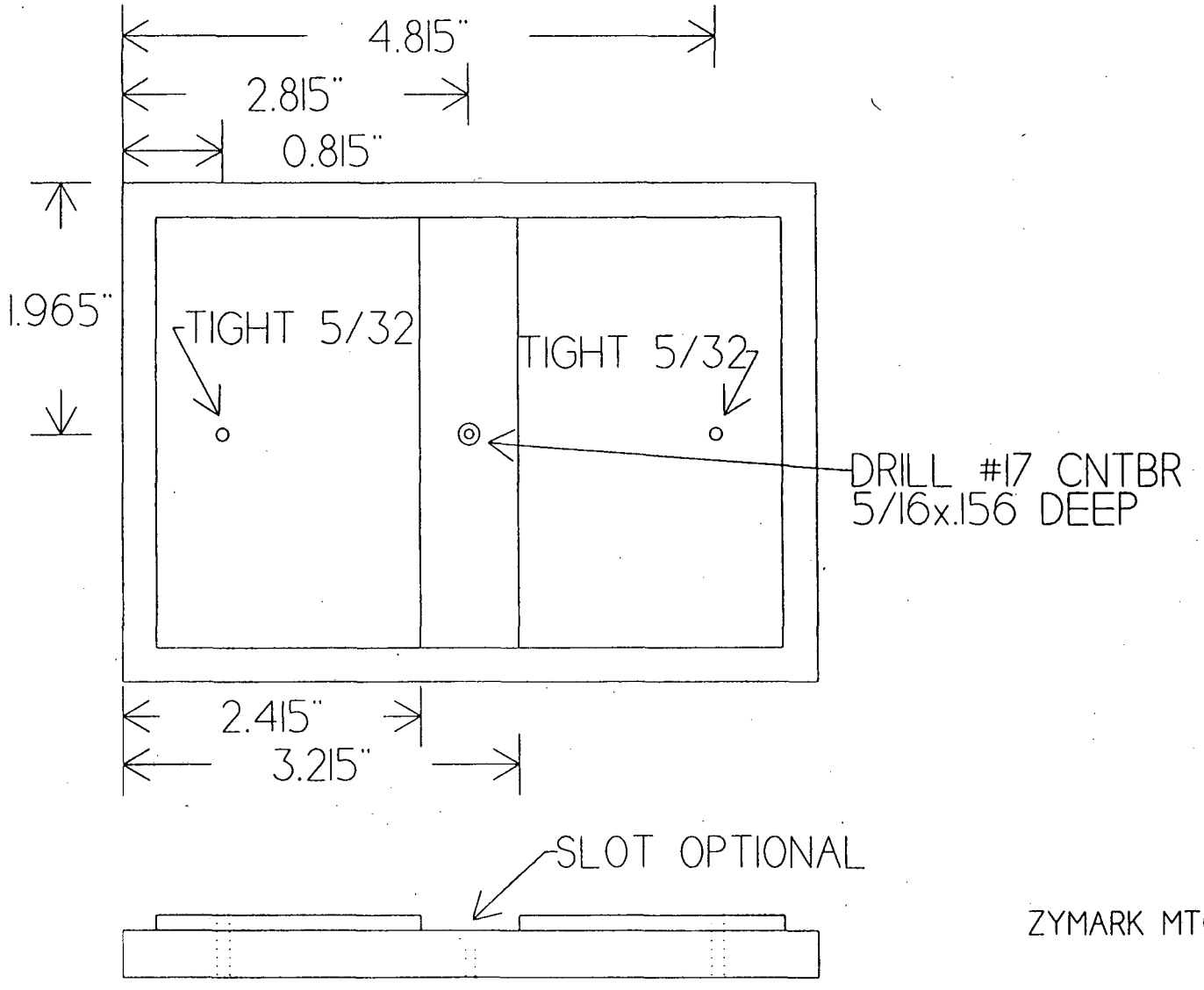
LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: MICROPLATE WORKSTATION		
COMPONENT NAME: BASE PLATE EDGE		
DWG. TYPE: DETAIL	ORIGINAL DATE: 4-20-93	REV. DATE: 4-21-93
DWG. BY: MICHAEL J. OSOFSKY		
CHK BY: WILLIAM SEARLES	FILE NAME: ORCA\WORKSTAT\BSPLATI	



LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: MICROPLATE WORKSTATION		
COMPONENT NAME: BASE PLATE HOLES		
DWG. TYPE: DETAIL	ORIGINAL DATE: 12-1-92	REV. DATE: 4-29-93
DWG. BY: MICHAEL J. OSOFSKY		
CHK. BY: WILLIAM SEARLES	FILE NAME: ORCAWORKSTATBSPLAT2	

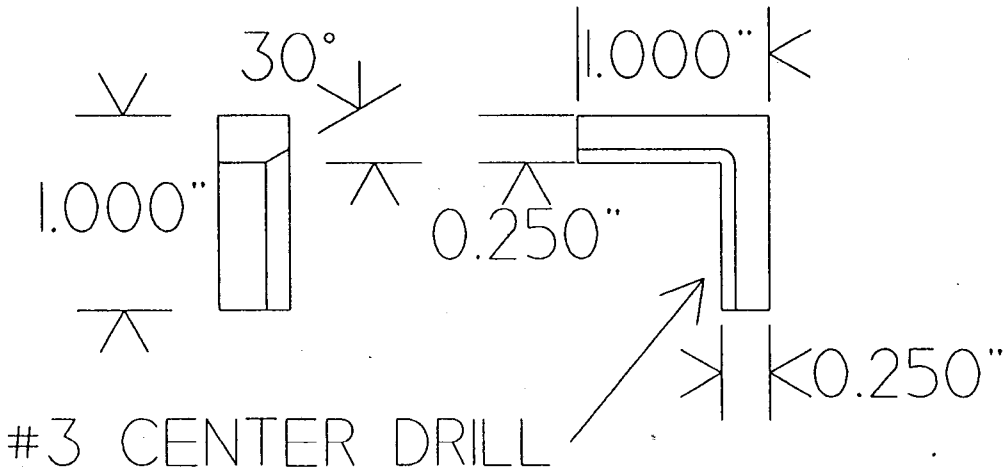


LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: MICROPLATE WORKSTATION		
COMPONENT NAME: BASE PLATE & OPTIONAL TAPE SLOT		
DWG. TYPE: DETAIL	ORIGINAL DATE: 12-1-92	REV. DATE: 4-28-93
DWG BY: MICHAEL J. OSOFSKY		
CHK BY: WILLIAM SEARLES	FILE NAME: ORCA\WORKSTAT\WKSTBS6	



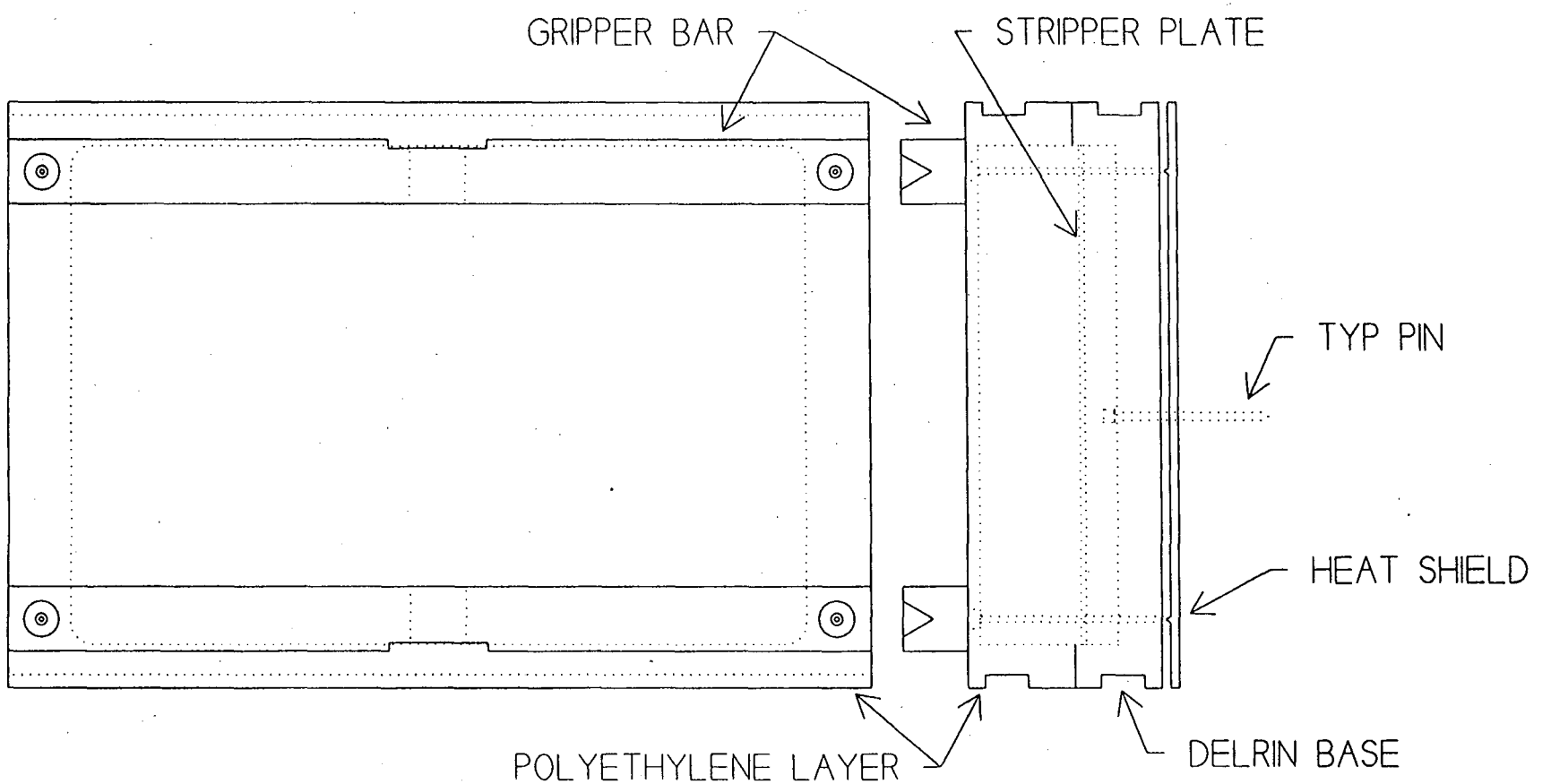
ZYMARK MTG OPTION

LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP			
PART OF: MICROPLATE WORKSTATION			
COMPONENT NAME: BASE PLATE & OPTIONAL TAPE SLOT			
DWG. TYPE: DETAIL	ORIGINAL DATE: 12-1-92	REV. DATE: 4-21-93	
DWG. BY: MICHAEL J. OSOFSKY			
CHK. BY: WILLIAM SEARLES	FILE NAME: ORCA\WORKSTAT\WKSTBS5		

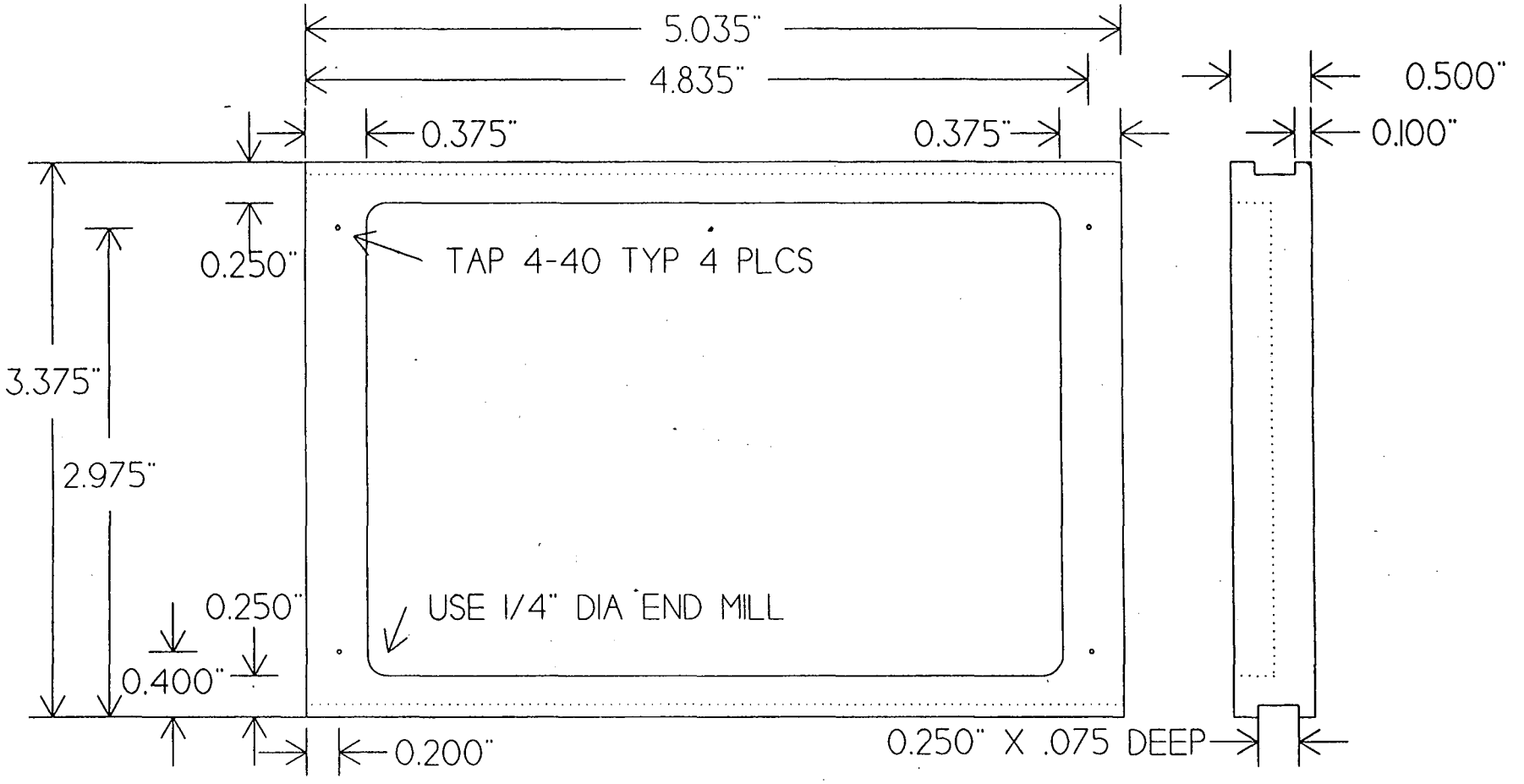


LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: MICROPLATE WORKSTATION		
COMPONENT NAME: GUIDE		
DWG. TYPE: DETAIL	ORIGINAL DATE: 12-1-92	REV. DATE: 4-20-93
DWG. BY: MICHAEL J. OSOFSKY		
CHK. BY: WILLIAM SEARLES	FILE NAME: ORCA\WORKSTAT\GUIDE	

Appendix E: 96–Pin Replicating Tool

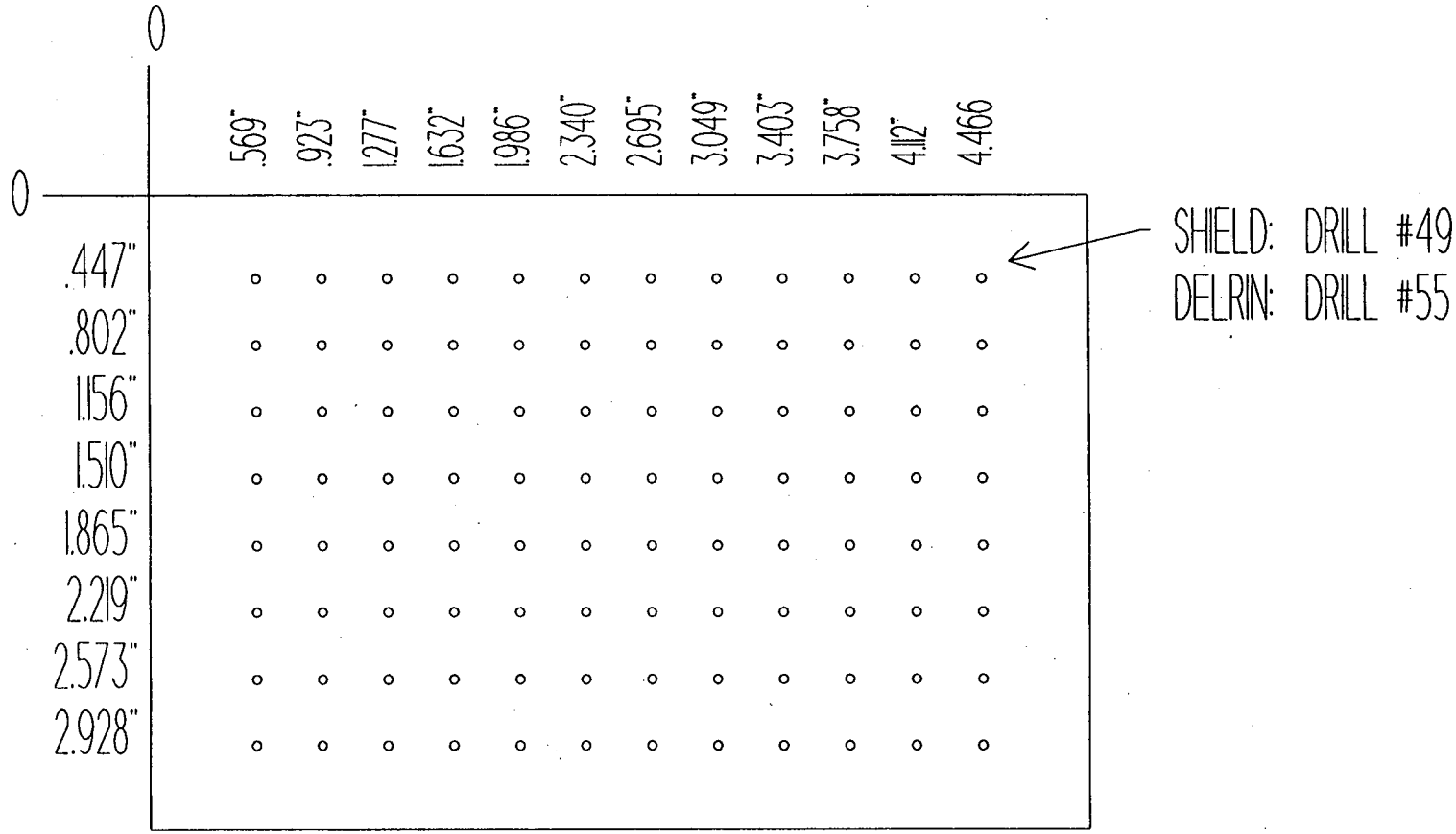


LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP			
PART OF: MULTIPIN TOOL			
COMPONENT NAME:			
DWG. TYPE: ASSEMBLY	ORIGINAL DATE: 12-1-92	REV. DATE: 4-23-93	
DWG. BY: MICHAEL J. OSOFSKY			
CHK. BY: WILLIAM SEARLES	FILE NAME: ORCA\MPTOOL\MPASMBLY		



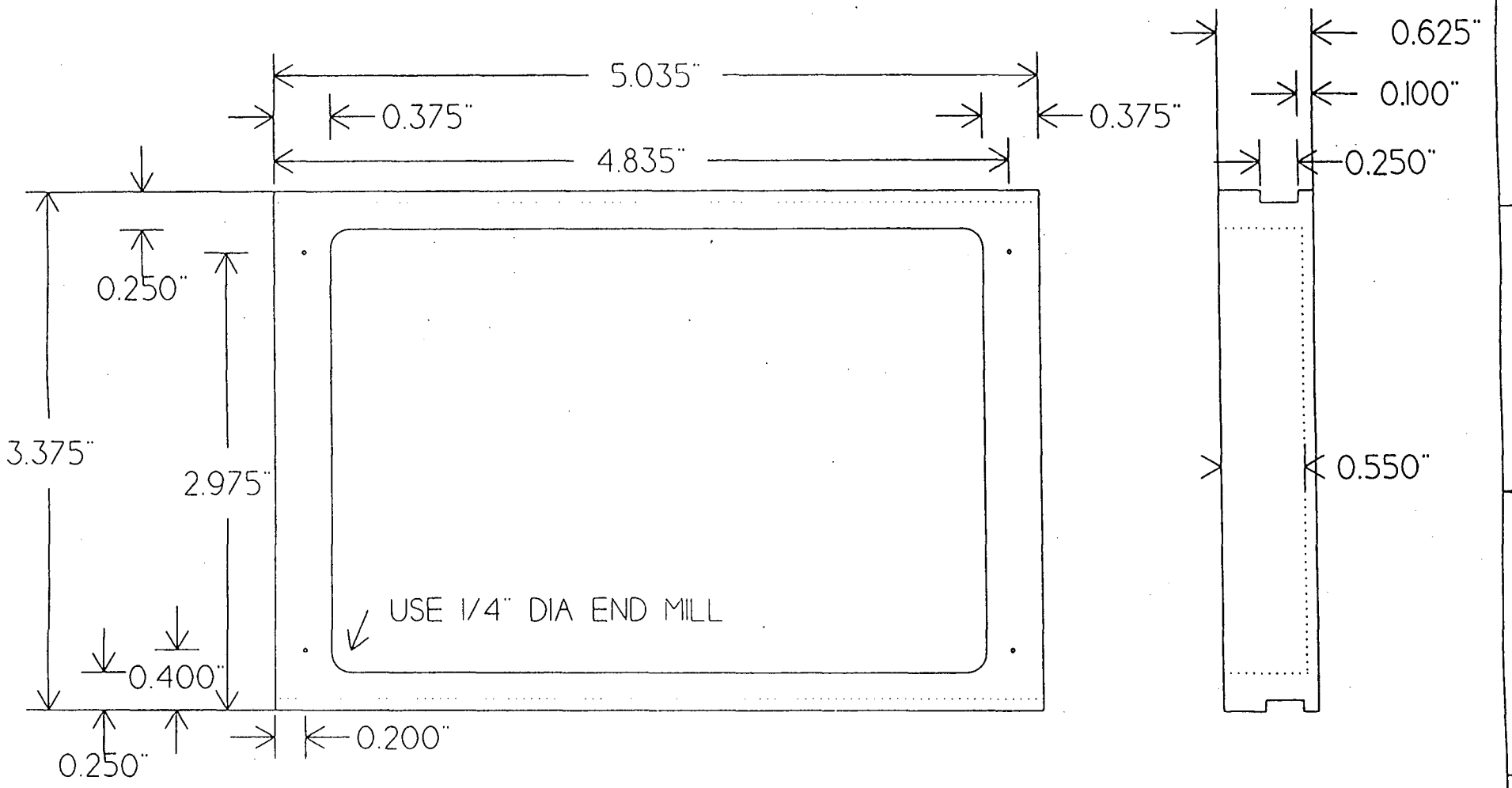
SEE REQUIRED PIN HOLE DWG

LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP			
PART OF: MULTIPIN TOOL			
COMPONENT NAME: DELRIN BASE			
DWG. TYPE: DETAIL	ORIGINAL DATE: 12-1-92	REV. DATE:	
DWG. BY: MICHAEL J. OSOFSKY			
CHK. BY: WILLIAM SEARLES	FILE NAME: ORCA\MPTOOL\MPDELRIN		



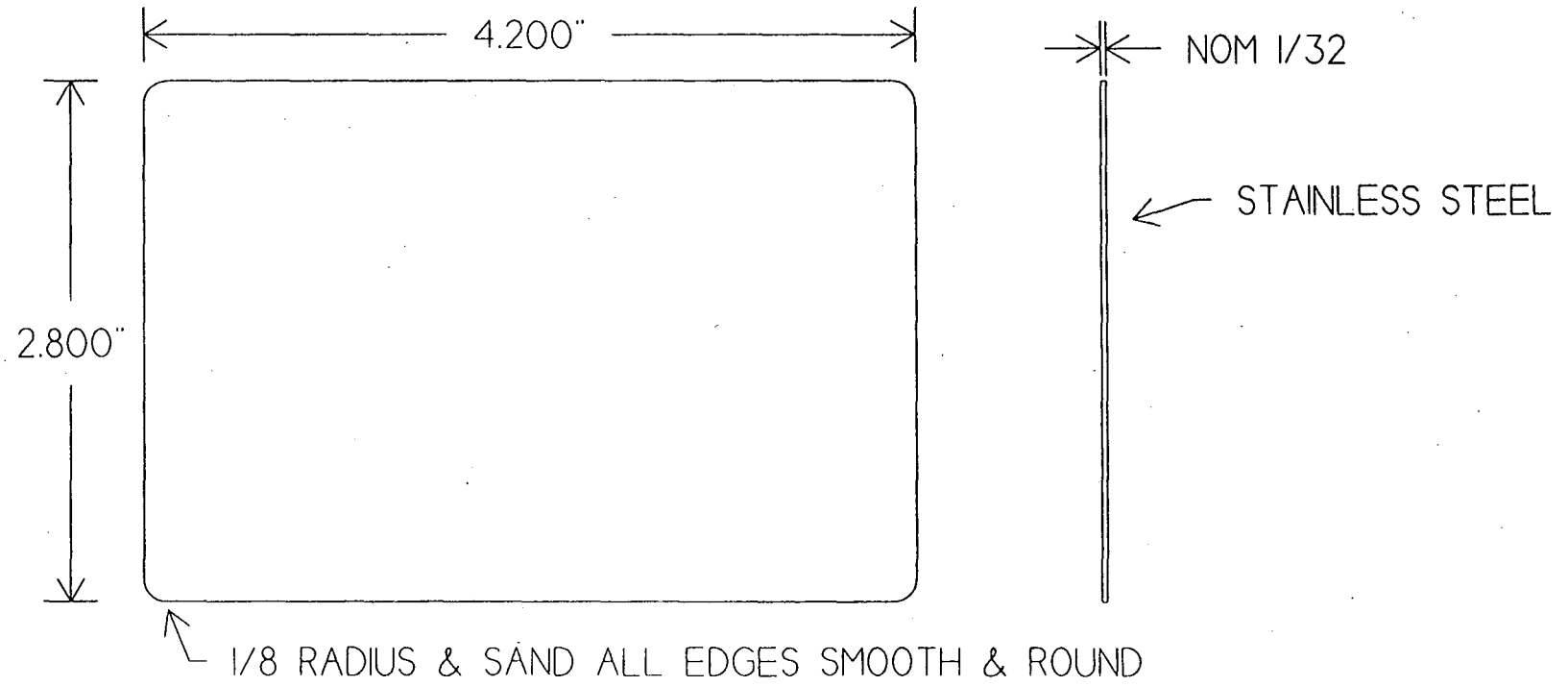
HOLE SPACING 9.0 mm

LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: MULTIPIN TOOL		
COMPONENT NAME: 96 PIN HOLES FOR DELRIN & SHIELD		
DWG. TYPE: DETAIL	ORIGINAL DATE: 12-1-92	REV. DATE: 4-23-93
DWG. BY: MICHAEL J. OSOFSKY		
CHK. BY: WILLIAM SEARLES	FILE NAME: ORCA\MPTOOL\96HOLES	

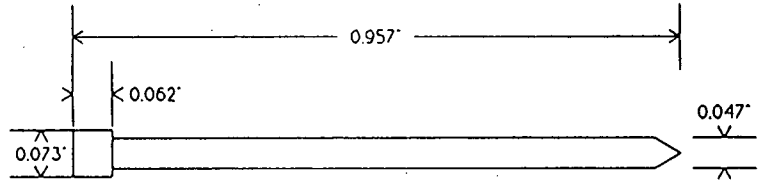


TYP 4 CORNERS--DRILL #32

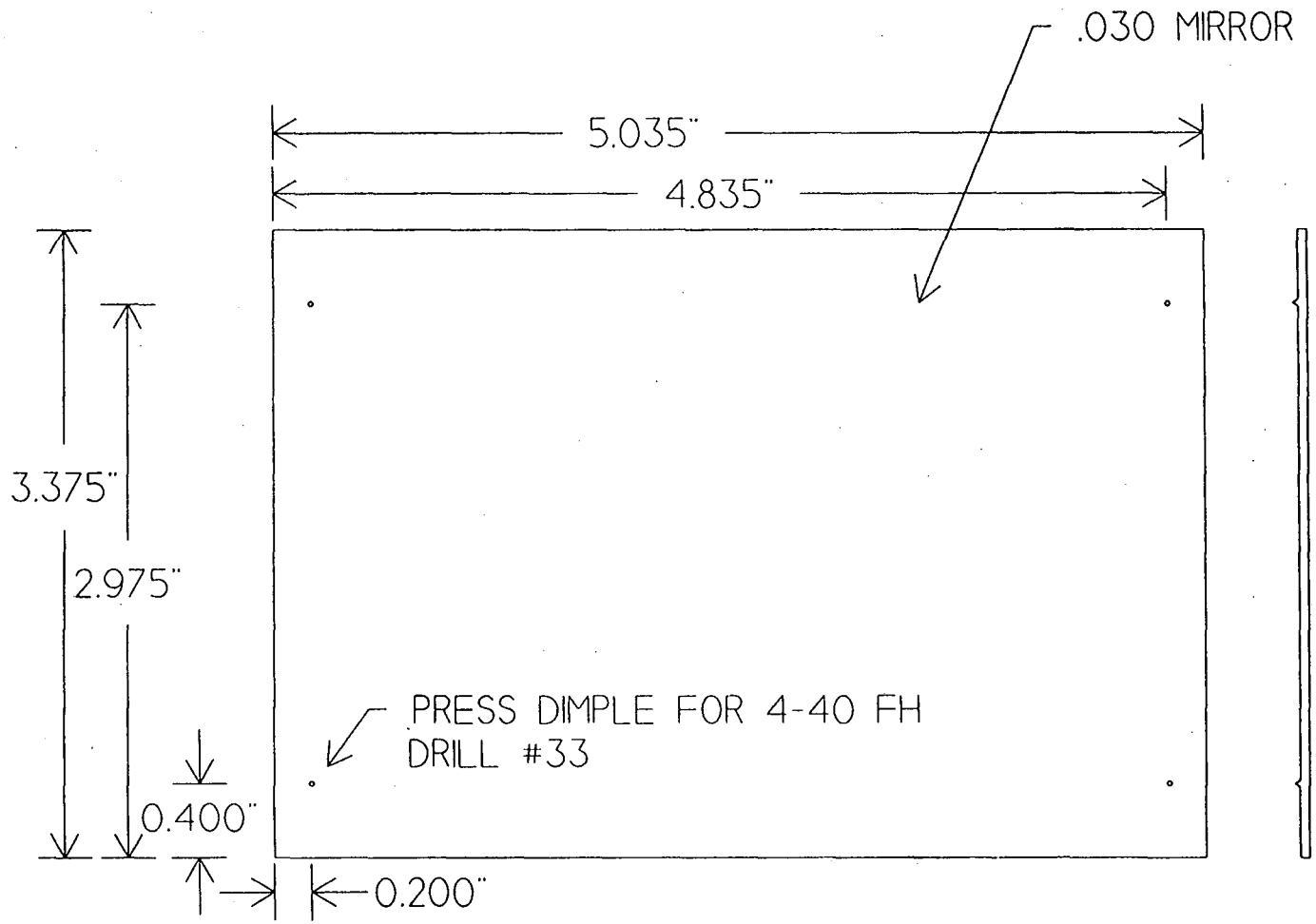
LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP			
PART OF: MULTIPIN			
COMPONENT NAME: POLYETHYLENE LAYER			
DWG. TYPE: DETAIL	ORIGINAL DATE: 12-1-92	REV. DATE: 4-23-93	
DWG. BY: MICHAEL J. OSOFSKY			
CHK. BY: WILLIAM SEARLES	FILE NAME: ORCA\MPTOOL\MPPOLY		



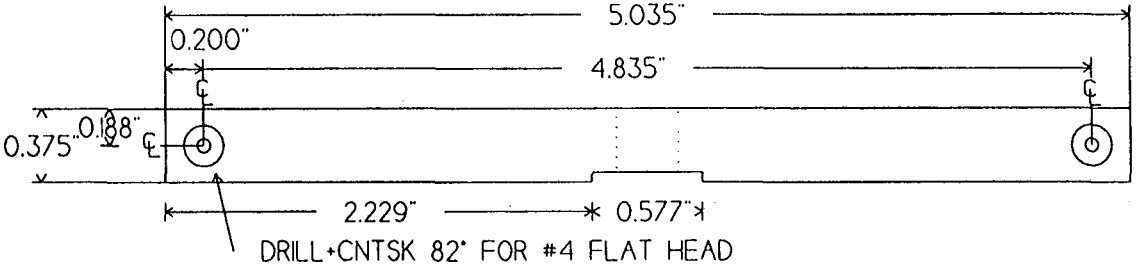
LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: MULTIPIN TOOL		
COMPONENT NAME: STRIPPER PLATE		
DWG. TYPE: DETAIL	ORIGINAL DATE: 12-1-92	REV. DATE:
DWG. BY: MICHAEL J. OSOFSKY		
CHK. BY: WILLIAM SEARLES	FILE NAME: ORCA\MPTOOL\STLPLATE	

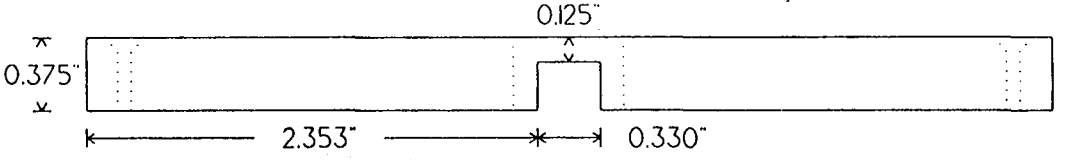


LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: MULTIPIN TOOL		
COMPONENT NAME: PIN		
DWG. TYPE: DETAIL	ORIGINAL DATE: 12-1-92	REV. DATE:
DWG. BY: MICHAEL J. OSOFSKY		
CHK BY: WILLIAM SEARLES	FILE NAME: ORCA\MPTOOL\MPPIN	



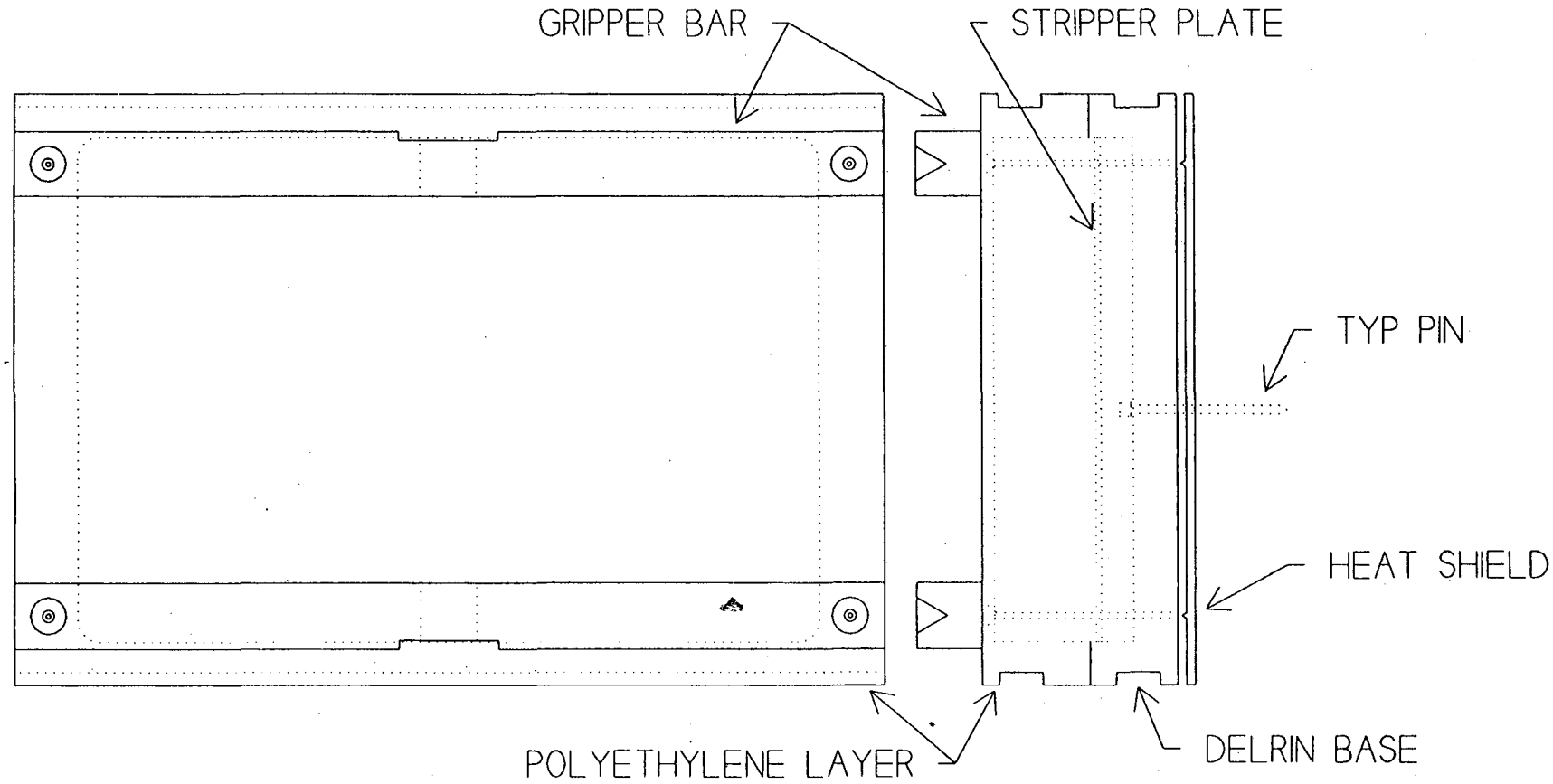
LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: MULTIPIN TOOL		
COMPONENT NAME: HEAT SHIELD		
DWG. TYPE: DETAIL	ORIGINAL DATE: 4-23-92	REV. DATE:
DWG. BY: MICHAEL J. OSOFSKY		
CHK BY: WILLIAM SEARLES	FILE NAME: ORCA\MPTOOL\HEATSHLD	





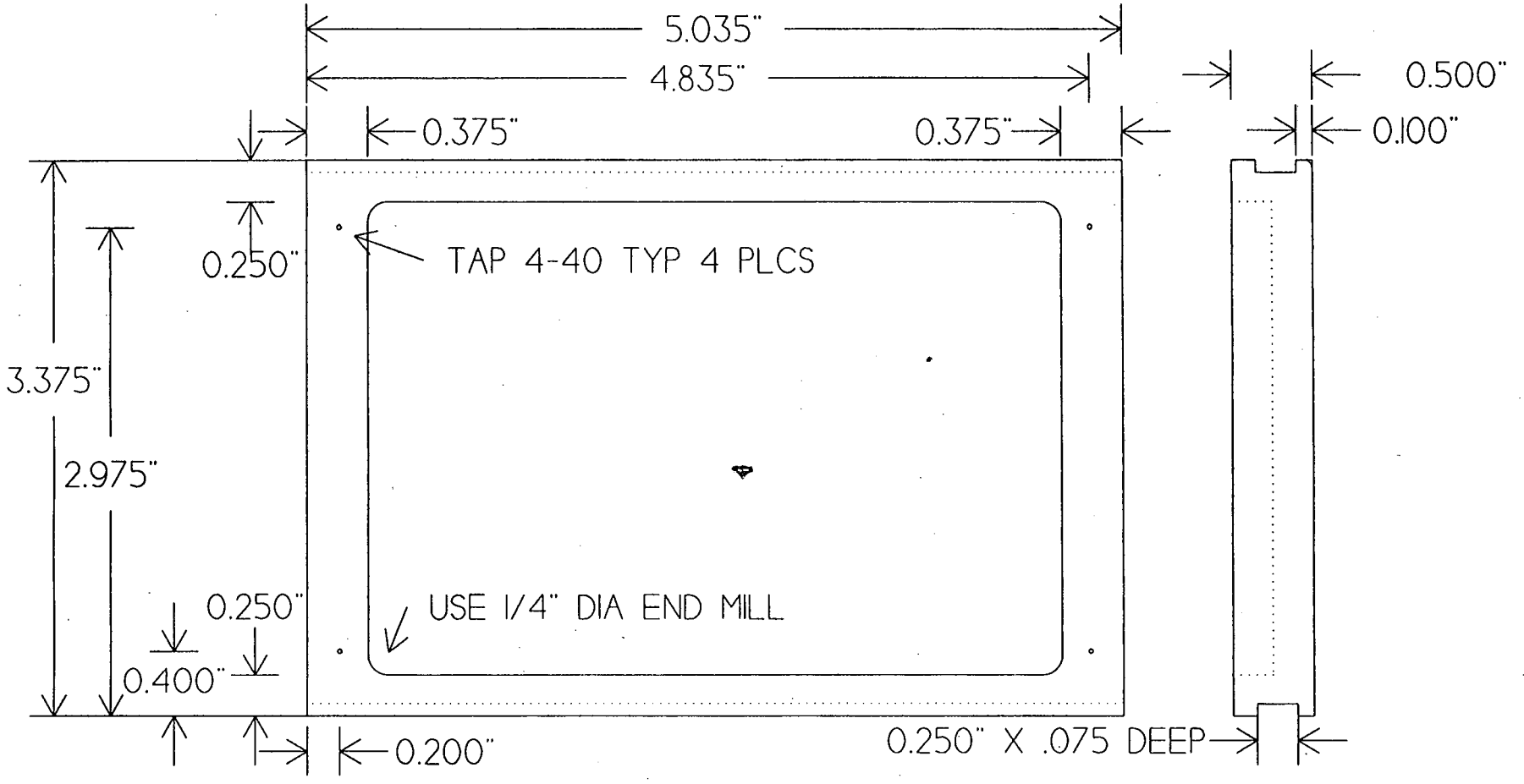
LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: MULTIPIN TOOL		
COMPONENT NAME: GRIPPER BAR		
DWG. TYPE: DETAIL	ORIGINAL DATE: 12-1-92	REV. DATE:
DWG. BY: MICHAEL J. OSOFSKY		
CHK. BY: WILLIAM SEARLES	FILE NAME: ORCA\MPTOOL\GRIPBAR	

Appendix F: 384–Pin Replication Tool



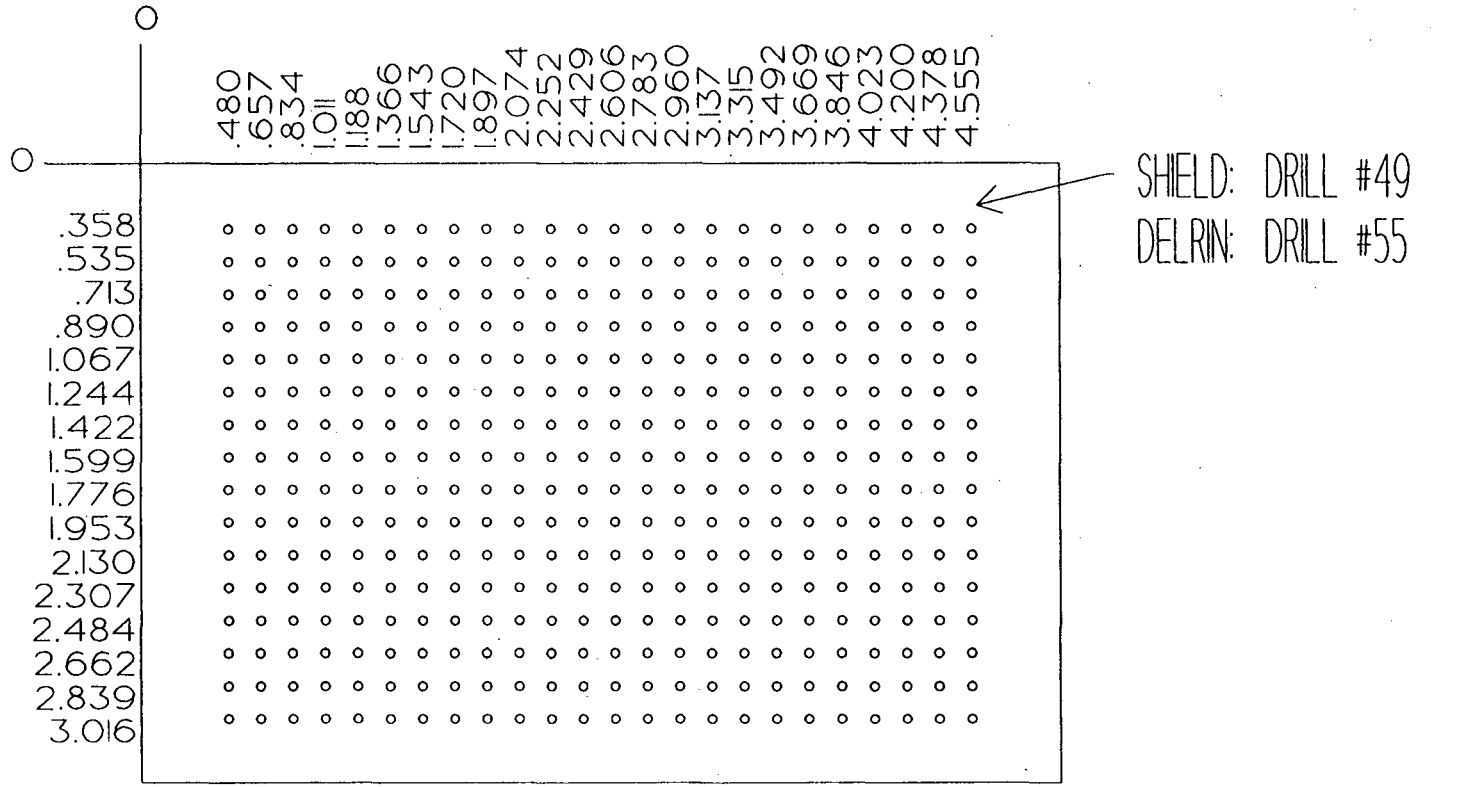
LAWRENCE BERKELEY LABORATORY
ENGINEERING DIVISION
HUMAN GENOME INSTRUMENTATION GROUP

PART OF: MULTIPIN TOOL			
COMPONENT NAME:			
DWG. TYPE: ASSEMBLY	ORIGINAL DATE: 12-1-92	REV. DATE: 4-23-93	
DWG. BY: MICHAEL J. OSOFSKY			
CHK. BY: WILLIAM SEARLES	FILE NAME: ORCA\MPTOOL\MPASMBLY		



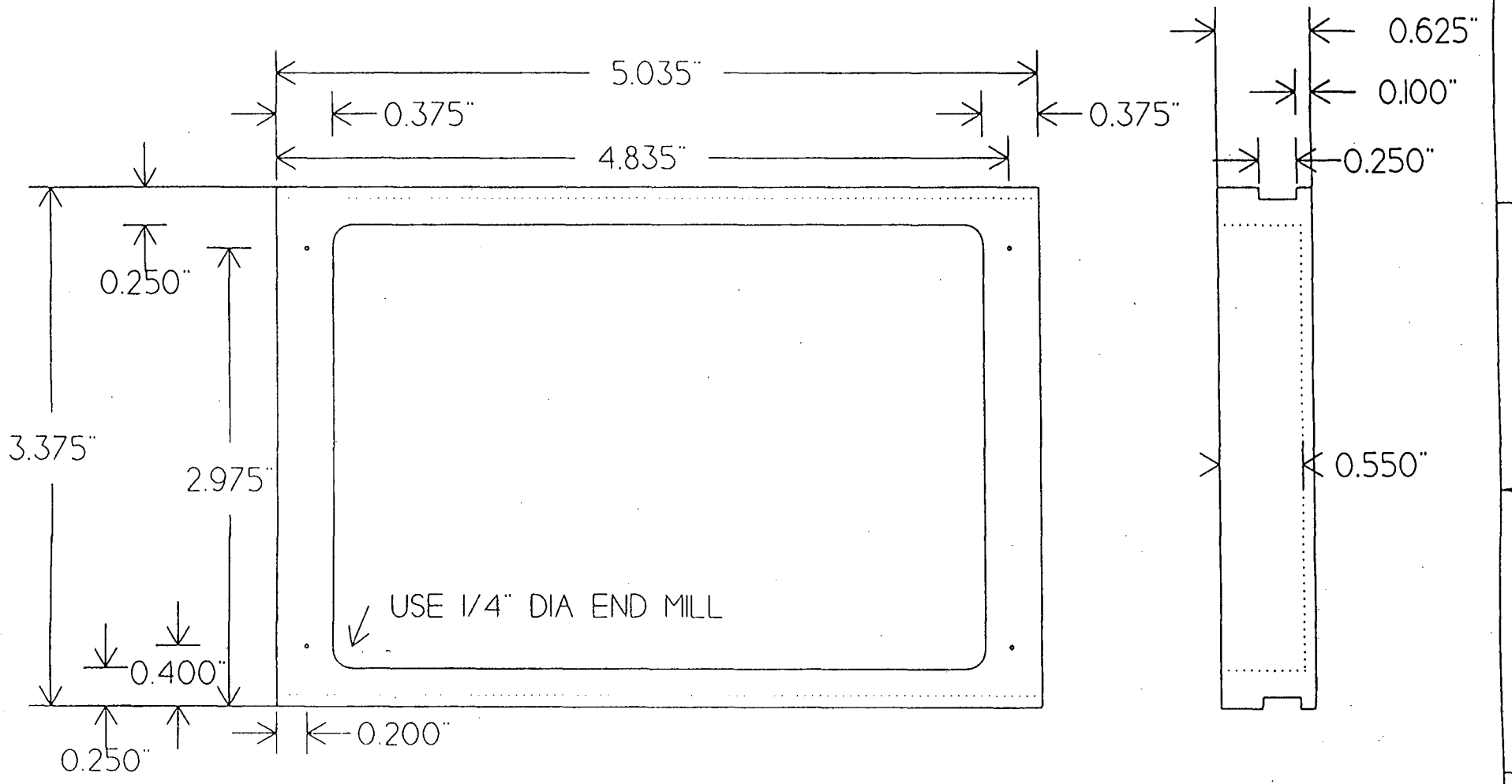
SEE REQUIRED PIN HOLE DWG

LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP			
PART OF: MULTIPIN TOOL			
COMPONENT NAME: DELRIN BASE			
DWG. TYPE: DETAIL	ORIGINAL DATE: 12-1-92	REV. DATE:	
DWG. BY: MICHAEL J. OSOFSKY			
CHK. BY: WILLIAM SEARLES	FILE NAME: ORCA\MPTOOL\MPDELRIN		



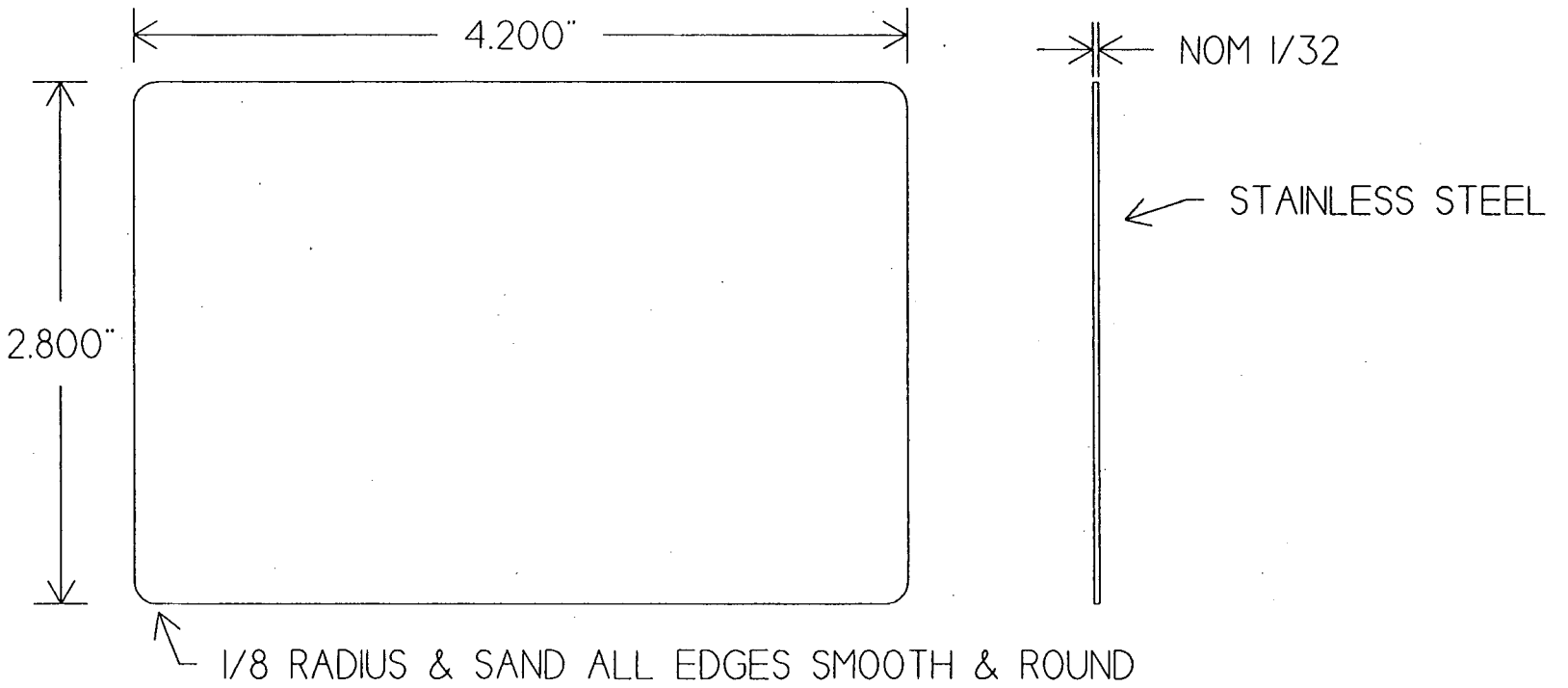
HOLE SPACING 4.5 mm

LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: MULTIPIN TOOL		
COMPONENT NAME: 384 PIN HOLES		
DWG. TYPE: DETAIL	ORIGINAL DATE: 12-1-92	REV. DATE:
DWG. BY: MICHAEL J. OSOFSKY		
CHK BY: WILLIAM SEARLES	FILE NAME: ORCA\MPTOOL\384HOLES	

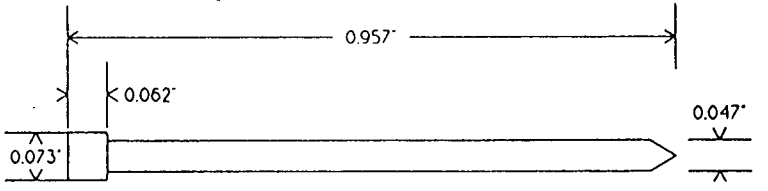


TYP 4 CORNERS--DRILL #32

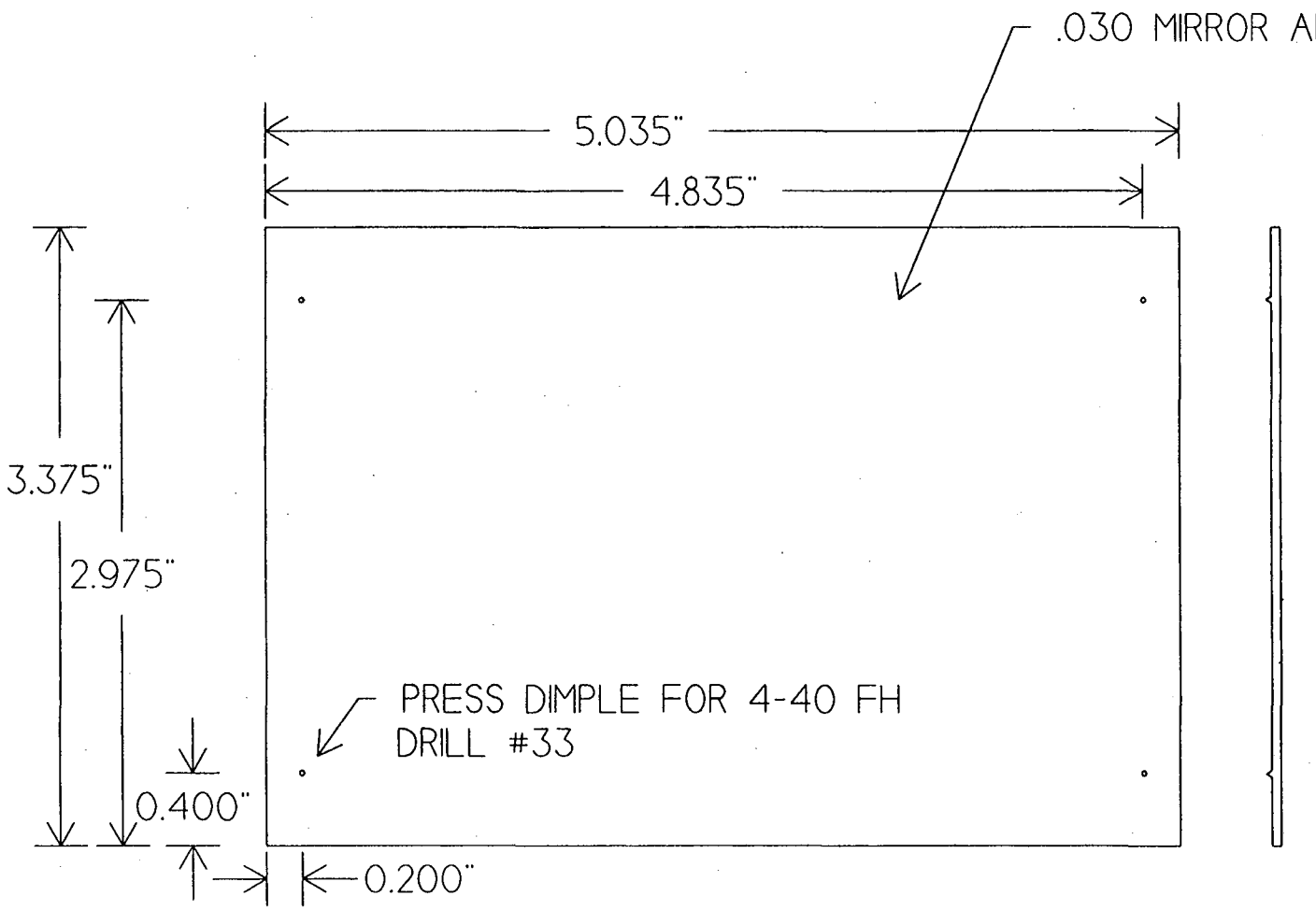
LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP			
PART OF: MULTIPIN			
COMPONENT NAME: POLYETHYLENE LAYER			
DWG. TYPE: DETAIL	ORIGINAL DATE: 12-1-92	REV. DATE: 4-23-93	
DWG. BY: MICHAEL J. OSOFSKY			
CHK BY: WILLIAM SEARLES	FILE NAME: ORCA\MPTOOL\MPPOLY		



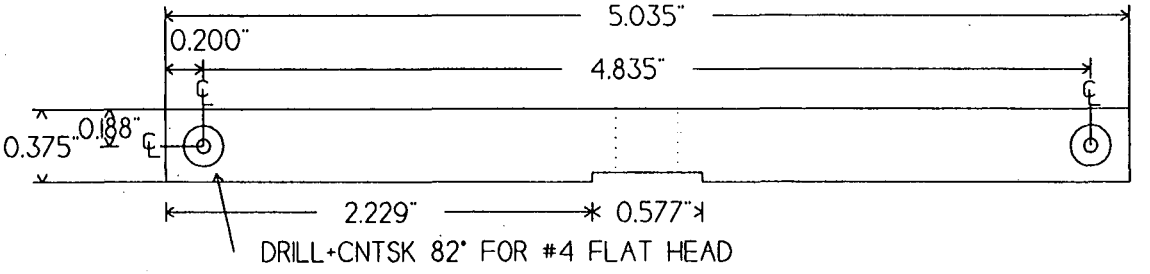
LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP			
PART OF: MULTIPIN TOOL			
COMPONENT NAME: STRIPPER PLATE			
DWG. TYPE: DETAIL	ORIGINAL DATE: 12-1-92	REV. DATE:	
DWG. BY: MICHAEL J. OSOFSKY			
CHK. BY: WILLIAM SEARLES	FILE NAME: ORCA\MPTOOL\STLPLATE		

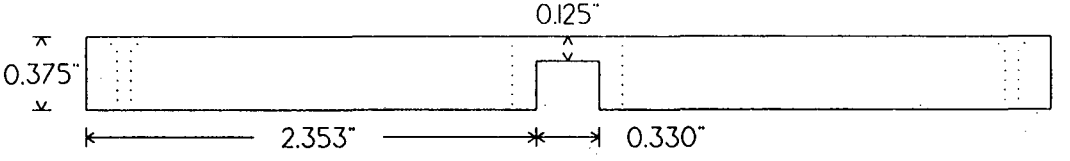


LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: MULTIPIN TOOL		
COMPONENT NAME: PIN		
DWG. TYPE: DETAIL	ORIGINAL DATE: 12-1-92	REV. DATE:
DWG. BY: MICHAEL J. OSOFSKY		
CHK BY: WILLIAM SEARLES	FILE NAME: ORCA\MPTOOL\MPPIN	



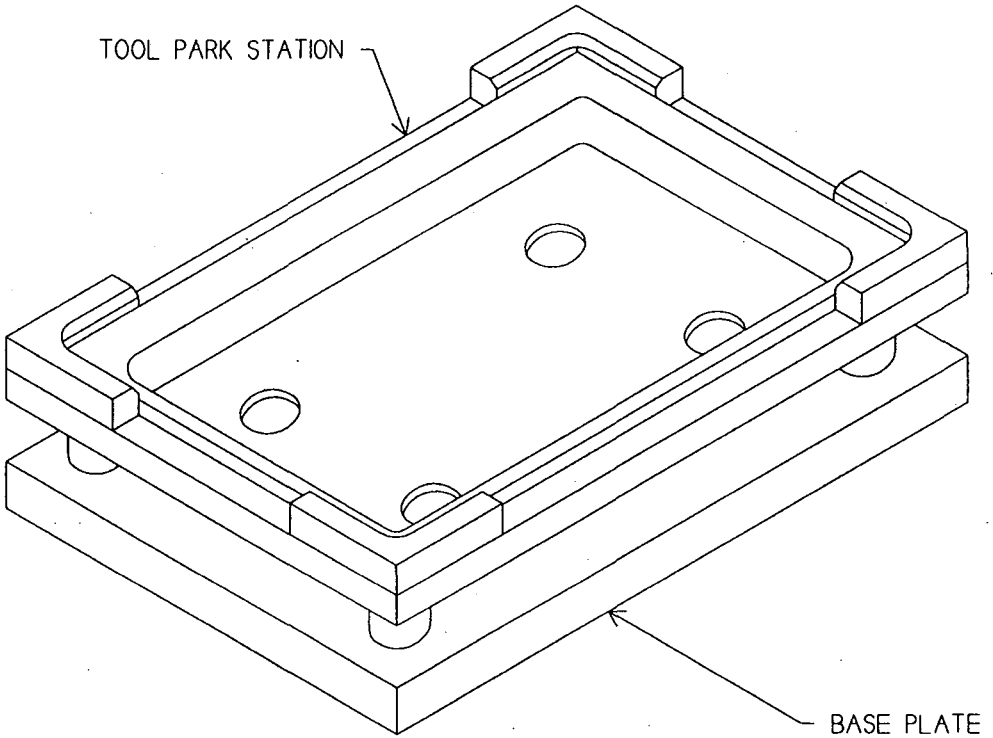
LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: MULTIPIN TOOL		
COMPONENT NAME: HEAT SHIELD		
DWG. TYPE: DETAIL	ORIGINAL DATE: 4-23-92	REV. DATE:
DWG. BY: MICHAEL J. OSOFSKY		
CHK BY: WILLIAM SEARLES	FILE NAME: ORCA\MPTOOL\HEATSHLD	



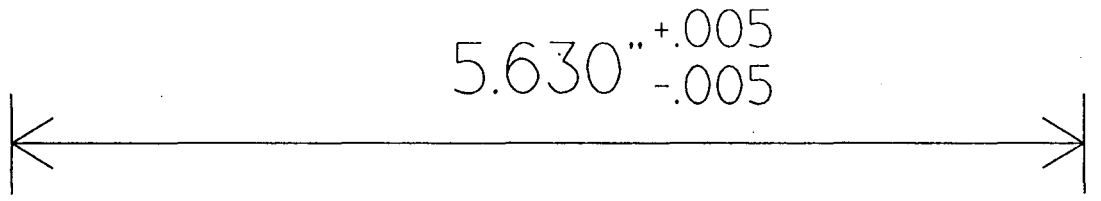


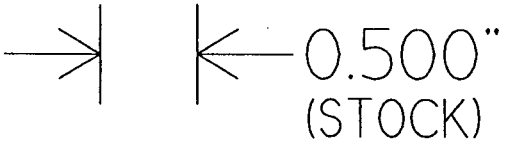
LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: MULTIPIN TOOL		
COMPONENT NAME: GRIPPER BAR		
DWG. TYPE: DETAIL	ORIGINAL DATE: 12-1-92	REV. DATE:
DWG. BY: MICHAEL J. OSOFSKY		
CHK. BY: WILLIAM SEARLES	FILE NAME: ORCA\MPTOOL\GRIPBAR	

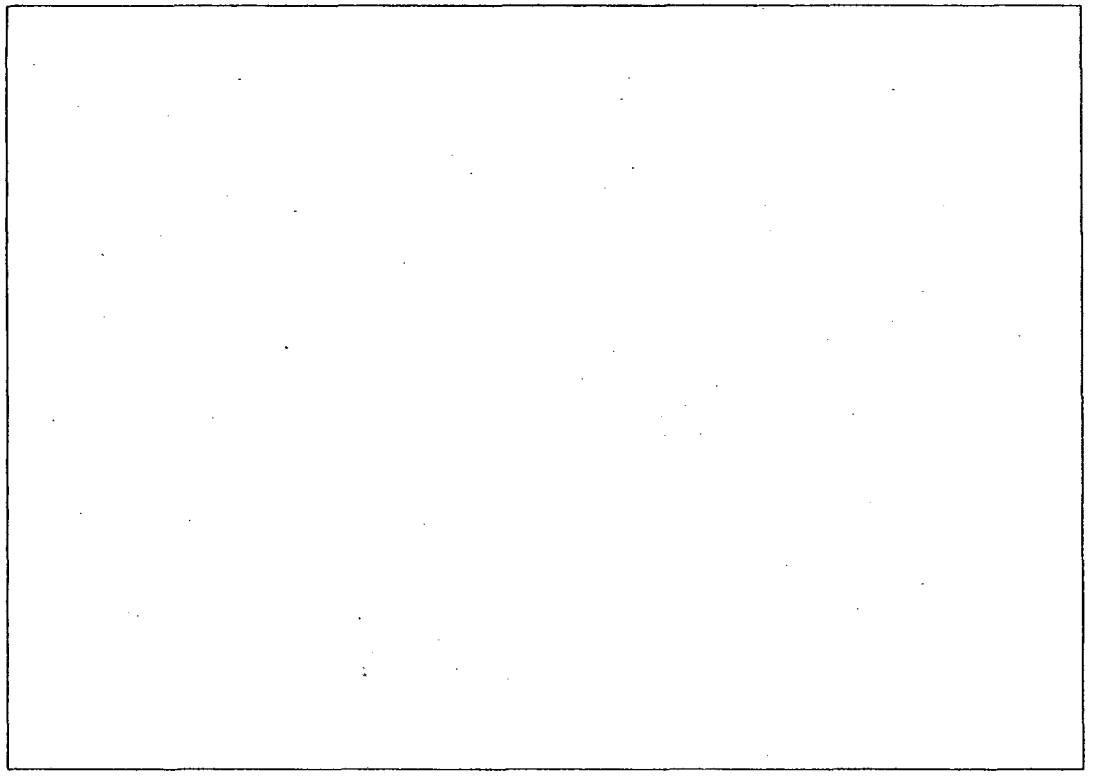
Appendix G: Multipin Tool Parking Station

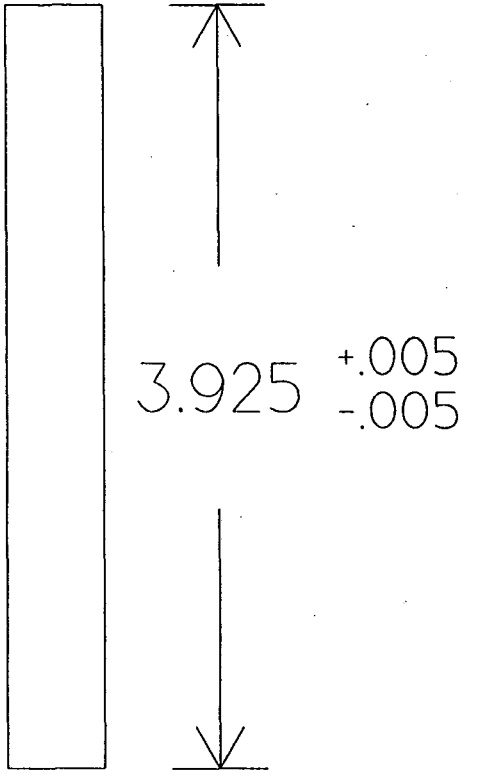


LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: TOOL PARK STATION		
COMPONENT NAME:		
DWG. TYPE: ORTHOG.	ORIGINAL DATE: 7/22/93	REV. DATE:
DWG. BY: J. HOME III		
CHK. BY: W. SEARLES	FILE NAME: ORCAWORKSTATORTHOG	

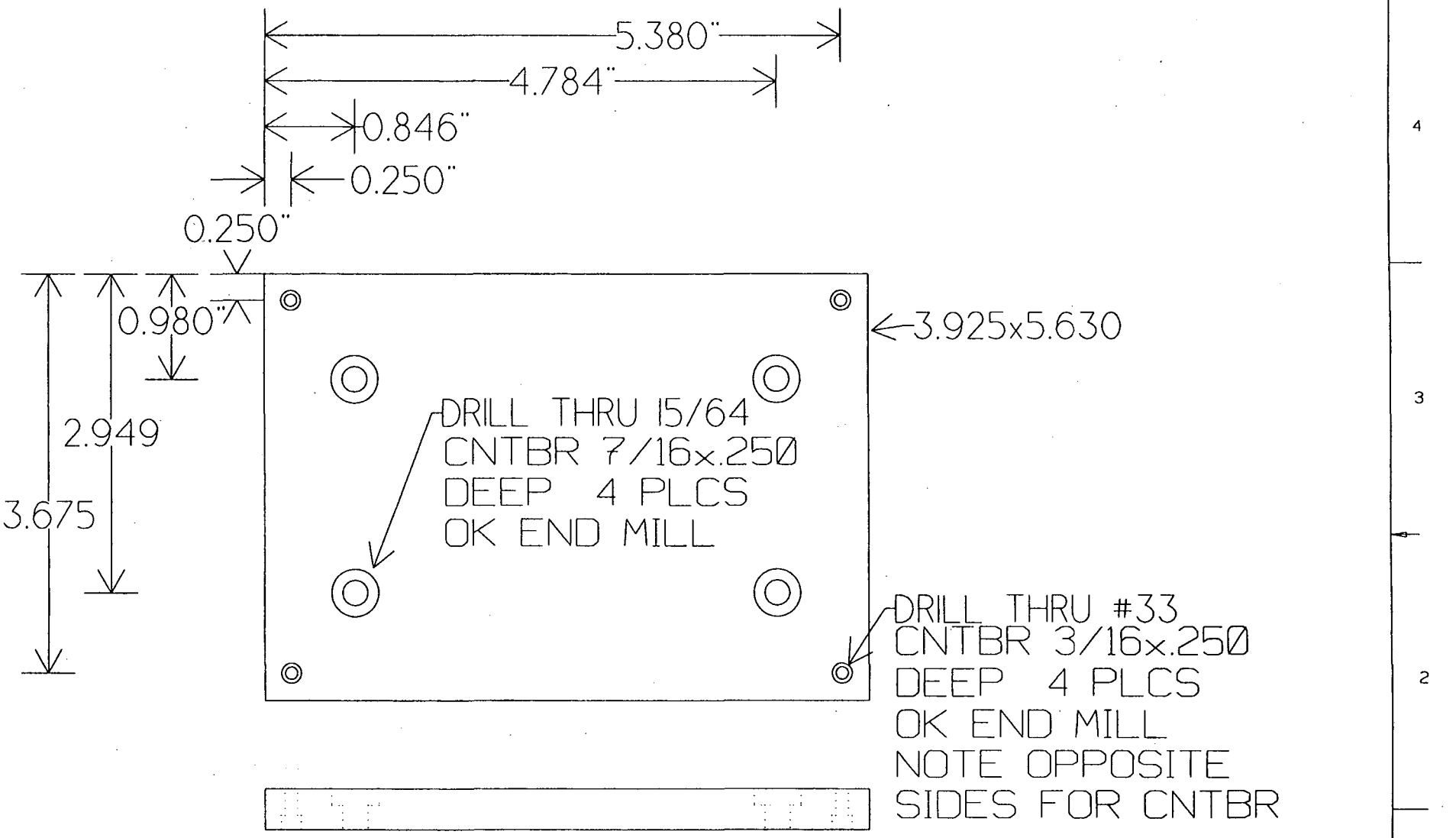






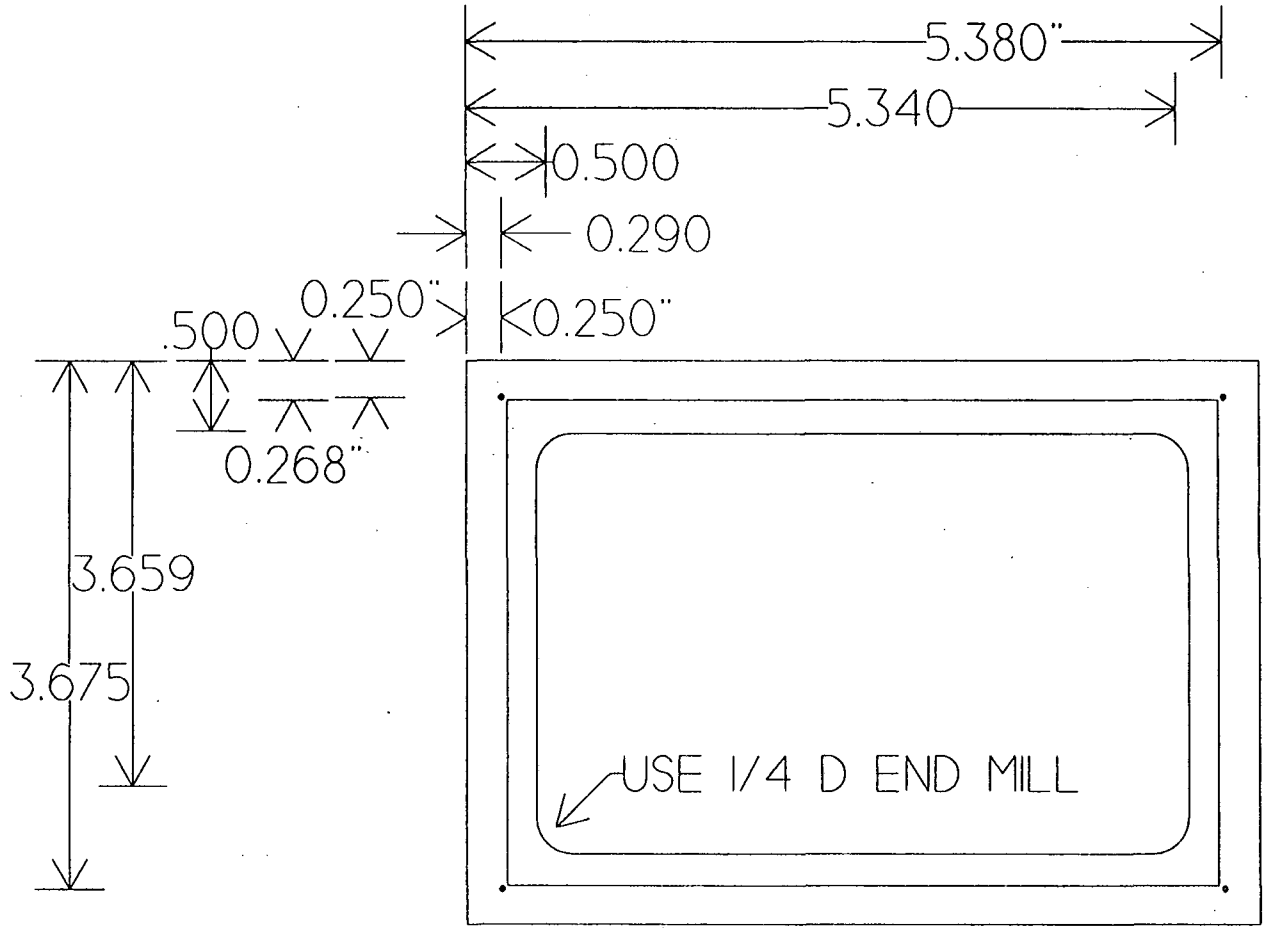


LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP			
PART OF: MICROPLATE WORKSTATION			
COMPONENT NAME: BASE PLATE			
DWG. TYPE: BLANK	ORIGINAL DATE: 12-1-92	REV. DATE: 4-21-93	
DWG. BY: MICHAEL J. OSOFSKY			
CHK. BY: WILLIAM SEARLES	FILE NAME: ORCAWORKSTATWKSTBS1		

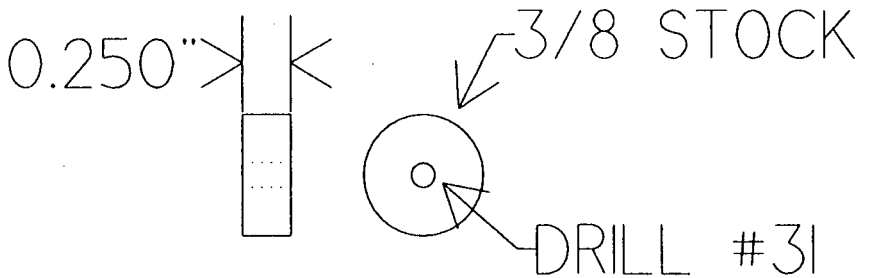


LAWRENCE BERKELEY LABORATORY
ENGINEERING DIVISION
HUMAN GENOME INSTRUMENTATION GROUP

PART OF: MULTIPIN TOOL PARK STATION		
COMPONENT NAME: BASE PLATE HOLES		
DWG. TYPE: DETAIL	ORIGINAL DATE: 6-3-93	REV. DATE: 7/15/93
DWG. BY: MICHAEL J. OSOFSKY		
CHK. BY: WILLIAM SEARLES	FILE NAME: ORCA\WORKSTAT\WKSTBS7	

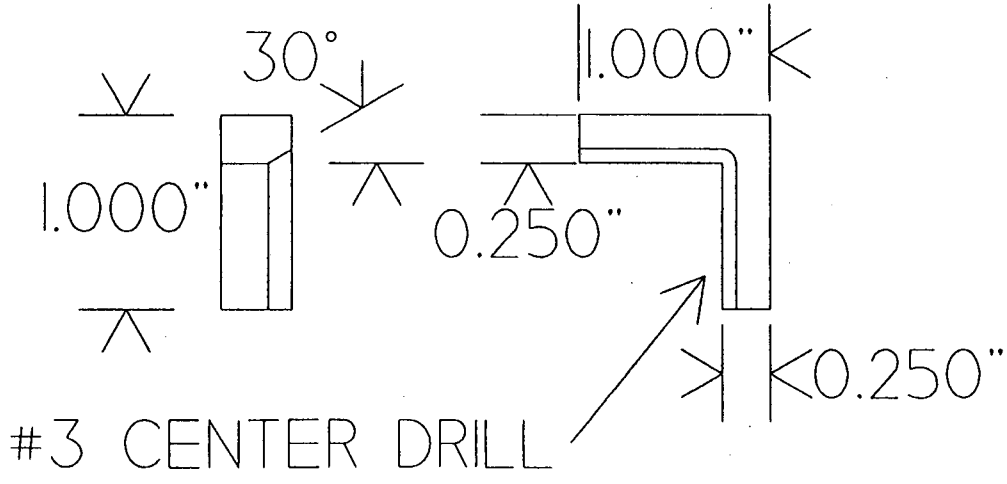


LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: MULTIPIN TOOL PARK STATION		
COMPONENT NAME: TOP PLATFORM		
DWG. TYPE: DETAIL	ORIGINAL DATE: 6-18-93	REV. DATE: 7-22-93
DWG. BY: MICHAEL J. OSOFSKY		
CHK. BY: WILLIAM SEARLES	FILE NAME: ORCAWORKSTATWKSTBS8	



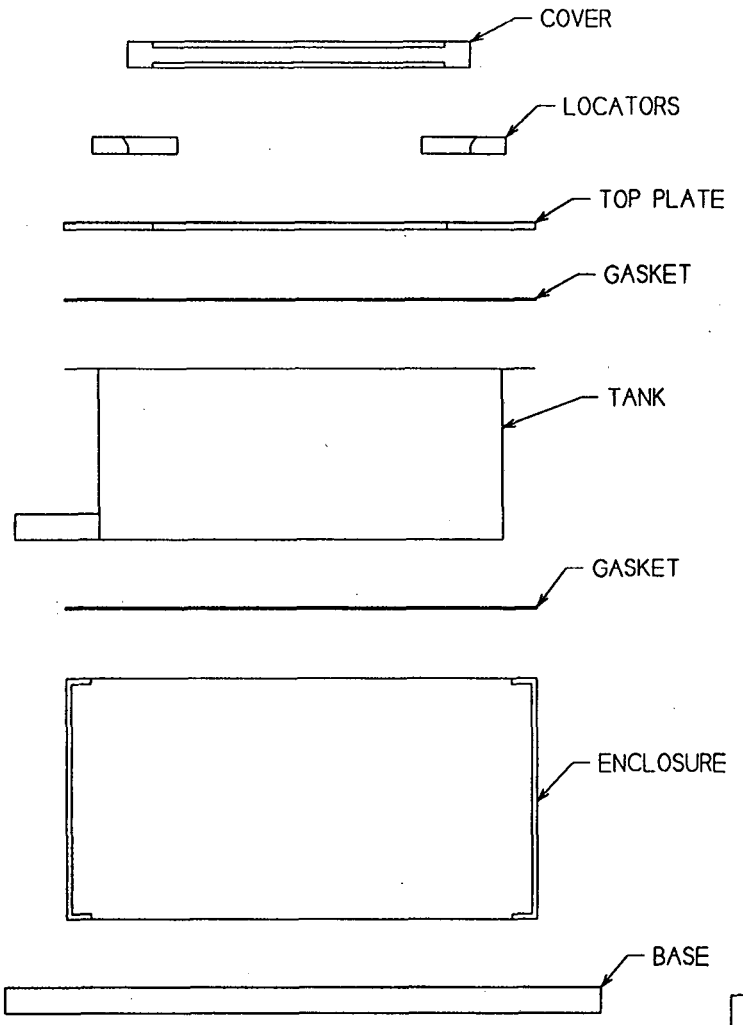
MAKE 4/UNIT

LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: MULTIPIN TOOL PARK STATION		
COMPONENT NAME: SPACER		
DWG. TYPE: DETAIL	ORIGINAL DATE: 6-18-93	REV. DATE: 7-15-93
DWG. BY: MICHAEL J. OSOFSKY		
CHK. BY: WILLIAM SEARLES	FILE NAME: ORCA\WORKSTAT\SPACER	



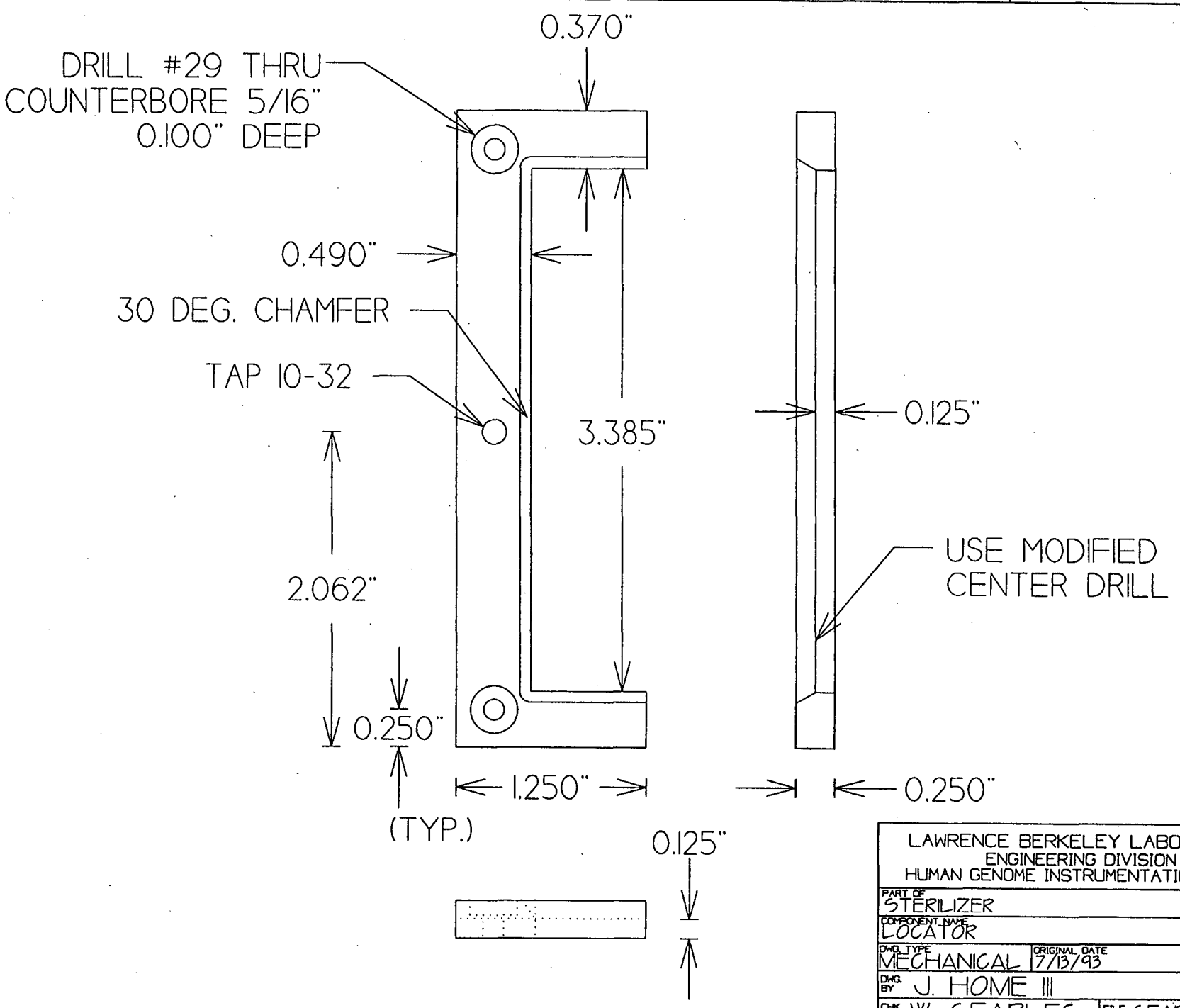
LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: MICROPLATE WORKSTATION		
COMPONENT NAME: GUIDE		
DWG. TYPE: DETAIL	ORIGINAL DATE: 12-1-92	REV. DATE: 4-20-93
DWG. BY: MICHAEL J. OSOFSKY		
CHK. BY: WILLIAM SEARLES	FILE NAME: ORCA\WORKSTAT\GUIDE	

Appendix H: Multipin Tool Sterilizer Bath

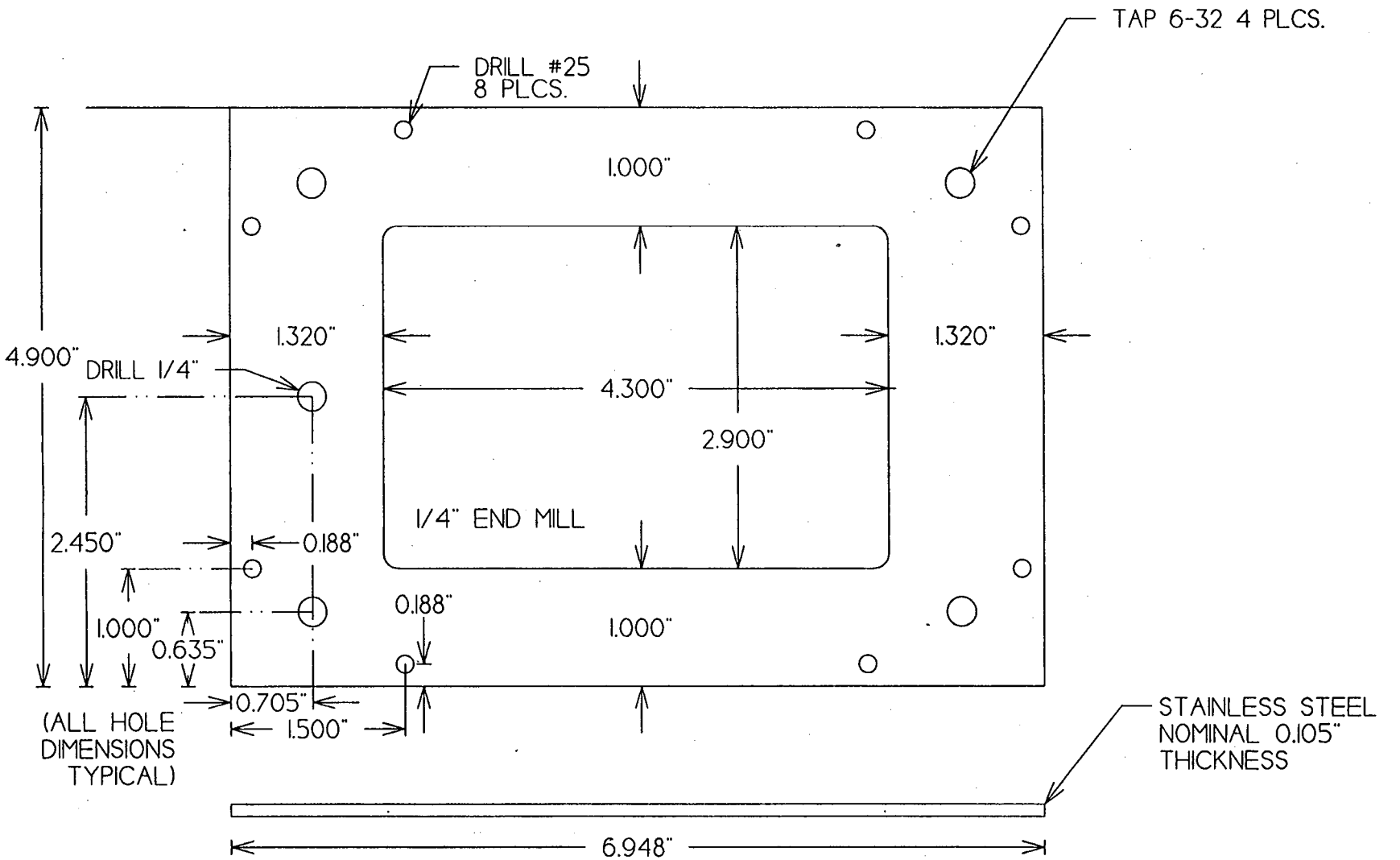


LAWRENCE BERKELEY LABORATORY
ENGINEERING DIVISION
HUMAN GENOME INSTRUMENTATION GROUP

PART OF: STERILIZING BATH			
COMPONENT NAME: ASSEMBLY DIAGRAM			
DWG. TYPE: ASSEMBLY	ORIGINAL DATE: 8/10/93	REV. DATE:	
DWG. BY: J. HOME III	MATERIAL:	QUANT.:	
CHK BY: W. SEARLES	FILE NAME: SEARLES/BHASMBLY		

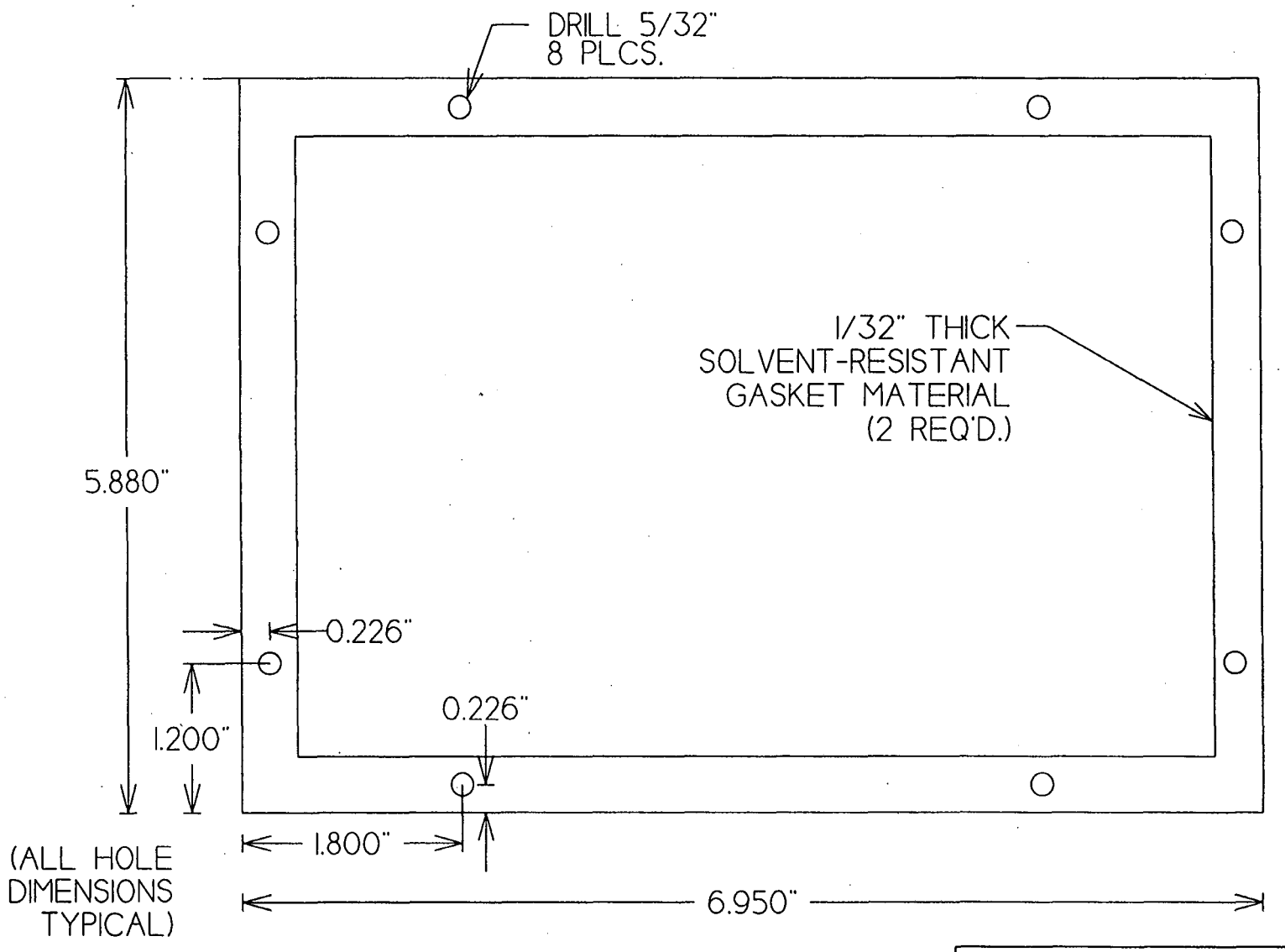


LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: STERILIZER		
COMPONENT NAME: LOCATOR		
DWG. TYPE: MECHANICAL	ORIGINAL DATE: 7/13/93	REV. DATE: 8/25/93
DWG. BY: J. HOME III		
CHK. BY: W. SEARLES	FILE NAME: SEARLES\BHLOCATR	

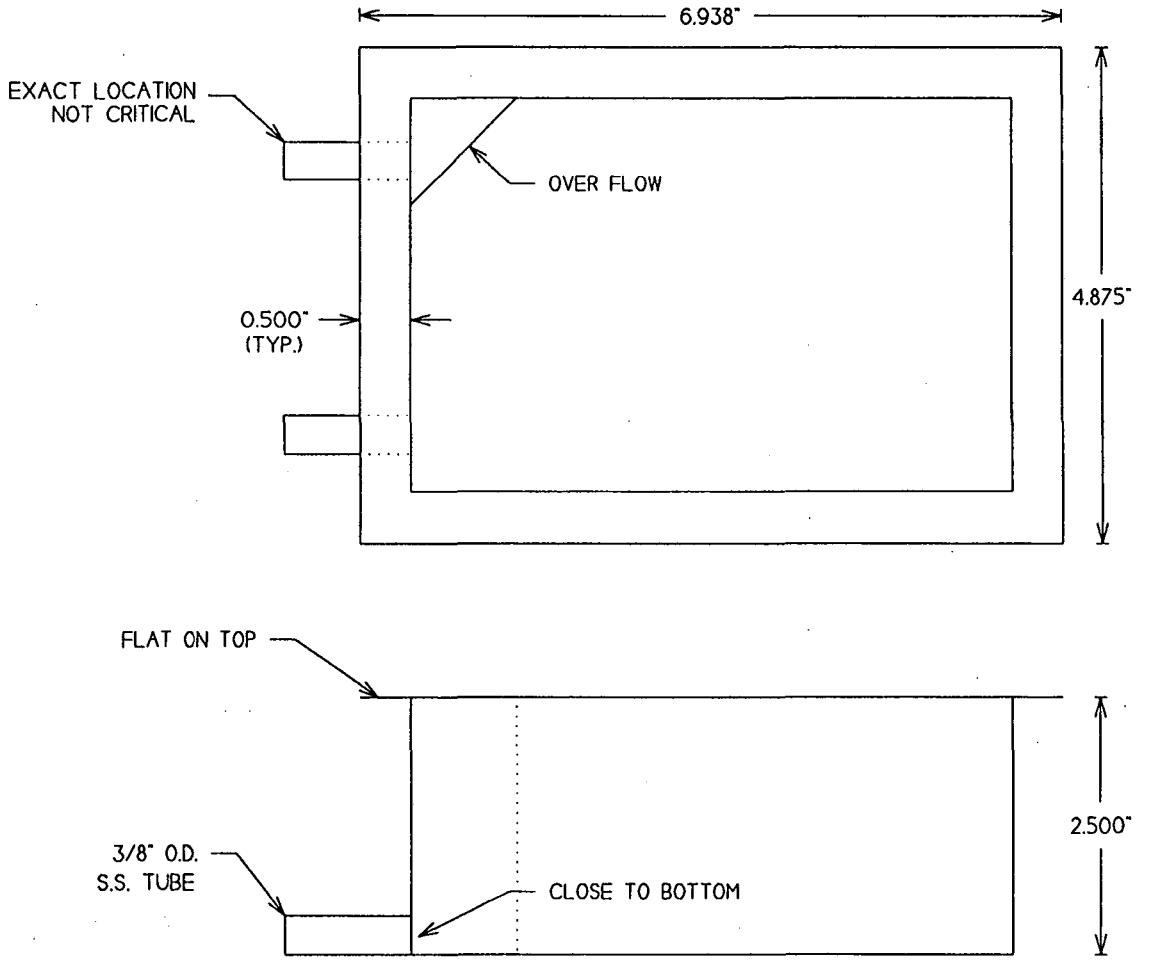


LAWRENCE BERKELEY LABORATORY
ENGINEERING DIVISION
HUMAN GENOME INSTRUMENTATION GROUP

PART OF: STERILIZER		
COMPONENT NAME: TOP PLATE		
DWG. TYPE: MECH.	ORIGINAL DATE: 7/13/93	REV. DATE: 8/25/93
DWG. BY: J. HOME III		
CHK BY: W. SEARLES	FILE NAME: SEARLES\BHTOP	

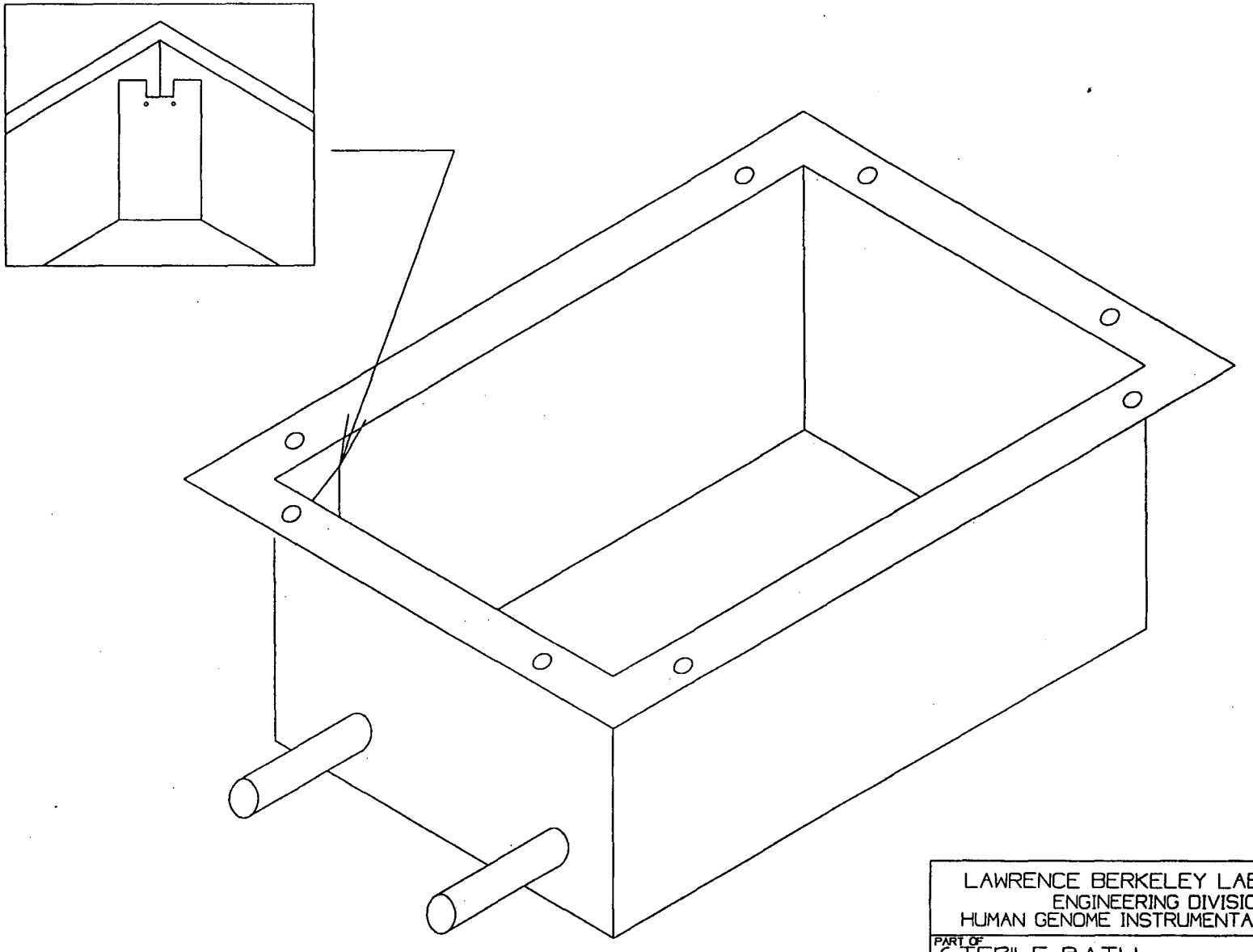


LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: STERILE BATH		
COMPONENT NAME: GASKET		
DWG. TYPE: MECH.	ORIGINAL DATE: 7/13/93	REV. DATE:
DWG. BY: J. HOME III		
CHK BY: W. SEARLES	FILE NAME: SEARLES\BHGASKT	



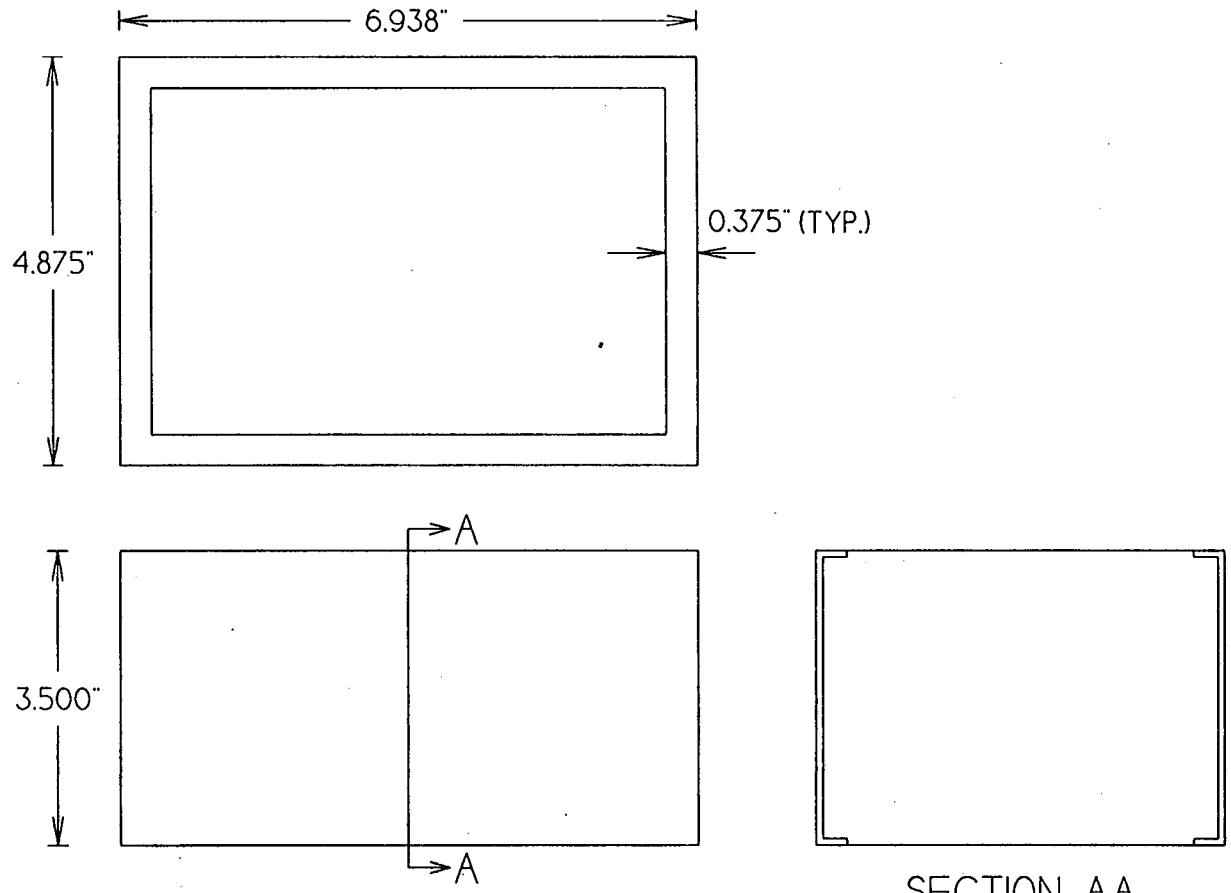
LAWRENCE BERKELEY LABORATORY
ENGINEERING DIVISION
HUMAN GENOME INSTRUMENTATION GROUP

PART OF: STERILE BATH		
COMPONENT NAME: BATH TANK		
DWG. TYPE: MECH.	ORIGINAL DATE	REV. DATE
DWG. BY: J. HOME III	MATERIAL	QUANT.
CHK. BY: W. SEARLES	FILE NAME: SEARLES/BHTANK	



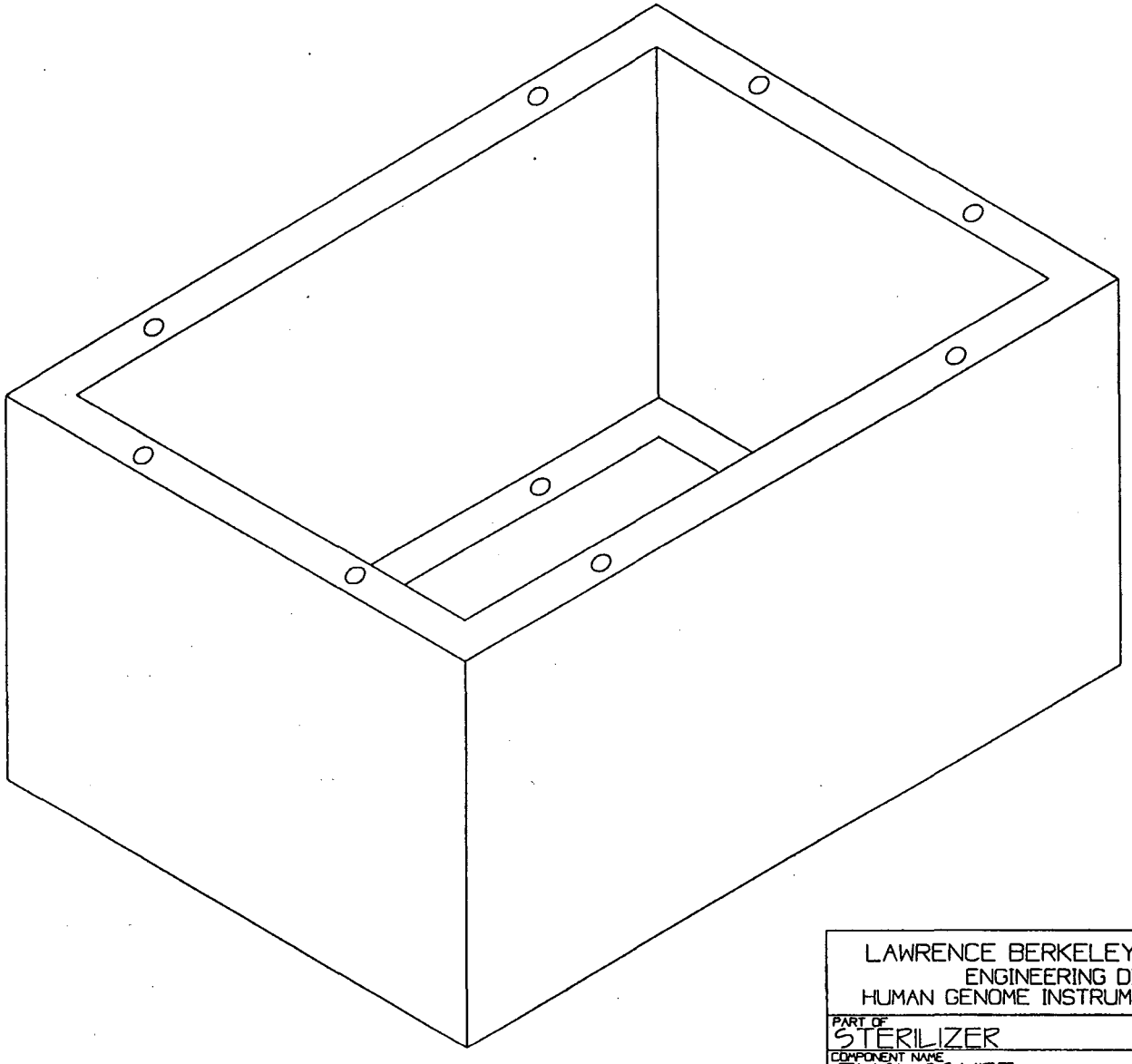
LAWRENCE BERKELEY LABORATORY
ENGINEERING DIVISION
HUMAN GENOME INSTRUMENTATION GROUP

PART OF: STERILE BATH			
COMPONENT NAME: BATH TANK			
DWG. TYPE: ORTHOG.	ORIGINAL DATE: 7/28/93	REV. DATE:	
DWG. BY: J. HOME III	MATERIAL: STAINLESS STEEL	QUANT.	
CHK. BY: W. SEARLES	FILE NAME: SEARLES\BHORTHG2		

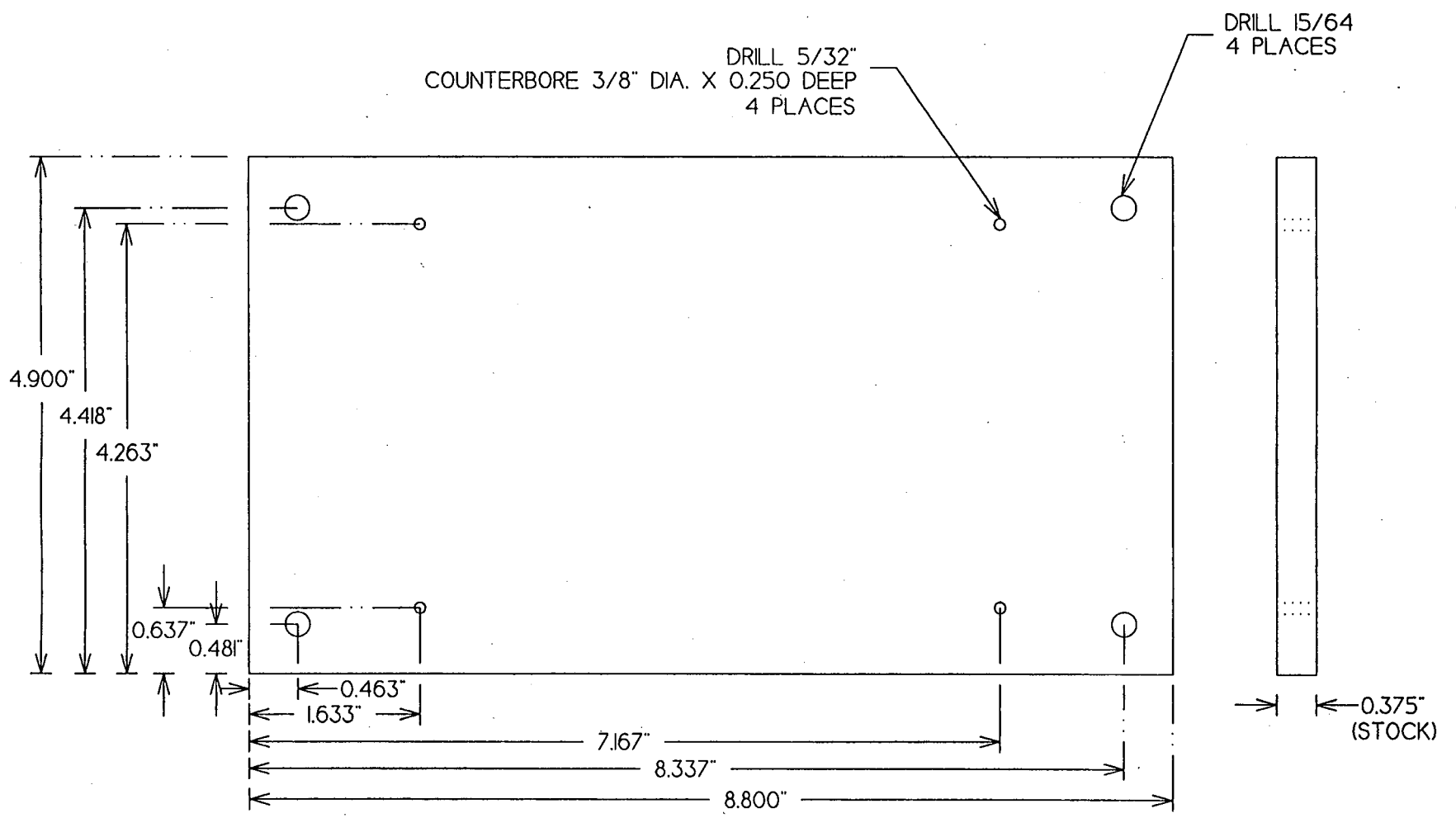


SECTION AA

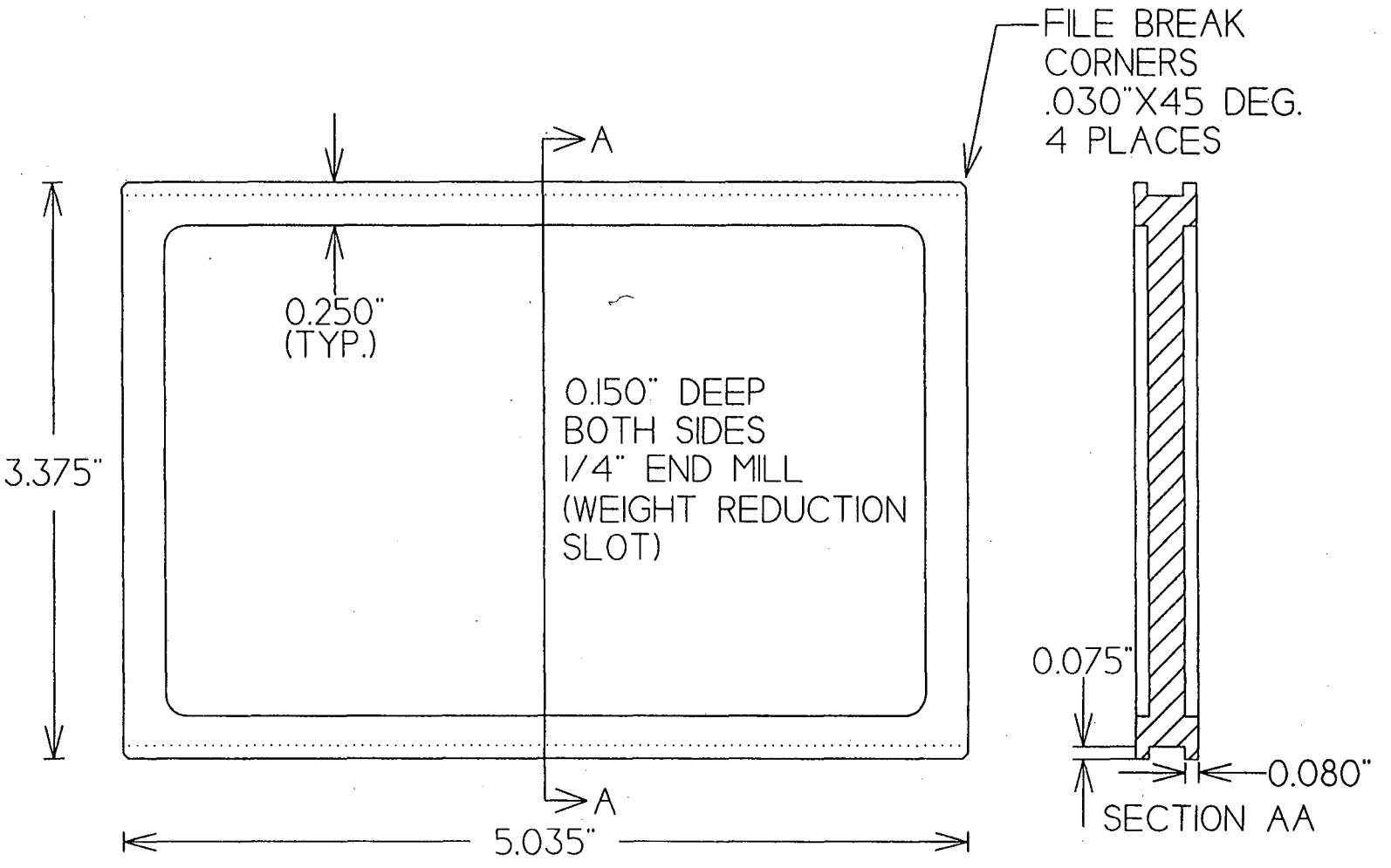
LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: STERILIZER		
COMPONENT NAME: ENCLOSURE		
DWG. TYPE: ORTHOG.	ORIGINAL DATE: 8/10/93	REV. DATE: 8/25/93
DWG. BY: J. HOME III	MATERIAL: ALUMINUM	QUANT.
CHK. BY: W. SEARLES	FILE NAME: SEARLES\BHHOLDTK	



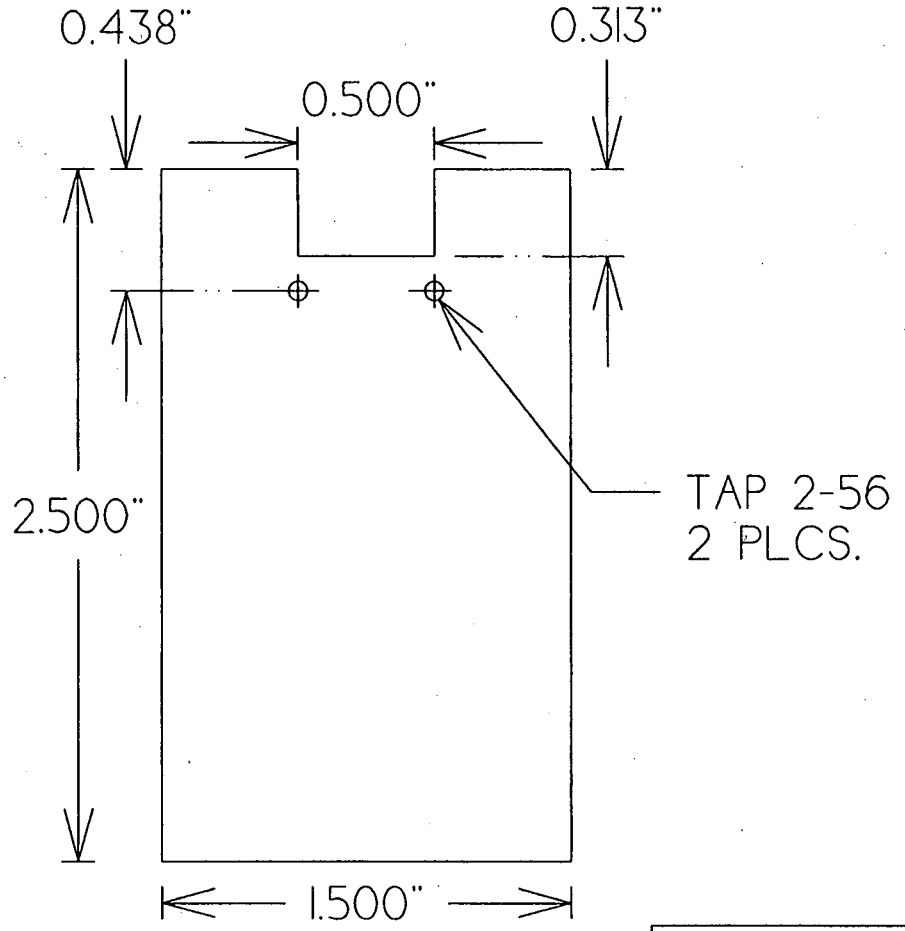
LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP			
PART OF: STERILIZER			
COMPONENT NAME: ENCLOSURE			
DWG. TYPE: ORTHOG.	ORIGINAL DATE: 7/30/93	REV. DATE: 8/25/93	
DWG. BY: J. HOME III	MATERIAL: ALUMINUM	QUANT.: 1	
CHK. BY: W. SEARLES	FILE NAME: SEARLES\BHORTHG3		



LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: STERILIZER		
COMPONENT NAME: BASE PLATE		
DWG. TYPE: MECHANICAL	ORIGINAL DATE: 7/13/93	REV. DATE: 8/25/93
DWG. BY: J. HOME III		
CHK BY: W. SEARLES	FILE NAME: SEARLES\BHBASE	



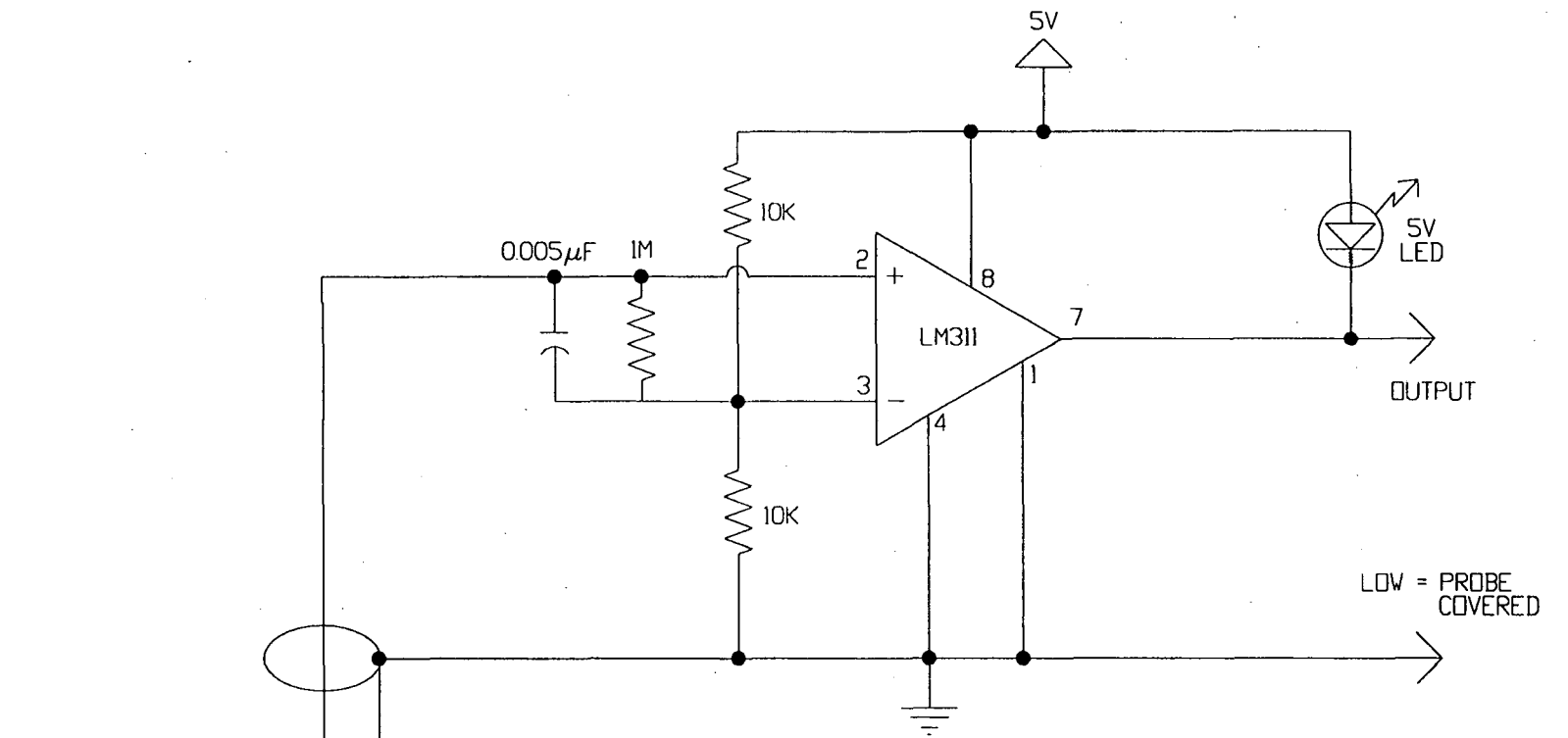
LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: STERILIZER		
COMPONENT NAME: COVER		
DWG. TYPE: MECH	ORIGINAL DATE: 7/15/93	REV. DATE: 8/25/93
DWG. BY: J. HOME III		
CHK. BY: W. SEARLES	FILE NAME: SEARLES\BHCOVER	



LAWRENCE BERKELEY LABORATORY
ENGINEERING DIVISION
HUMAN GENOME INSTRUMENTATION GROUP

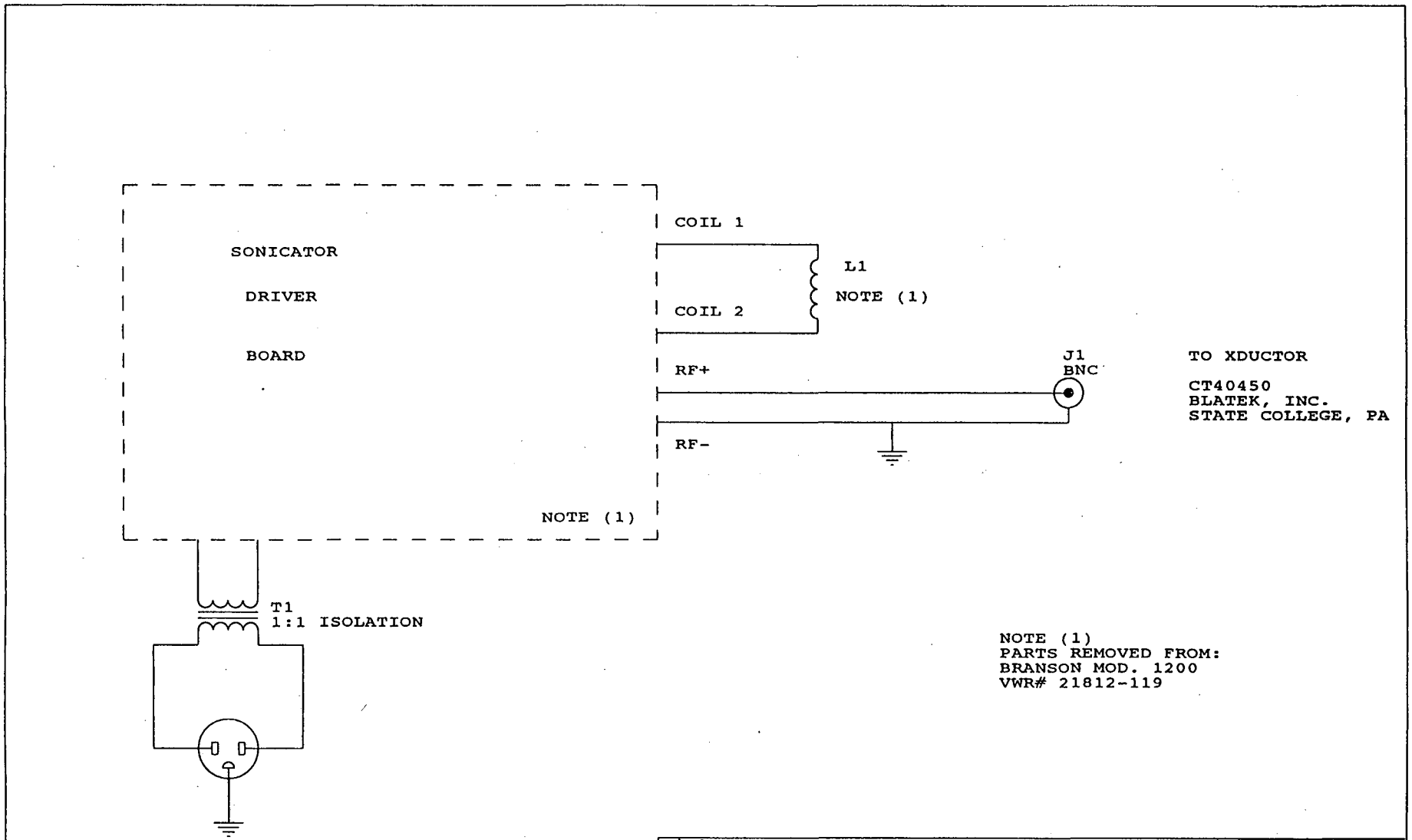
PART OF: STERILE BATH			
COMPONENT NAME: OVER FLOW			
DWG. TYPE: MECH.	ORIGINAL DATE: 7/28/93	REV. DATE	
DWG. BY: J. HOME III	MATERIAL	QUANT.	
CHK. BY: W. SEARLES	FILE NAME: SEARLES/BHOVERFL		

Appendix I: Multipin Tool Sterilizer Bath Level Sensor



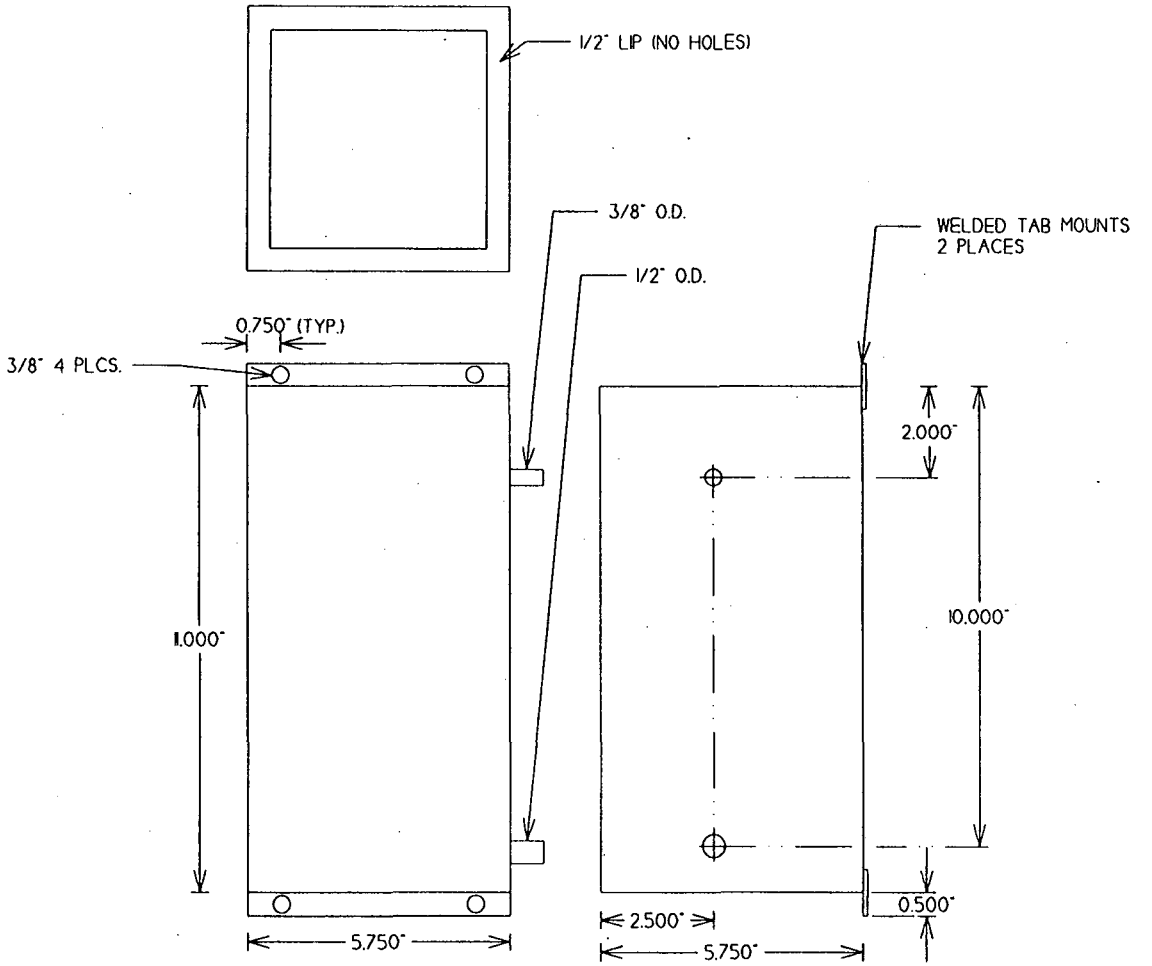
LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: STERILIZER BATH		
COMPONENT NAME: LEVEL SENSOR		
DWG. TYPE: SCHEMATIC	ORIGINAL DATE: 7/27/93	REV. DATE: 7/28/93
DWG. BY: J. HOME III	MATERIAL	QUANT.
CHK. BY: W. SEARLES	FILE NAME: SEARLES/CIRUIT	

Appendix J: Multipin Tool Sterilizer Bath Sonicator Driver



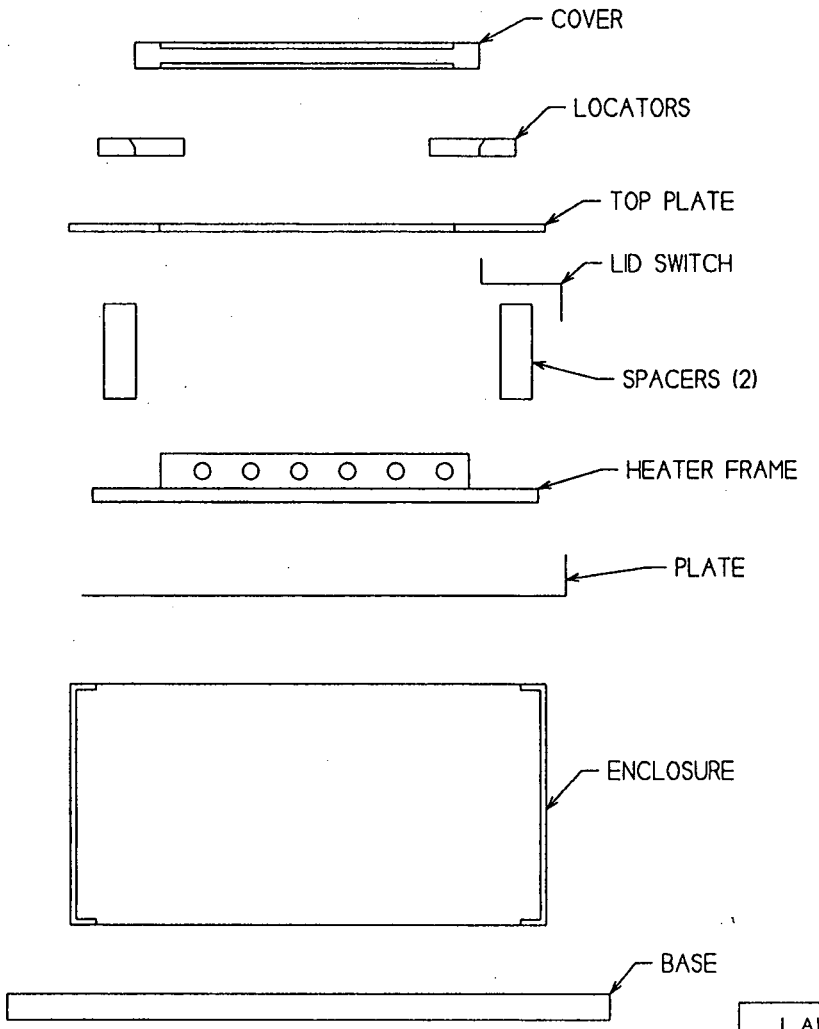
Title	SONICATOR POWER SUPPLY		
Drawn	Date	LAWRENCE BERKELEY LABORATORY UNIVERSITY OF CALIFORNIA ENGINEERING DIVISION SCIENCE DEPARTMENT	
Checked	Date		
Approved	Date		
Engineer		Size A / Document Number	REV
File Name		Date: October 18, 1993 / Sheet of	

Appendix K: Multipin Tool Sterilizer Reservoir



LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: STERILE BATH		
COMPONENT NAME: HOLDING TANK		
DWG. TYPE: MECH.	ORIGINAL DATE: 7/19/93	REV. DATE:
DWG. BY: J. HOME III		
CHK. BY: W. SEARLES	FILE NAME: SEARLES/BHTANK	

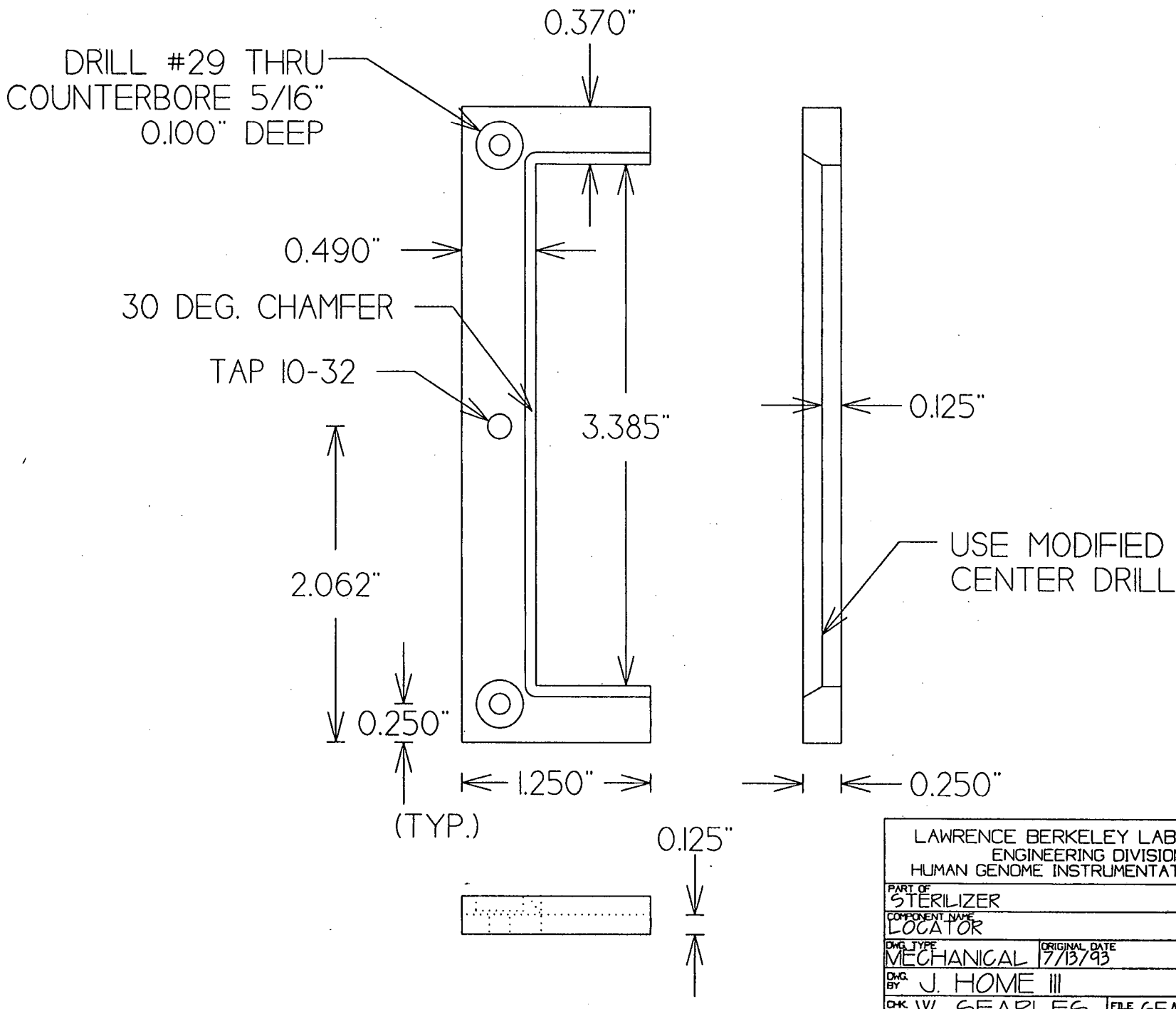
Appendix L: Multipin Tool Sterilizer Heater



LAWRENCE BERKELEY LABORATORY
ENGINEERING DIVISION
HUMAN GENOME INSTRUMENTATION GROUP

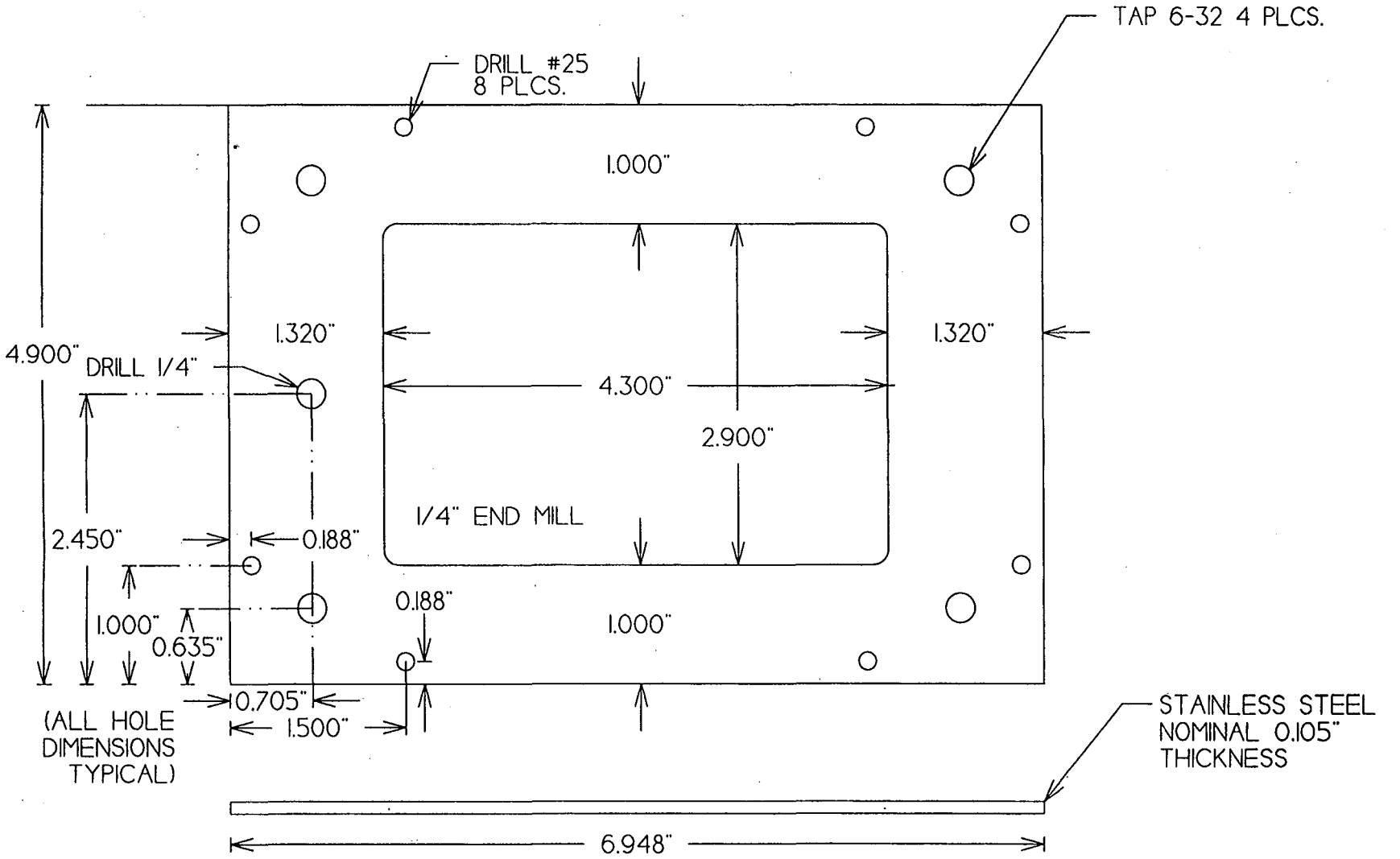
PART OF: MLTITOOL DRYER			
COMPONENT NAME: ASSEMBLY DIAGRAM			
DWG. TYPE: ASSEMBLY	ORIGINAL DATE: 8/1/93	REV. DATE:	
DWG. BY: J. HOME III	MATERIAL:		QUANT.:
CHK. BY: W. SEARLES	FILE NAME: SEARLES/DRASMBLY		

A L. 1.

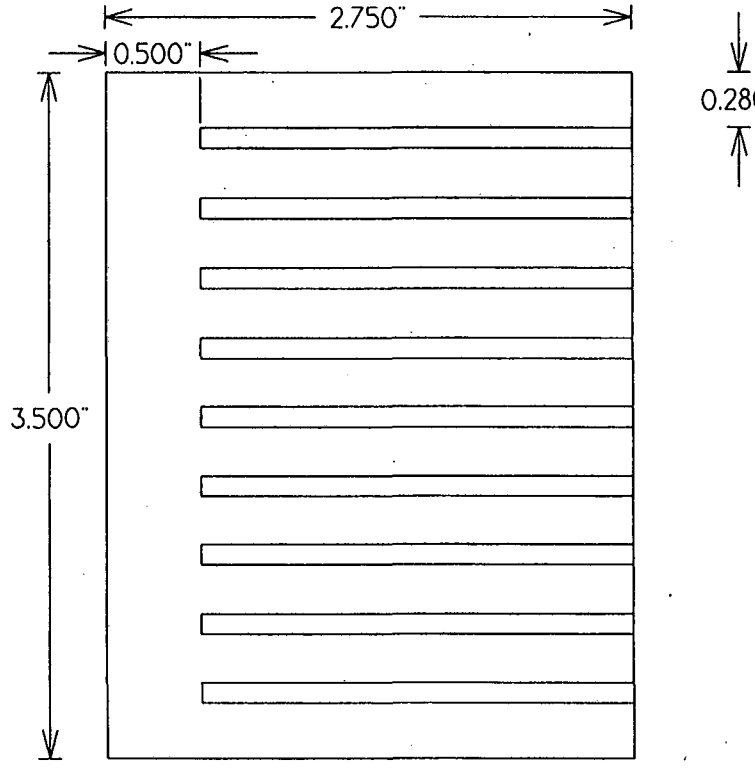


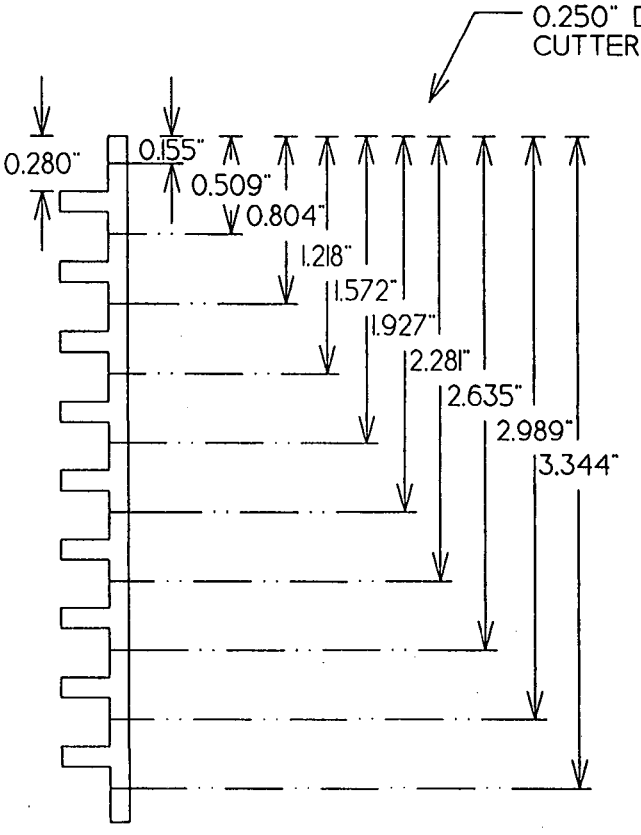
LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: STERILIZER		
COMPONENT NAME: LOCATOR		
DWG. TYPE: MECHANICAL	ORIGINAL DATE: 7/13/93	REV. DATE: 8/25/93
DWG. BY: J. HOME III		
CHK. BY: W. SEARLES	FILE NAME: SEARLES\BHLOCATR	

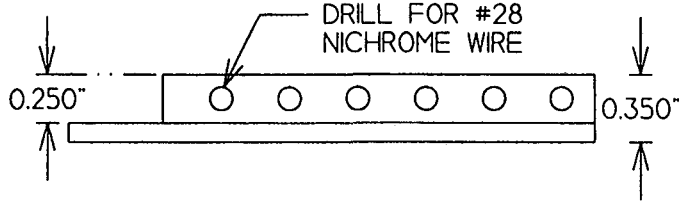
L. 2.



LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: STERILIZER		
COMPONENT NAME: TOP PLATE		
DWG. TYPE: MECH.	ORIGINAL DATE: 7/13/93	REV. DATE: 8/25/93
DWG. BY: J. HOME III		
CHK. BY: W. SEARLES	FILE NAME: SEARLES\BHTOP	

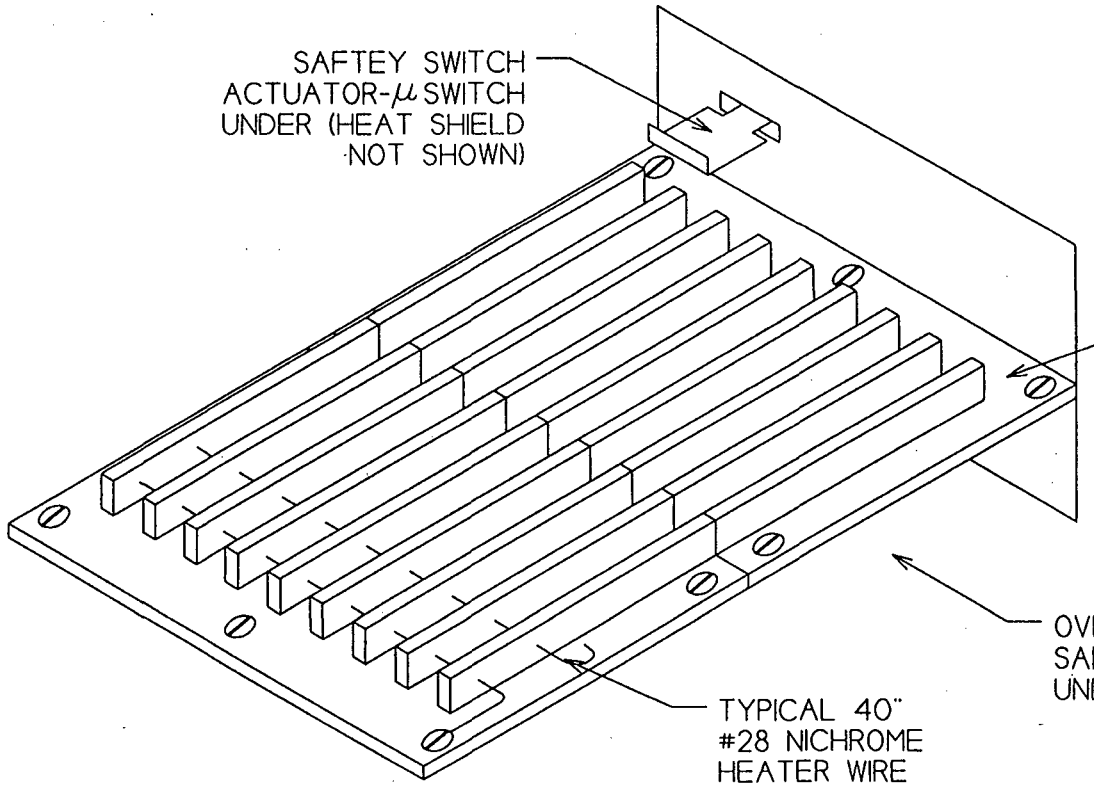




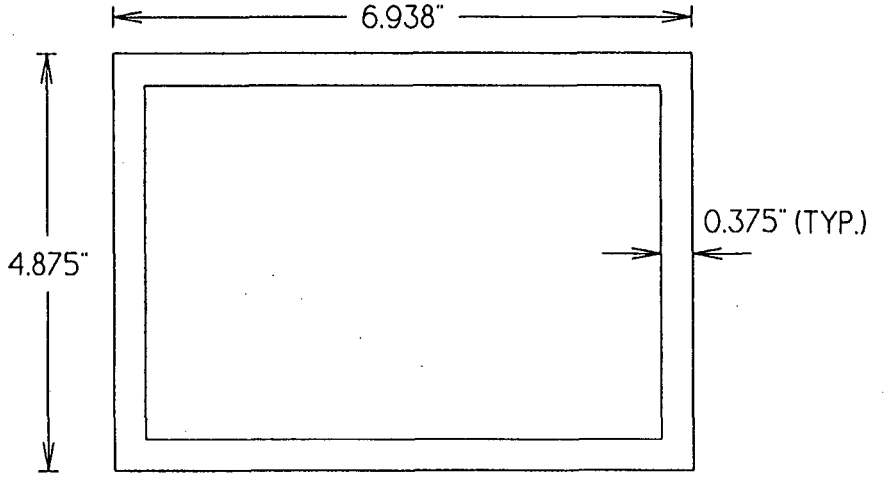


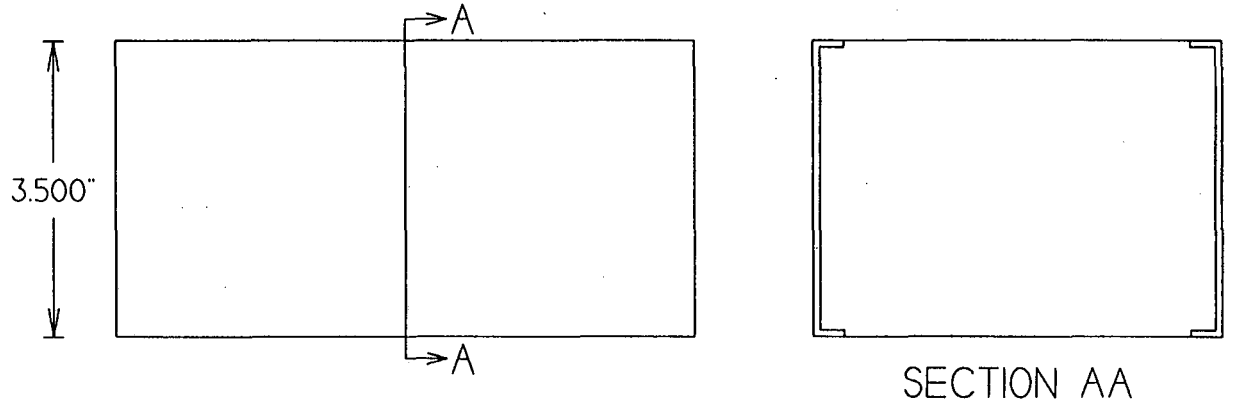
LAWRENCE BERKELEY LABORATORY
ENGINEERING DIVISION
HUMAN GENOME INSTRUMENTATION GROUP

PART OF: STERILE DRYER		
COMPONENT NAME: HEATER FRAME		
DWG. TYPE: MECH.	ORIGINAL DATE: 7/19/93	REV. DATE: 8/25/93
DWG. BY: J. HOME III		
CHK. BY: W. SEARLES	FILE NAME: SEARLES/BHHEATER	



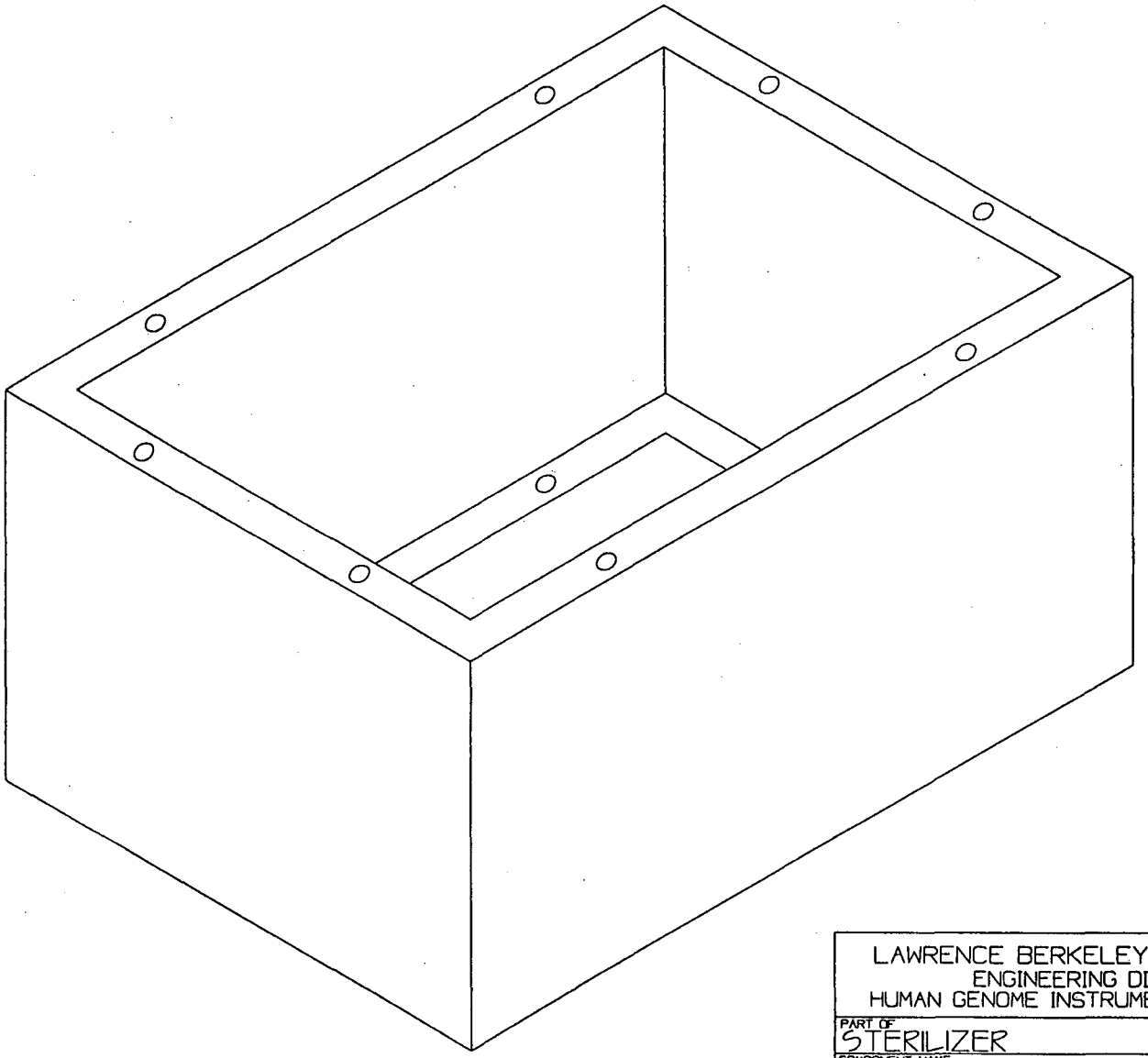
LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: STERILE DRYER		
COMPONENT NAME: HEATING PLATE		
DWG. TYPE: ORTHOGONAL	ORIGINAL DATE: 7/11/93	REV. DATE: 8/25/93
DWG. BY: J. HOME III	MATERIAL	QUANT.
CHK. BY: W. SEARLES	FILE NAME: SEARLES\BHORTHG4	



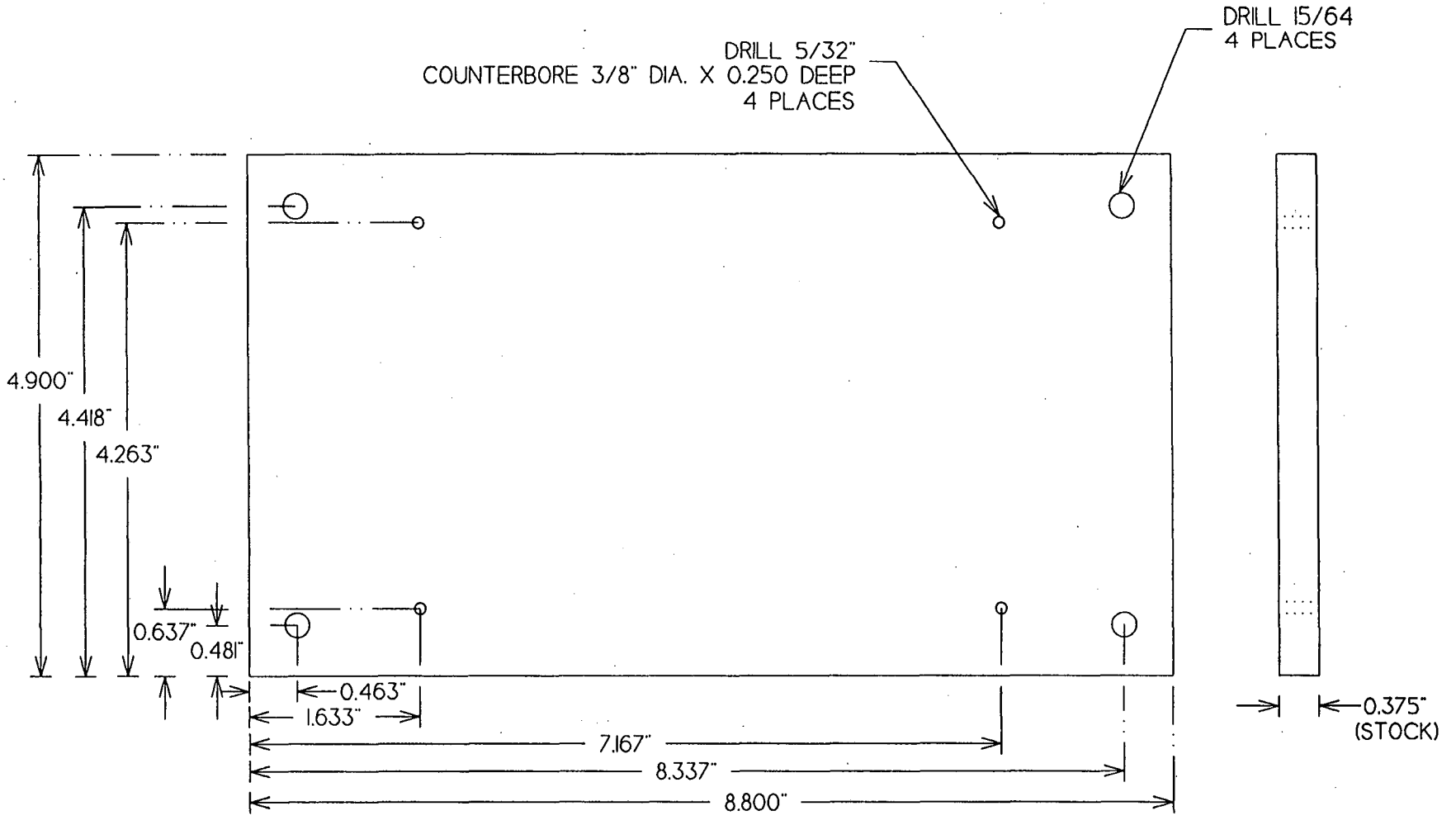


SECTION AA

LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP			
PART OF: STERILIZER			
COMPONENT NAME: ENCLOSURE			
DWG. TYPE: ORTHOG.	ORIGINAL DATE: 8/10/93	REV. DATE: 8/25/93	
DWG. BY: J. HOME III	MATERIAL: ALUMINUM	QUANT.: 1	
CHK BY: W. SEARLES	FILE NAME: SEARLES\BHHOLDTK		



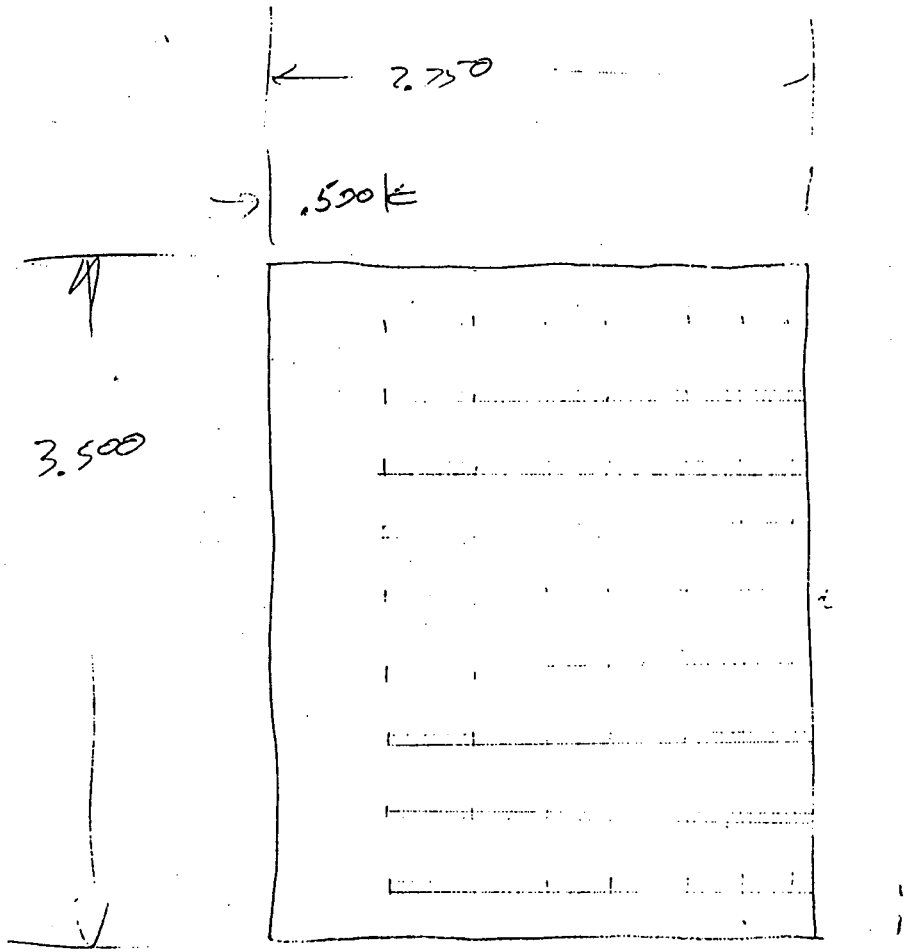
LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: STERILIZER		
COMPONENT NAME: ENCLOSURE		
DWG. TYPE: ORTHOG.	ORIGINAL DATE: 7/30/93	REV. DATE: 8/25/93
DWG. BY: J. HOME III	MATERIAL: ALUMINUM	QUANT.: 1
CHK. BY: W. SEARLES	FILE NAME: SEARLES\BHORTHG3	

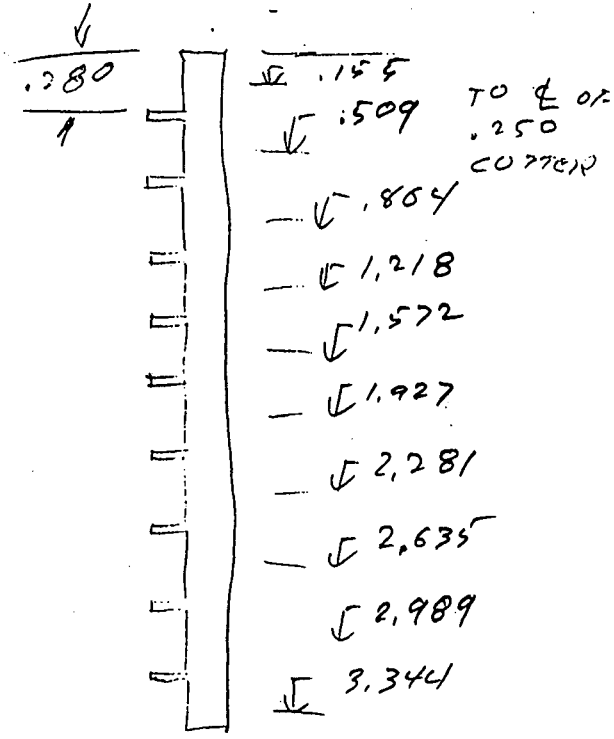


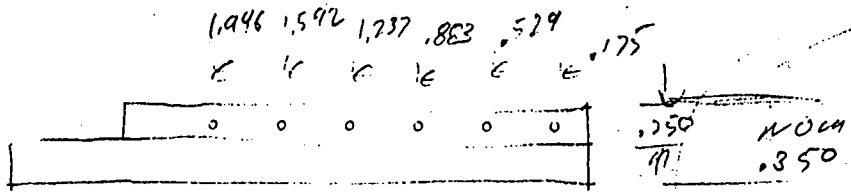
LAWRENCE BERKELEY LABORATORY ENGINEERING DIVISION HUMAN GENOME INSTRUMENTATION GROUP		
PART OF: STERILIZER		
COMPONENT NAME: BASE PLATE		
DWG. TYPE: MECHANICAL	ORIGINAL DATE: 7/13/93	REV. DATE: 8/25/93
DWG. BY: J. HOME III		
CHK. BY: W. SEARLES	FILE NAME: SEARLES\BHBASE	

HEATT

HEATER WIRE GUI



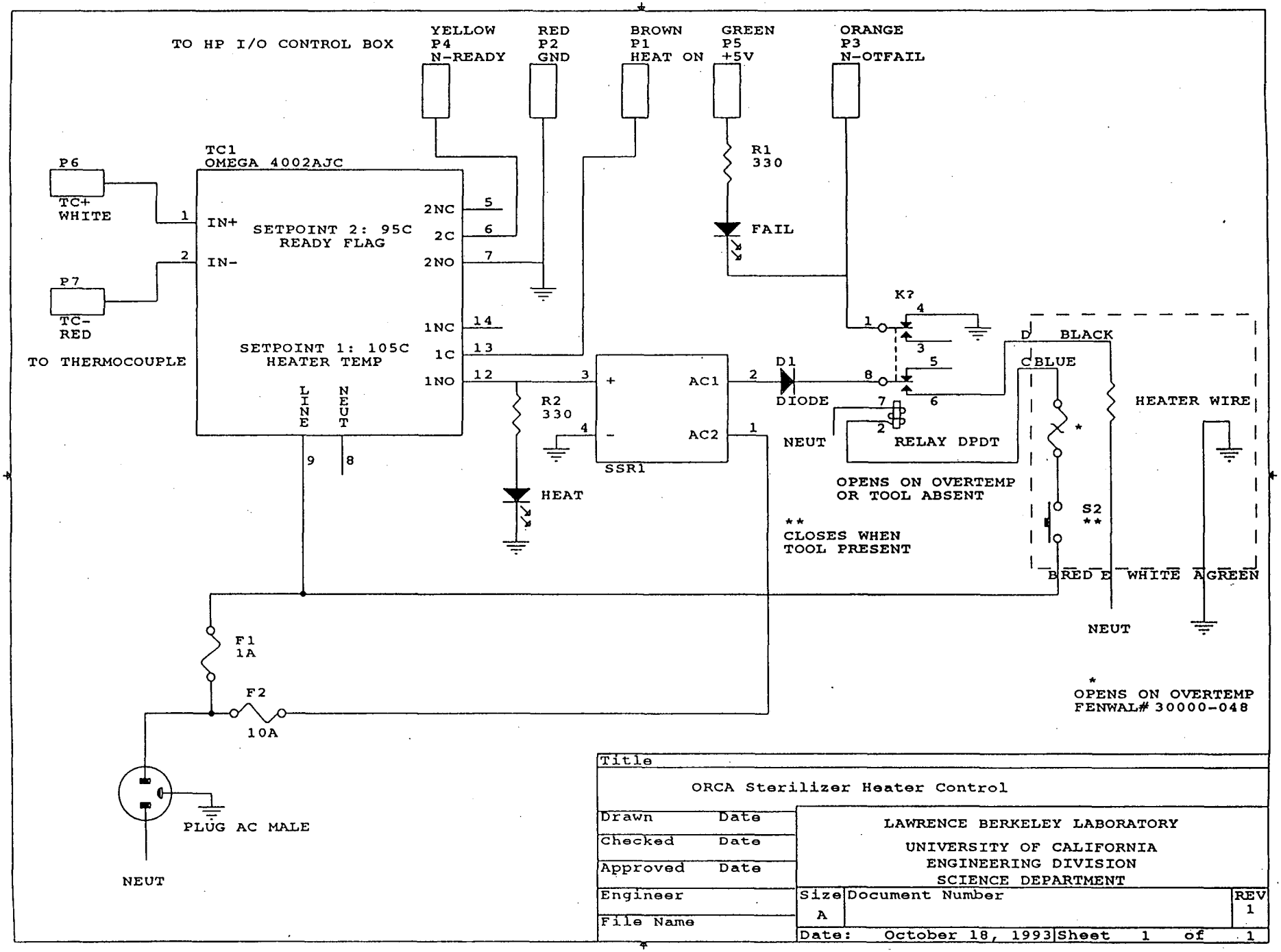




MACHINABLE
CERAMIC
(CAVA "A")

2 PER

Appendix M: Multipin Tool Sterilizer Heater Control

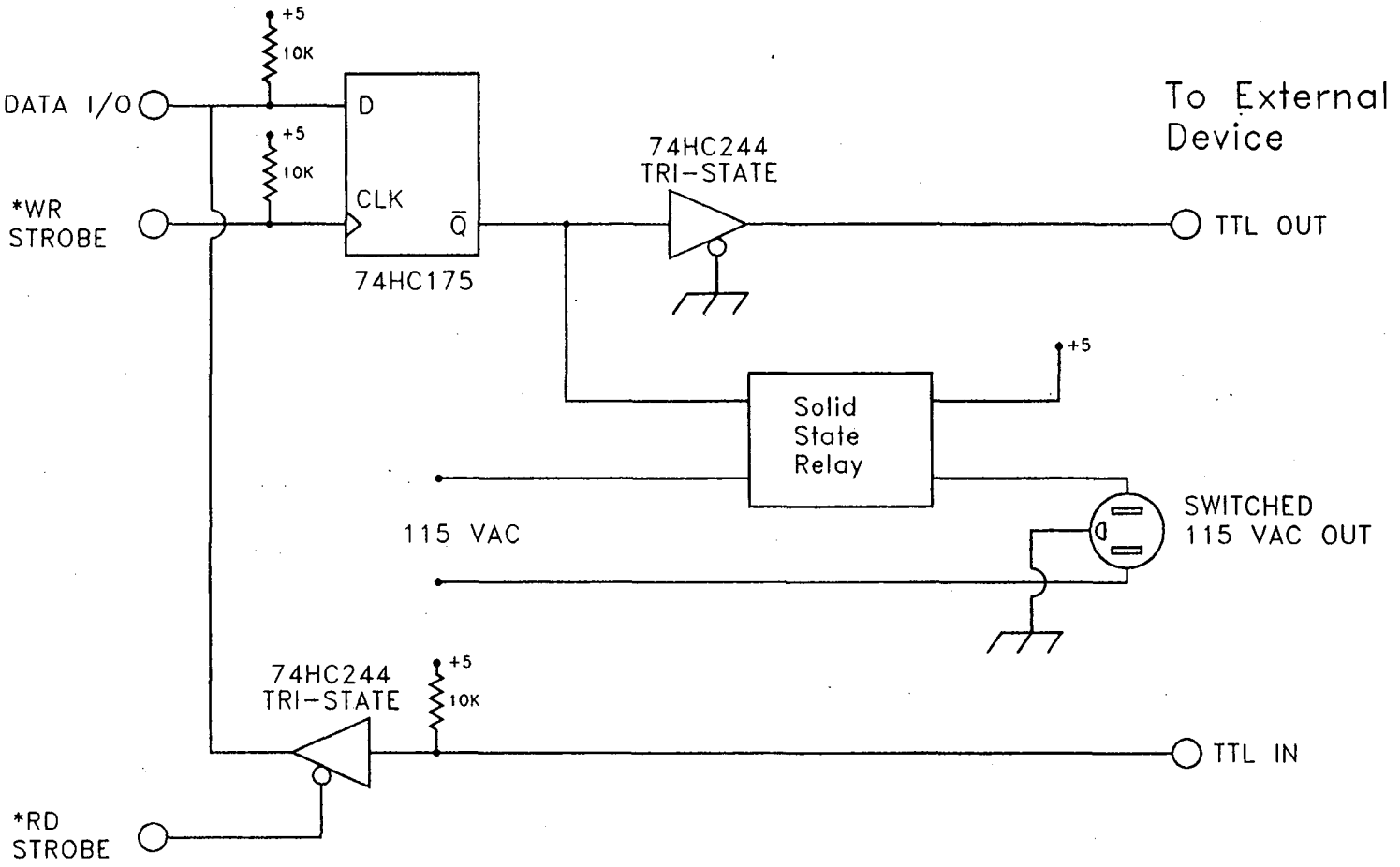

TO HP I/O CONTROL BOX
YELLOW
P4
N-READY
RED
P2
GND
BROWN
P1
HEAT ON
GREEN
P5
+5V
ORANGE
P3
N-OTFAIL
TC1
OMEGA 4002AJC
P6
TC+
WHITE
P7
TC-
RED
TO THERMOCOUPLE
IN+
IN-
SETPOINT 2: 95C
READY FLAG
SETPOINT 1: 105C
HEATER TEMP
2NC
2C
2NO
1NC
1C
1NO
LINE
NEUT
R1
330
FAIL
K?
R2
330
HEAT
SSR1
AC1
AC2
D1
DIODE
NEUT
RELAY DPDT
OPENS ON OVERTEMP
OR TOOL ABSENT
** CLOSES WHEN
TOOL PRESENT
D BLACK
C BLUE
HEATER WIRE
S2
**
B RED E WHITE A GREEN
NEUT
* OPENS ON OVERTEMP
FENWAL# 30000-048
F1
1A
F2
10A
PLUG AC MALE
NEUT
Title
ORCA Sterilizer Heater Control
Drawn Date
Checked Date
Approved Date
Engineer
File Name
LAWRENCE BERKELEY LABORATORY
UNIVERSITY OF CALIFORNIA
ENGINEERING DIVISION
SCIENCE DEPARTMENT
Size A
Document Number
REV 1
Date: October 18, 1993
Sheet 1 of 1

Appendix N: I/O Control Box (1 Of 8 Bits)

ORCA I/O CONTROL BOX

1 of 8 bits

From H-P 3488A
44474A Card



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