HA-2203

Progress Report No. 4

RESEARCH PROGRAM TO DEVELOP A TECHNOLOGY IMPROVEMENT PROGRAM FOR CLOSED DIE FORGING

Contract Number NAS8-20093
Control Nr. DCN 1-5-30-12531(1F)

December 1965

For

George C. Marshall Space Flight Center
National Aeronautics and Space Administration
Huntsville, Alabama

Prepared by: J. R. Long

Reviewed by: L. W. Davis

Approved by: P. E. Anderson

By

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Copy No. 10

FOREWORD

This report was prepared by Harvey Engineering Laboratories for Research and Development, a division of HARVEY ALUMINUM (Incorporated), under Contract Number NAS8-20093, Control Number DCN-1-5-30-12531 (1F), for the George C. Marshall Space Flight Center of the National Aeronautics and Space Administration. The work was administered under the technical direction of Mr. Charles N. Irvine, Manufacturing Engineering Laboratory, as the Contracting Officer's authorized representative during the administration of this contract.

ABSTRACT

15822

The objective of this project is to develop advanced die forging techniques that are applicable to producing more sophisticated and closer toleranced shapes from high strength space material such as 7075 aluminum alloy, 8Al-1Mo-1V titanium alloy, and maraging steel.

This report covers the period of September through November, 1965. It presents and discusses the drawings for the dies designed for this project and also discusses a series of preliminary test runs made on flat dies with aluminum alloy 7075.

Author

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LIST OF ILLUSTRATIONS

I. DESCRIPTION OF FORGING DIES

A. Flat Dies for Aluminum Forging

These dies are shown in Drawing 20-09301. As noted in previous reports, the dies were designed as simply as possible and with the thought that they could be easily moved in and out of the forging press. The working face was made 12 in. x 12 in. to provide ample pressing area. The thickness was made 4 in. to provide a high heat capacity so that they could be heated in a furnace adjacent to the press and would not cool too rapidly on transfer from the furnace to the press (actual trials indicate that they can be removed from the furnace and mounted in the press in a matter of two to three minutes with very little loss in temperature). A thermocouple well is provided to measure the die temperature 1/2-inch below the center of the working face. The arrangement for holding the dies in the press is indicated in the drawing. It allows the dies to easily be dropped in place and locked by a simple tapered key. Dismounting is equally simple. The dies are made of prehardened die steel normally used for forging aluminum and will be operated in the range of 400 to 900°F.

These dies are completed and have been used for a number of forging trials as indicated in Section III. Their performance indicates that they will suit the purposes of the project.

B. Flat Die for Titanium and Maraging Steel (Drawing No. 20-09302)

Because of the higher forging temperature used for titanium and maraging steels, the dies for these have been designed in Inconel 713 C. This alloy is capable of operating in the temperature range of 1600 to 1900°F without excessive softening or oxidation. It is available only as a casting and is generally prepared as an investment type casting using vacuum melting techniques. These factors place limitations on the size and weight of single pieces available. To meet these limitations, the design used for the aluminum forging dies was modified as shown in the referenced drawing. In this design, the weight was reduced by making the working face 8-1/2 inches in diameter and providing slots in the base. However, the slots were later omitted when the supplier found that he could handle more weight than originally estimated. For economy, and for speed and ease in mounting the dies in the press, the base was made to fit the same holder used for the low temperature die.

These Inconel 713 dies are currently being made. One die has been received and found to be sound as cast; i.e., free of shrink and gas cavities when checked by X-Ray. In solidification of this piece, a slight concavity developed in the working face, and an X-Ray inspection was made to be sure there were no shrink cavities under the working face. This die is now undergoing machining operations to smooth the face and provide for fit in the holders.

In passing, it should be noted that this is the heaviest piece to be cast in Inconel 713 by the supplier. It weighs 91 lbs. It is also the thickest section (4 inches) that has been cast. The alloy is normally produced in thin castings, generally under 1/2-inch thick and about 80 pounds maximum weight. The vacuum melt equipment and characteristics of the alloy and the investment process usually limit the total melt weight to 175 pounds. About 50 percent of this weight is required for gating and risers. In this case, the simplicity of the shape made it possible to use a greater portion of the metal for the casting.

The second die is expected to be shipped in three weeks. It will also be inspected for soundness before machining.

C. <u>Cupping Dies</u> (Drawing 20-09303)

These dies are intended for making cup type forgings with wall thicknesses varying from 0.100 to 0.250-inch. For purpose of making a comparison of the relative effects of wall thickness variation, the starting slug size is kept constant, and the wall variation is obtained by the changing punches. Both the punch and the cylinder inserts are designed for quick and simple placement. Like the flat dies, they will be heated in a furnace adjacent to the press and will be quickly transferred and positioned for use in as short a time as possible so that the loss in temperature will be at a minimum. The temperature of the die parts, at the time of forging, will be monitored through use of thermocouples that will be inserted through holes that are not at this time indicated on the drawings.

Sheet 1 of Drawing 20-09303 is an assembly drawing of the complete die. It is shown in two positions; that is, with press closed and the cup as formed on the punch and with the press open and the cup stripped off the punch. The active die parts to be heated are outlined in red and are shown in detail on Sheet 3. For the forging of aluminum, these parts are made of pre-hardened die steel and for the forging of titanium and steel, they are made of Inconel 713C. Machining of the die holders and punches and insert of die steel are about 75% completed. The Inconel 713C parts are being cast and are expected to be delivered the first week of December.

II. PRESSURE MEASUREMENT

The press used in this project is a 500-ton hydraulic press with a normal hydraulic line pressure of about 2500 psi. To measure this pressure and obtain a record of the actual pressure used under the various forging conditions, a BLH pressure cell, with a 5000 psi capacity, has been inserted in the hydraulic gauge line. While this pressure can be obtained from a dial gauge on the press, the response of this gauge is slow,and oscillation of the needle in response to pressure surges makes it difficult to obtain accurate readings. In contrast, the pressure cell provides a means of recording the pressure which can then be read easily after the forging is completed.

The output from the pressure cell is recorded on an Offner Dynograph Amplifier Recorder. This recorder, and the pressure cell, have been calibrated in a standard hydraulic pressure testing system. The standardization data are given in Table I and are plotted in Figure 1.

Table I. Calibration of Pressure Cell and Recording System

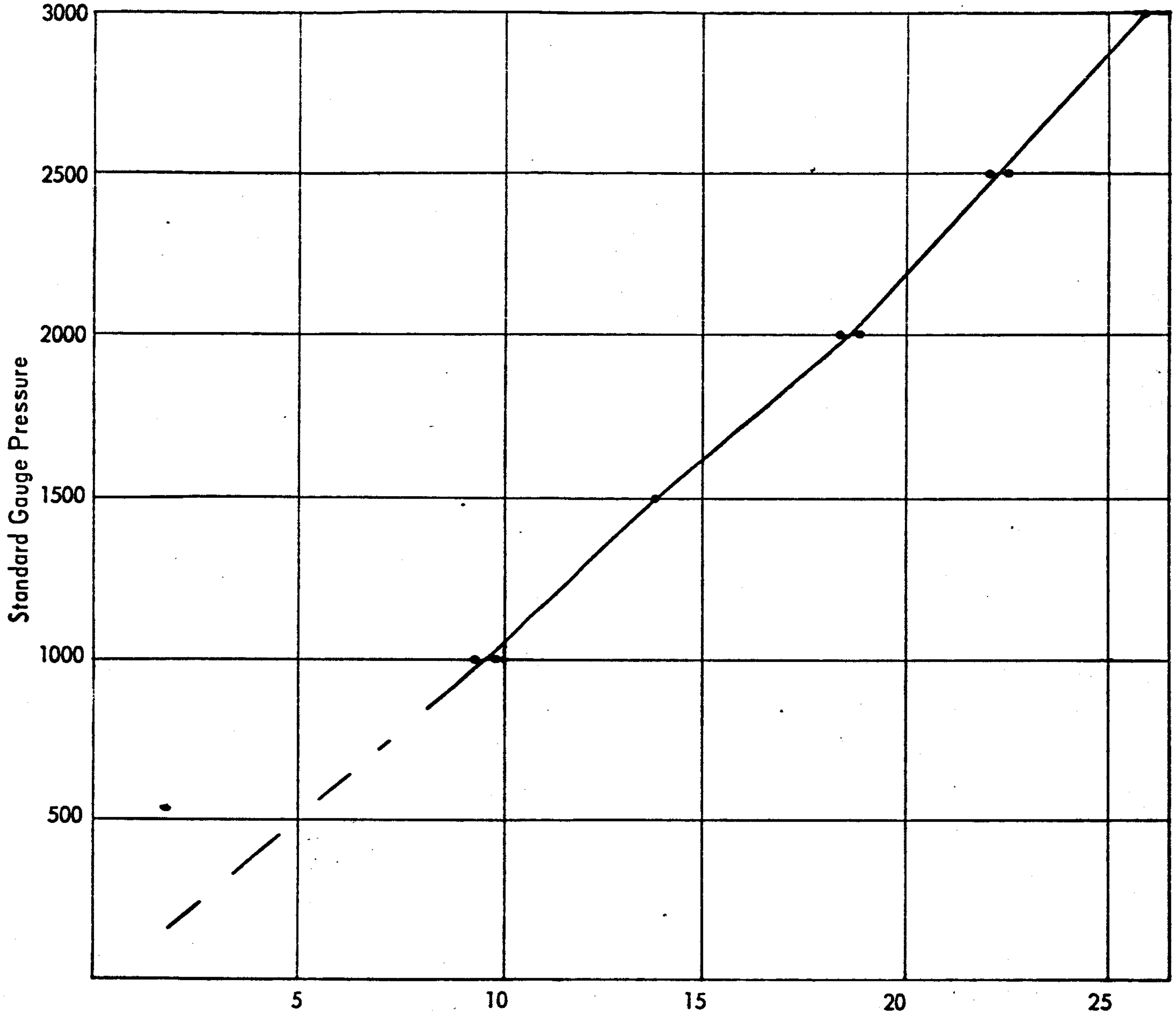
Standard Gauge Pressure (psi)	Graduation of Recorder Graph
1000	9.5
1500	14.0
2000	19.0
2500	22.5
3000	26.0
2500	22.0
2000	18.5
1500	14.0
1000	10.0

III. PRELIMINARY FORGING TESTS

A series of preliminary forging tests have been conducted on the 7075 aluminum alloy. These were intended as a tryout for heating and handling of the dies, temperature changes of the dies over short periods, and as a general check of the pressure recording system. The data collected during these tests are shown in Table II and in Figures 1, 2, and 3.

These tests showed that the dies could be transferred from the heating furnace and could be locked in place, in the press, in three to four minutes. This time is short enough to hold the loss of temperature to a few degrees before start of forging. Change of temperature during forging, due to loss of heat to the press and to the atmosphere between forgings, is much more significant. However, the forgings can be run in less than one minute-per-piece with temperature changes of only 5 to 10 degrees between forgings. This is illustrated in Figure 2 which is a rough plot of Test 3.

Figure 3 is a rough plot of some of the data in Table II. It shows the pressure in tons/square inch plotted against die temperature. Group One tests were run with no lubrication on the dies and about 23 tons/sq.in. was required. Group Two tests were run with Aqua-Dag swabbed on the dies and they show less of a temperature effect than expected. This is believed to be due to the increasing effectiveness of the lubricant as the temperature decreases. That is, the Aqua-Dag adhered to the die better at the lower temperature, and therefore obscured the effect of die temperature. Group Three tests, in which the Aqua-Dag was sprayed on (thus covering the die more effectively), shows the same general trend; and, because of the better application, lower pressures were required. In Group Four, graphite in an oil base with kerosene as a carrier was used. These tests required still lower pressures but again showed only minor temperature effects. This is also believed to be due to better adherence of the lubricant at the lower temperature of application.



Scale Graduations

Figure 1. Calibration of Pressure Recording System

Table II. Preliminary Forging Test Data
Upset Forging 7075 Aluminum Alloy

Test	Sample	Stock Temp.	Die Temp.	Pressure	Load on Ram	Forged Specimen			Comment
						Thickness	Area	Unit Load	
1	1	800	685	2280	515	.218	-	-	No lube
	2	"	665	2250	510	.218	22.2	23.0	"
	3	"	650	2300	520	.222	22.6	23.0	"
	4	"	645	2280	515	.215	23.6	22.2	"
2-1	1	800	705	2160	490	.175	28.2	17.4	Aqua-Dag
	2	"	680	"	"	.179	26.5	18.5	Swab
	3	"	755	"	"	.200	24.5	20.0	"
2-2	4	800	585	2160	490	.218	22.8	21.5	Aqua-Dag
	5	"	565	"	"	.218	22.8	21.5	Swab
	6	"	560	"	"	.220	22.6	21.7	"
2-3	7	800	495	2160	490	.220	22.7	21.6	Aqua-Dag
	8	"	485	"	"	.212	23.4	21.0	Swab
	9	"	475	"	"	.208	23.9	20.5	"
3-1	1	800	685	2150	488	.156	30.9	15.9	Aqua-Dag
	2	"	660	"	"	.168	29.0	16.9	Spray
	3	"	645	"	"	.166	28.8	17.0	"
3-2	4	800	600	2150	488	.165	29.6	16.5	Aqua-Dag
	5	"	585	"	"	.167	27.8	17.6	Spray
	6	"	655	"	"	.167	27.3	18.0	"
3-3	7	800	510	2150	488	.171	28.5	17.2	Aqua-Dag
	8	"	505	"	"	.168	29.2	16.8	Spray
	9	"	495	"	"	.165	29.7	16.5	"
	10	"	490	"	"	.170	28.8	17.0	"
4-1	1	800	630	2210	501	.144	34.4	14.6	Oil-Dag
	2	"	610	"	"	.135	36.2	13.8	Spray
	3	"	610	"	"	.136	35.9	13.9	"
	4	"	595	2260	510	.134	37.5	13.6	"
	5	"	580	2210	501	.146	33.7	14.9	"
4-2	6	800	515	2260	510	.157	32.2	15.6	Oil-Dag
	7	"	510	2210	501	.155	31.5	15.9	Spray
	8	"	505	2260	510	.163	39.6	17.2	"
	9	"	505	2260	510	.151	32.1	15.9	"
	10	"	500	2260	510	.163	30.5	16.7	"

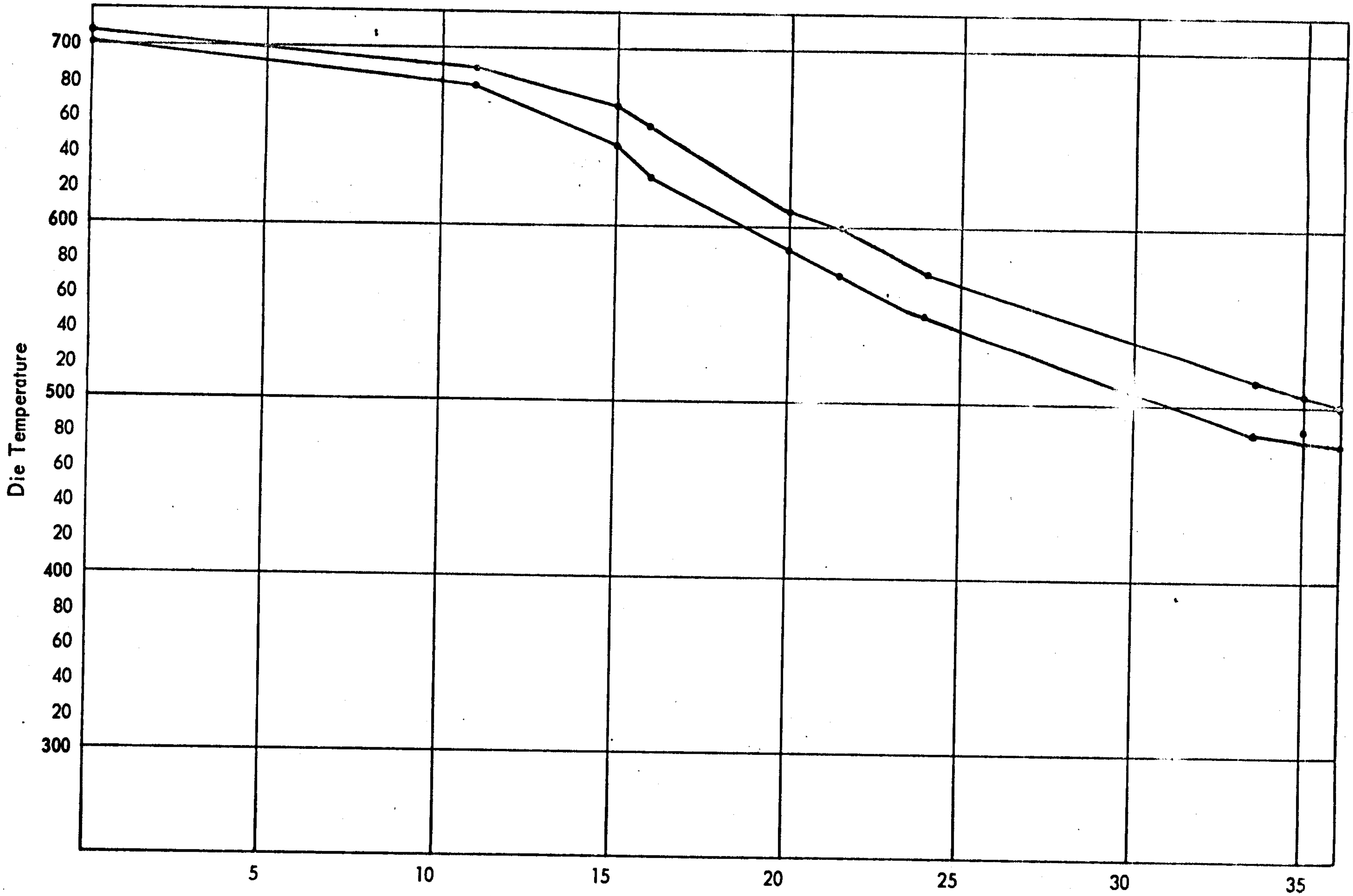


Figure 2. Run 3 – Aqua-Dag, Spray

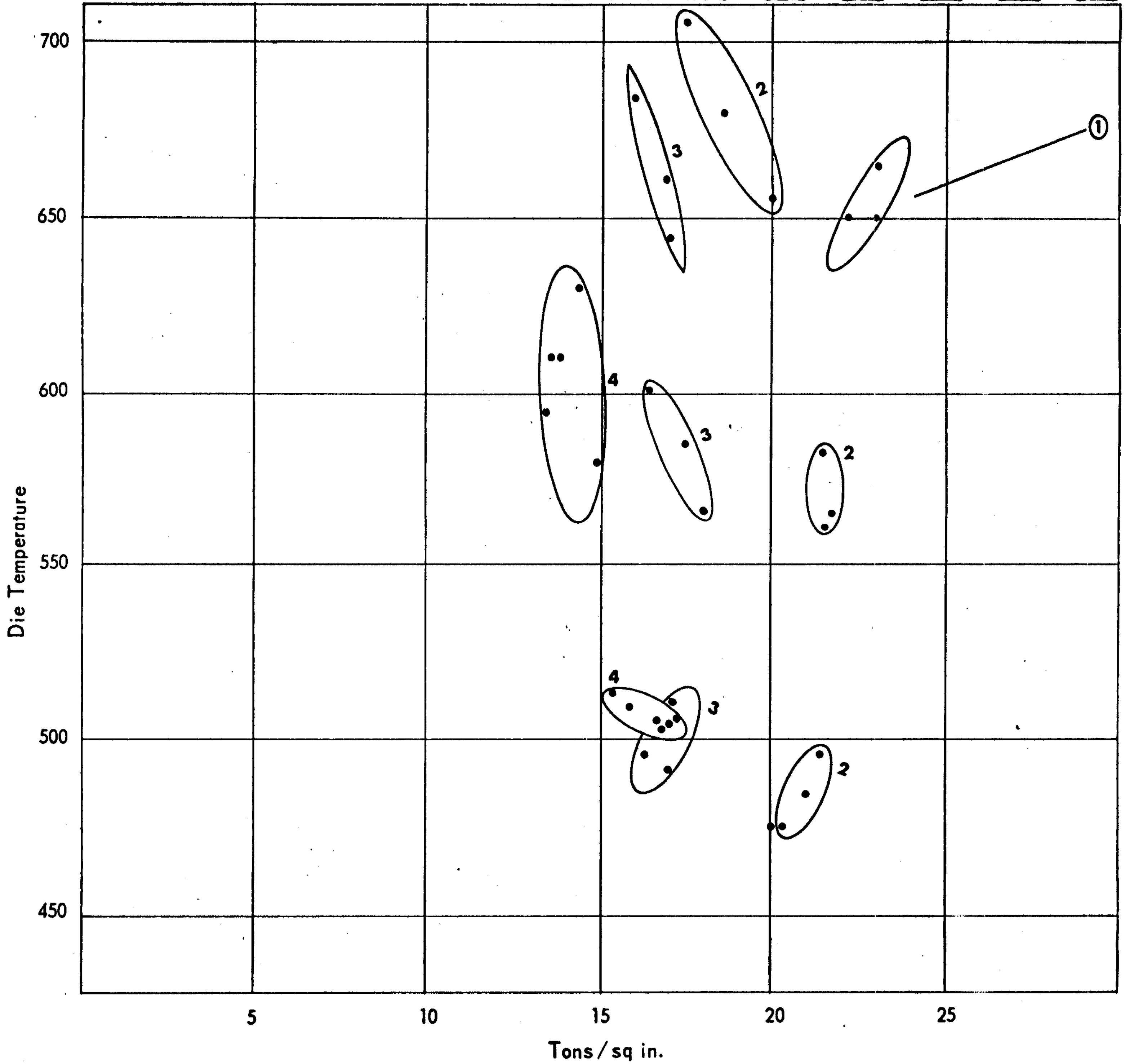


Figure 3. Die Temperature vs. Pressure

IV. WORK PROJECTED FOR NEXT PERIOD

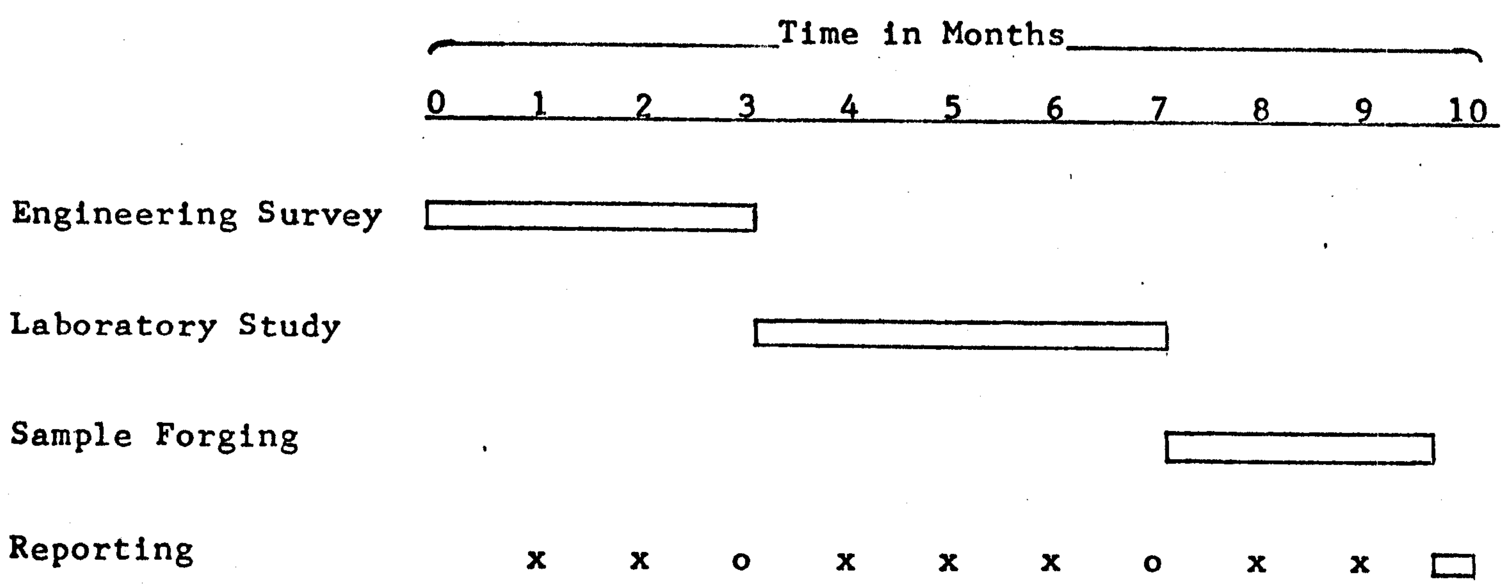
During the forthcoming period, forging tests for aluminum alloy 7075 will be continued, and machine work on the flat dies for titanium and maraging steel will be continued.

Machine work on the cupping dies will also be continued.

V. PROGRAM PLAN

The program schedule for this project is presented on the following page.

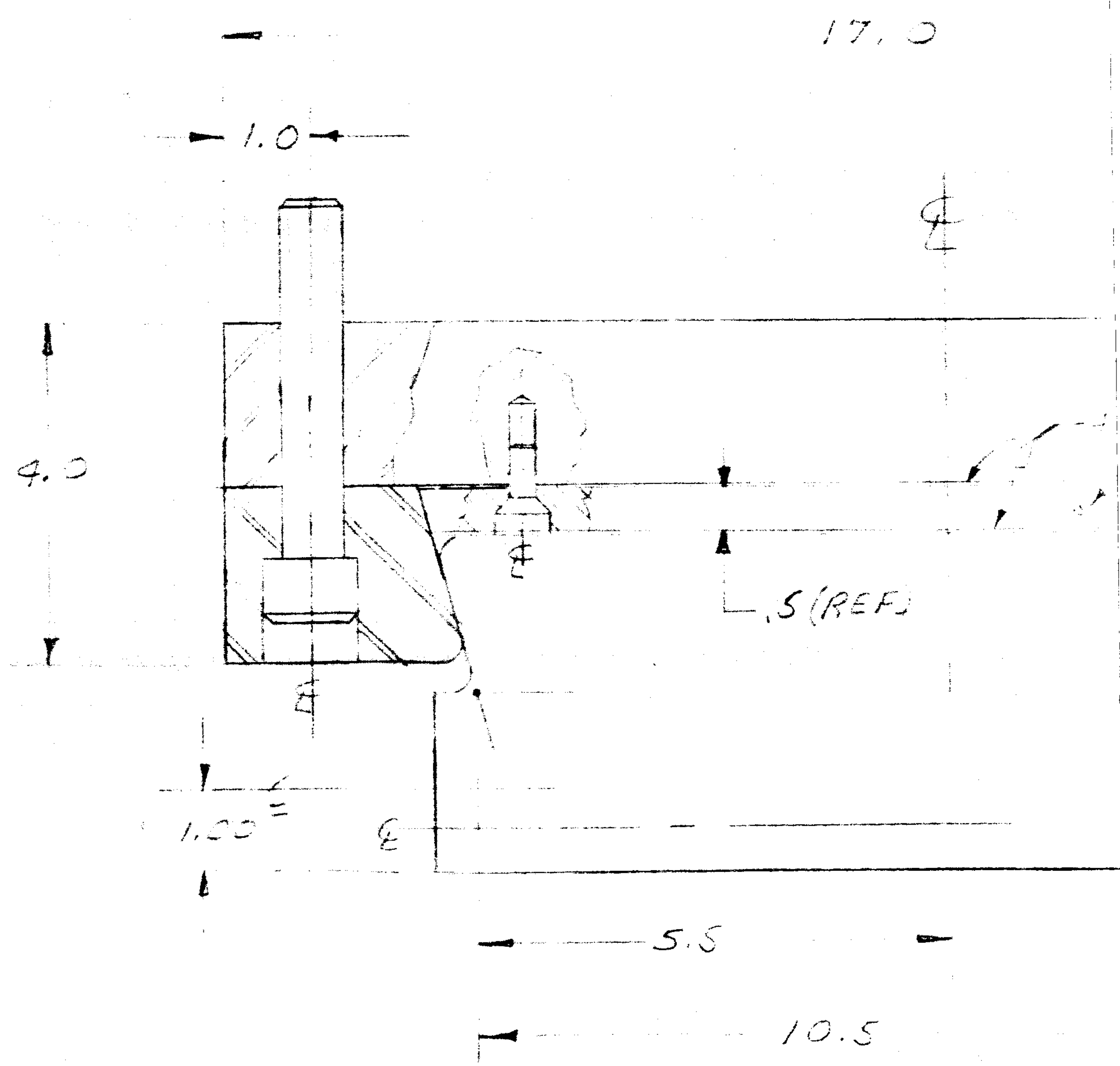
PROGRAM SCHEDULE



Monthly progress reports - x
Phase reports - o
Final report - □

APPENDIX

Drawing No.	Chg.	Dated	Title
20-09301	D	12-8-65	Die-Forging
20-09302	A	10-4-65	Die Forging (Use with 20-09301)
20-09303	A	11-14-65	
Sht 1 of 4			Cupping Die
Sht 3 of 4			Cupping Die Details
20-09304	Orig	9-23-65	Forging Slug



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4.0
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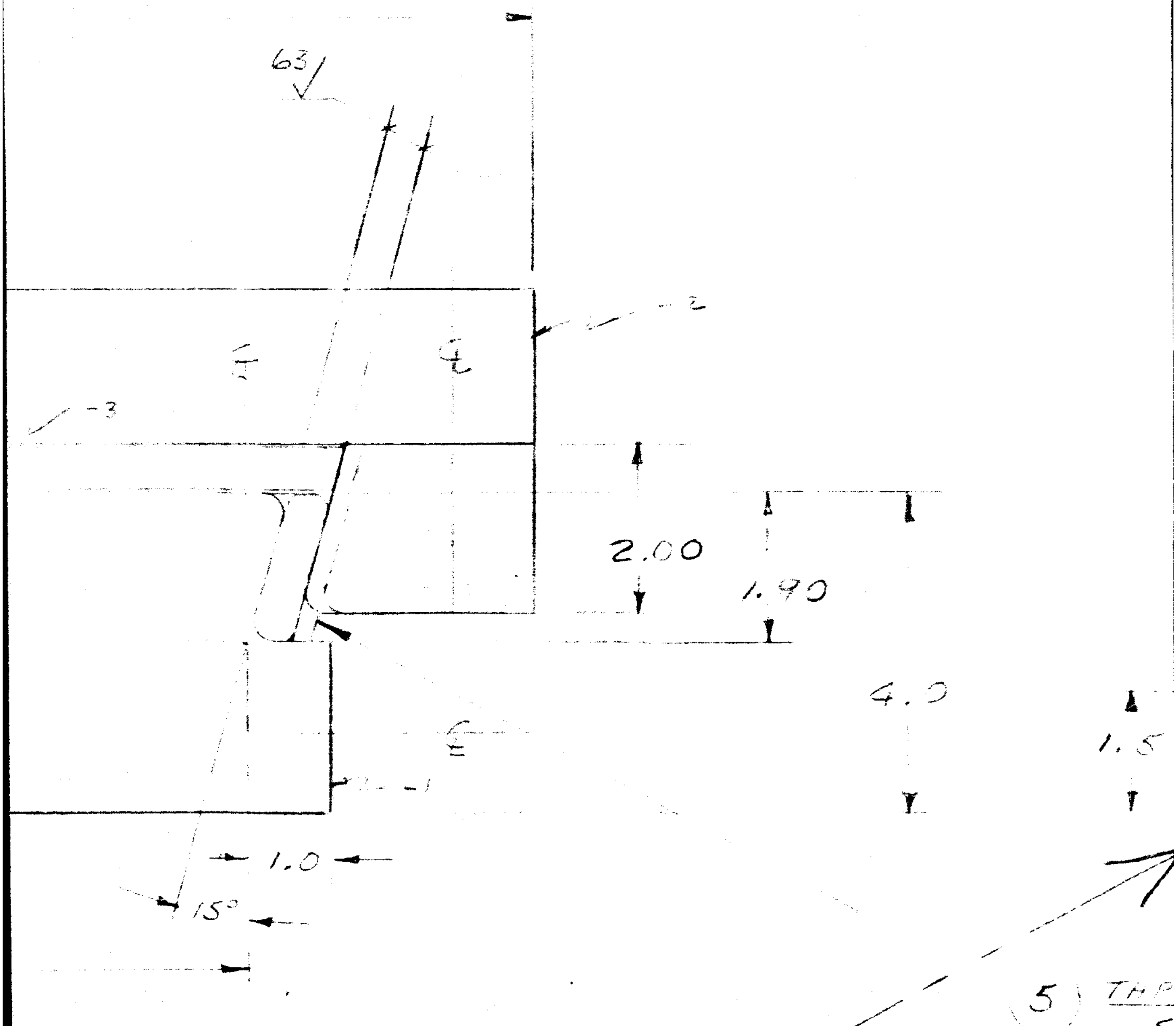
1.00
5.5
10.5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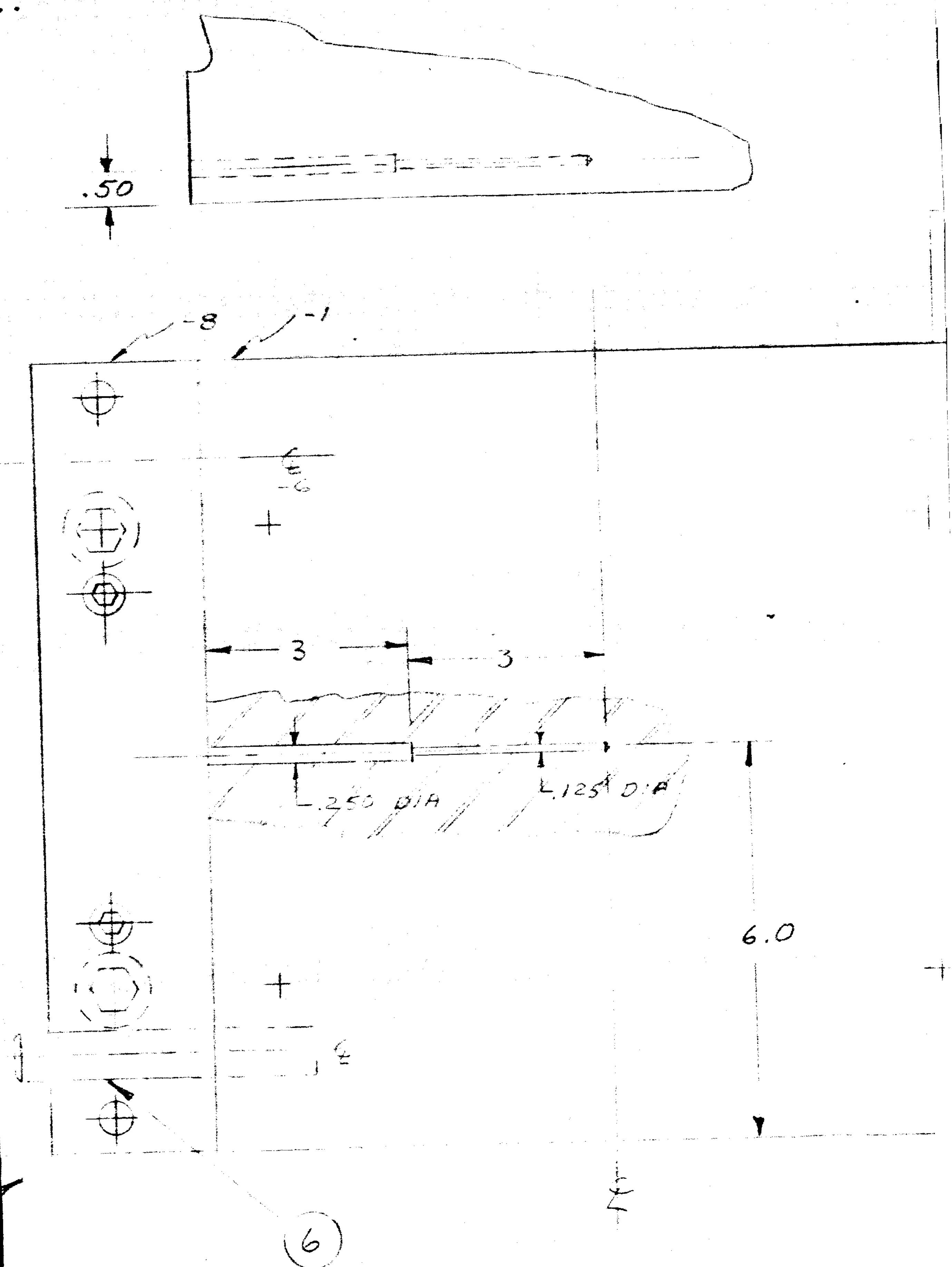
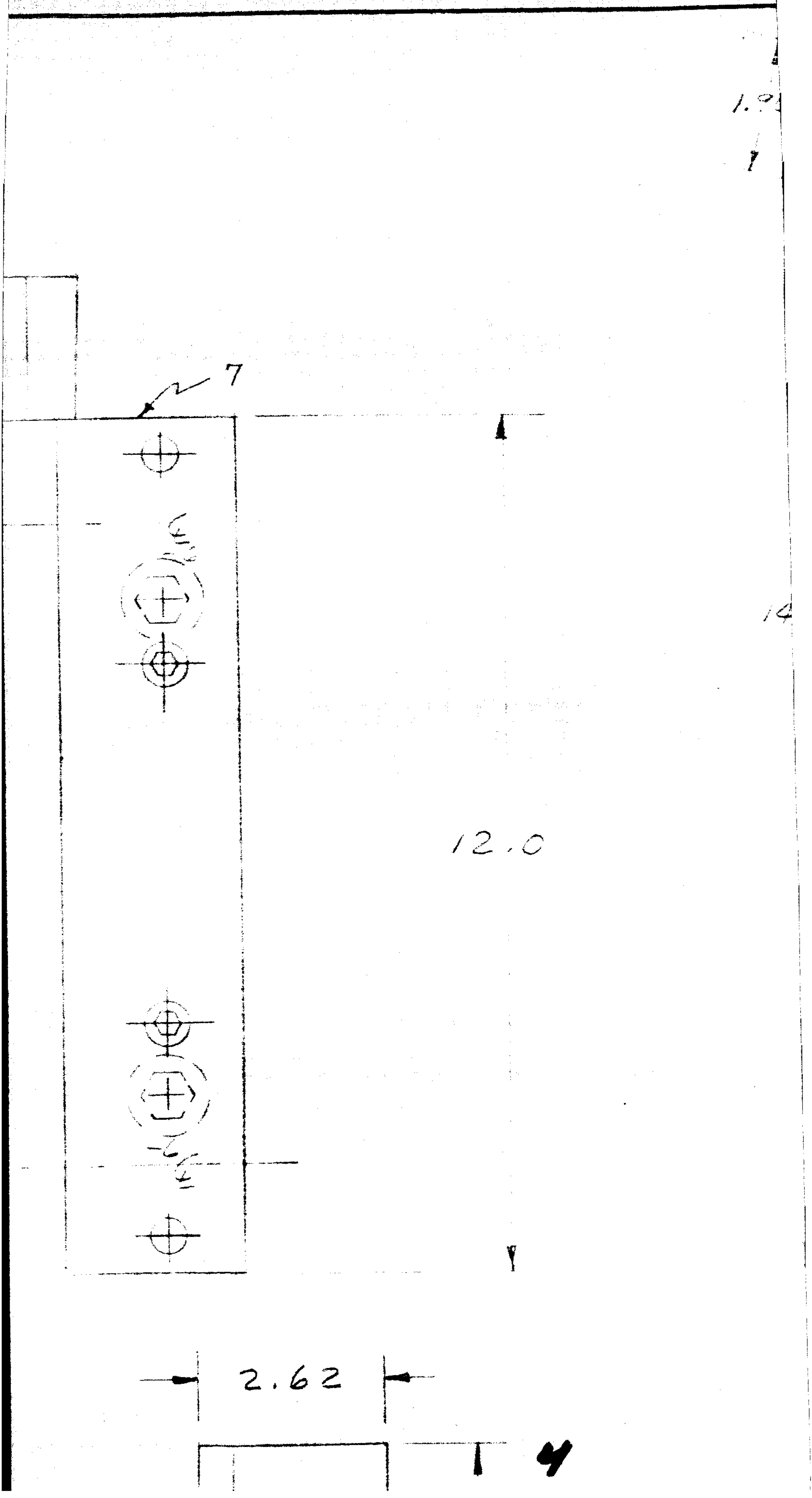
-2
-3
2.00
1.90
4.0
1.5
1.0
15°
5



ER .25 PER FOOT
EE DET.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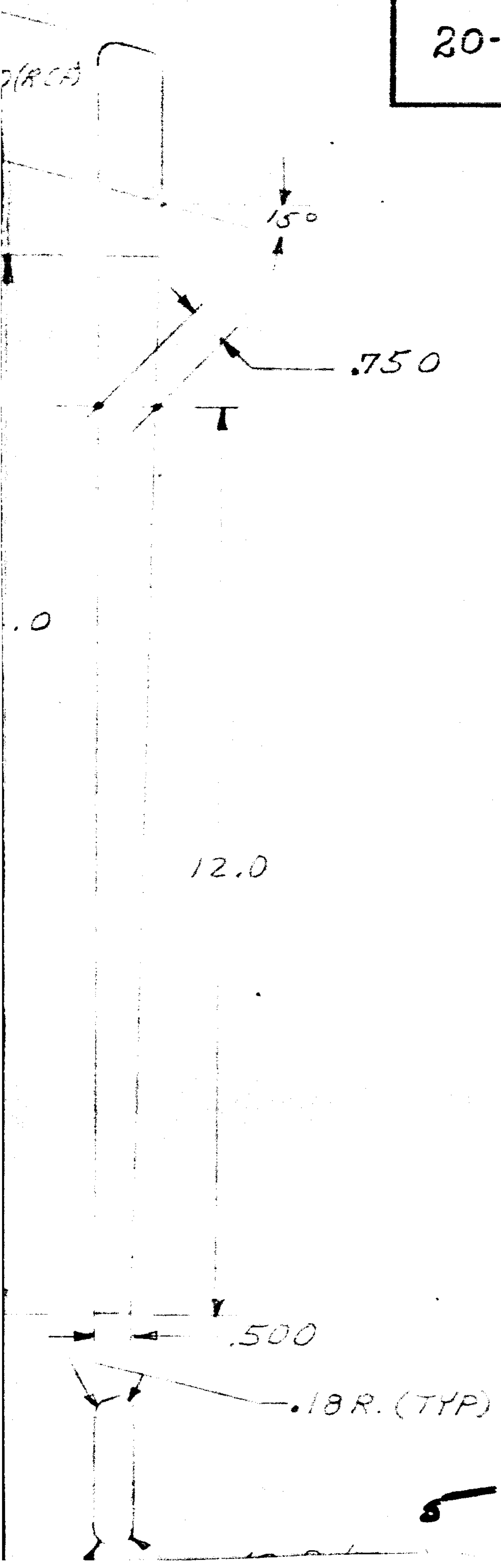
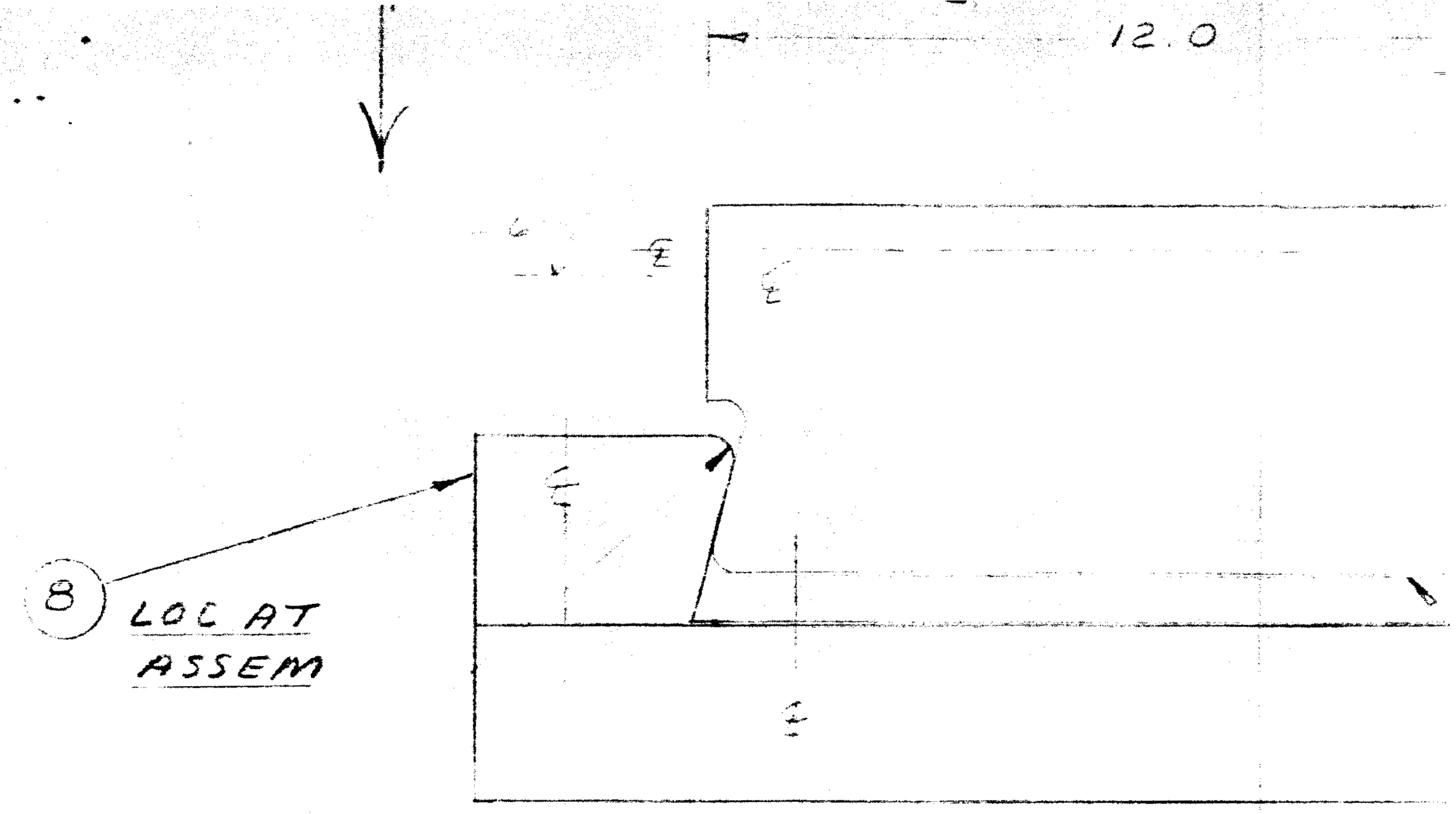
12.0
2.62
4

20-09301





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DIE ASSEMBL
UPPER & LOWER

.. AT ASSEM
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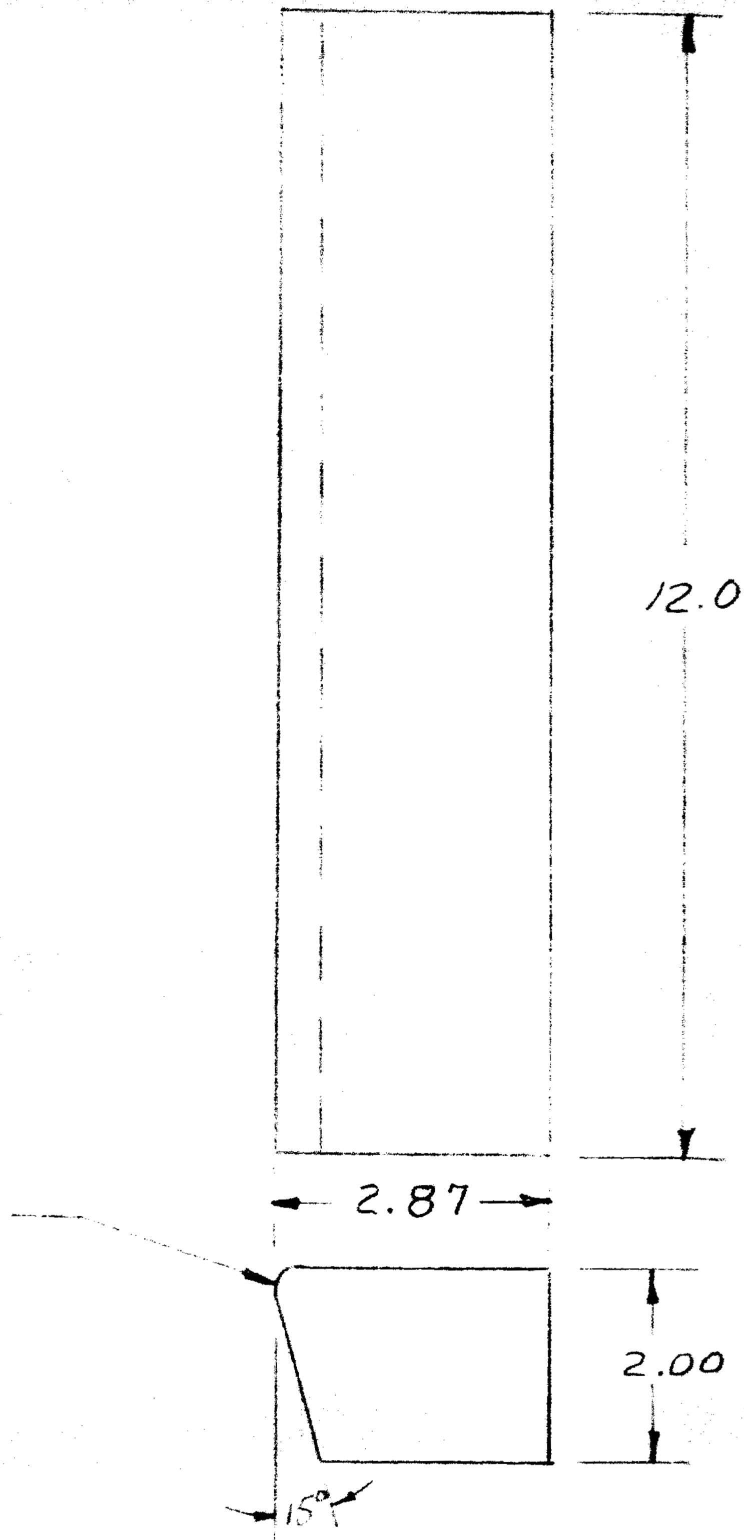
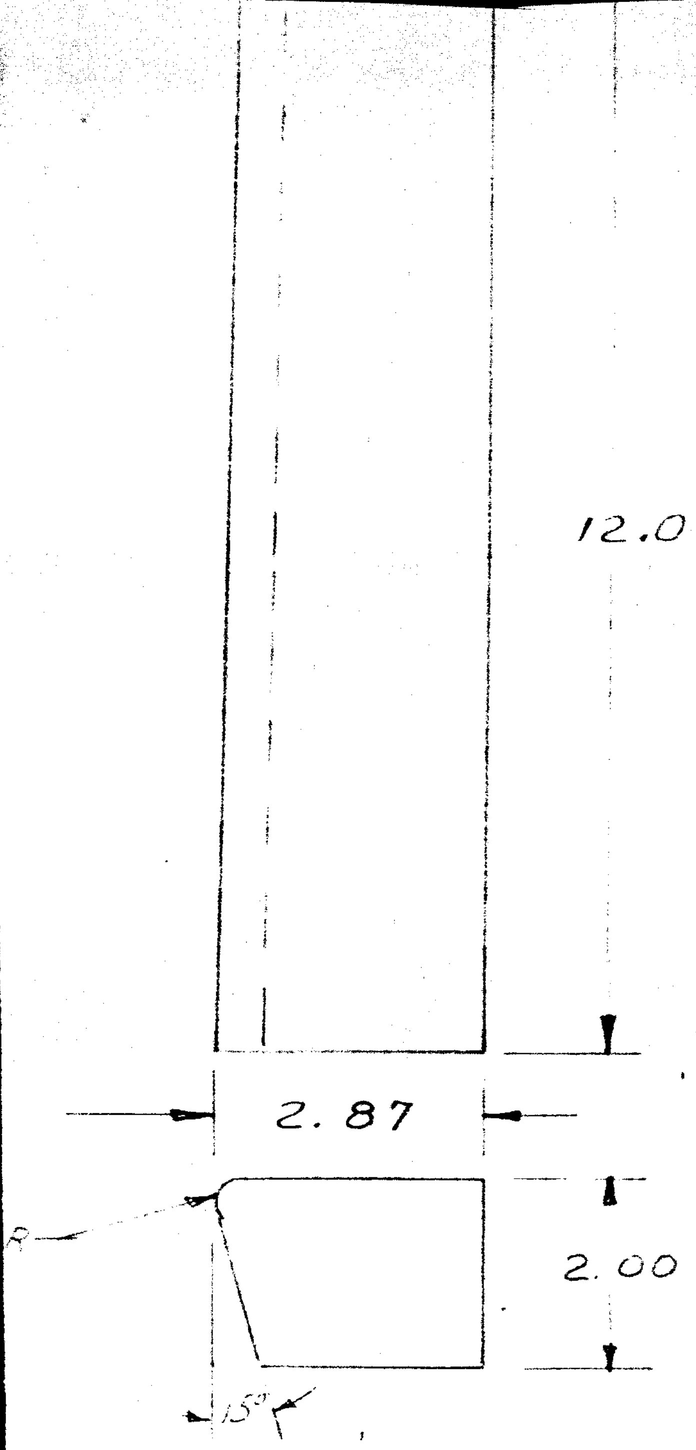


.25

DET-8



DET. 7

8
7
6
5
4
3
2
1

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	SEE N.O.C	9-65	[illegible]	HW
	CHANGE DWG NO. WRS 2009	8/30	[illegible]	HW

NO. REQ.	NEXT ASSEM.	MODEL

ACT. WT	ISSUE DATE	ISSUE NUMBER
CALC. WT		

DIE -

.20 -.02 R. (TYP)

DET-5

NO. REQ.	SIZE	DESCRIPTION	ARMY	NAVY	
2	2 X 3 X 12		MILD STEEL		
2	2 X 3 X 12		MILD STEEL		
8	3/4 DIA X 4 1/2		MILD STEEL		
2	1.0 X 2.0 X 14		4130 STEEL		
4	1/4-20 X 12 X 12 FLATTENED EXPANDED METAL (.029 X .036 DIAMOND, .25 X 1.0/8)				
2	1/2 X 12 X 12 1/2		TRANSITE		
2	2 X 12 X 17		MILD STEEL		
2	4 X 12 X 12		HARDTEM	FX-FINKL HEPPENSTAL	

MATERIAL — MATERIAL SPECIFICATION

= GRIND
= SMOOTH MACHINE
= MACHINE
= ROUGH MACHINE

FINISH

LIMITS UNLESS OTHERWISE SPECIFIED
.X = ± .06
.XX = ± .03
.XXX = ± .005
.XXXX = ± .0005
ANGULAR ± 1/2°

APPROVED	[signature]	8-20-65
PRO. ENG.	[signature]	8-20-65
STRESS		
CHECKED	Lee Evans	8-20-65
DRAWN BY	Lee Evans	8-3-65

SCALE 1/2 SIZE

JOB NO.

HEAT TREAT

HARVEY Aluminum
TORRANCE, CALIFORNIA

HARVEY ENGINEERING LABORATORIES

FORGING

DWG. NO. 20-09301

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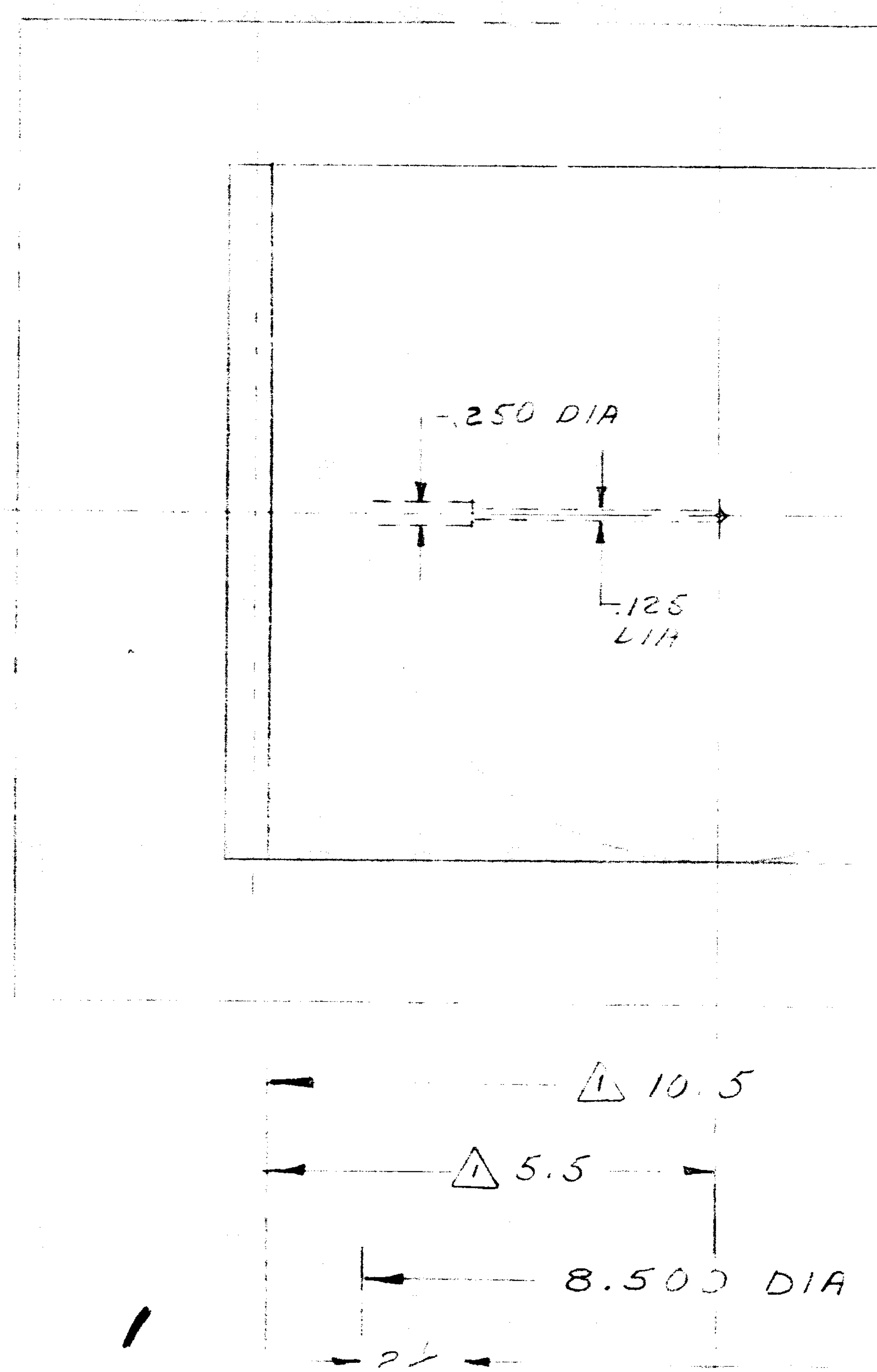
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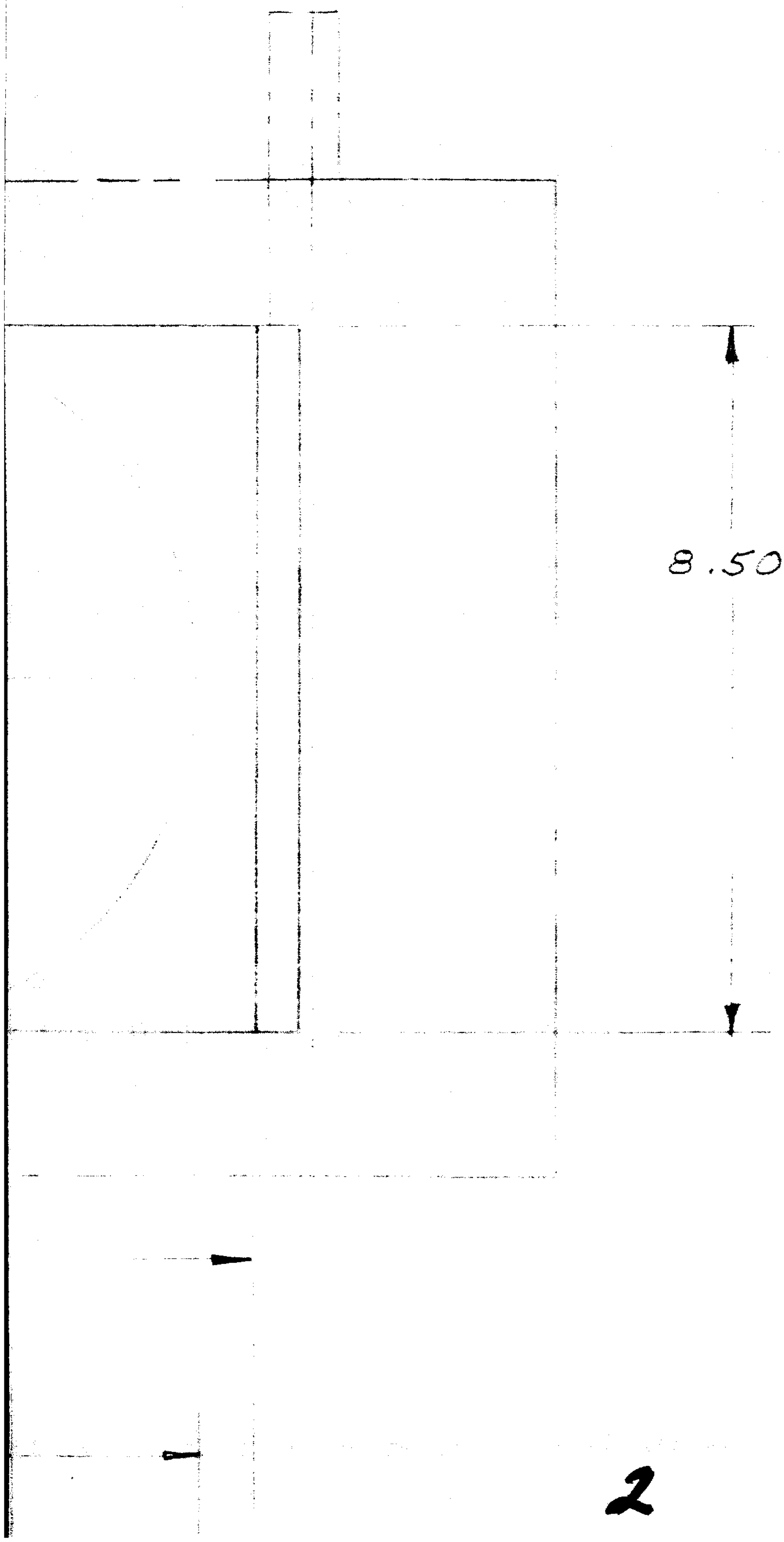
.125 DIA
1 10.5
1 5.5
8.500 DIA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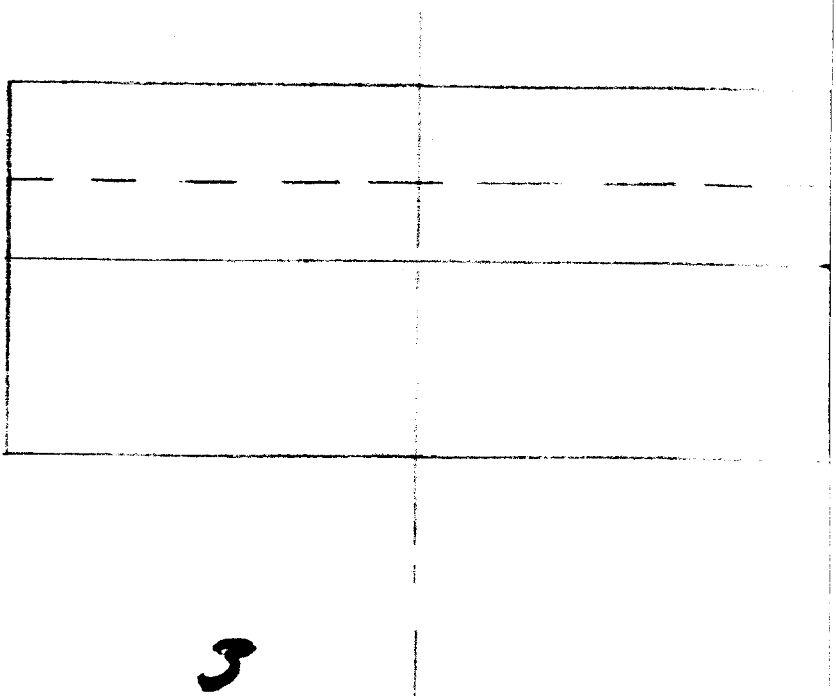

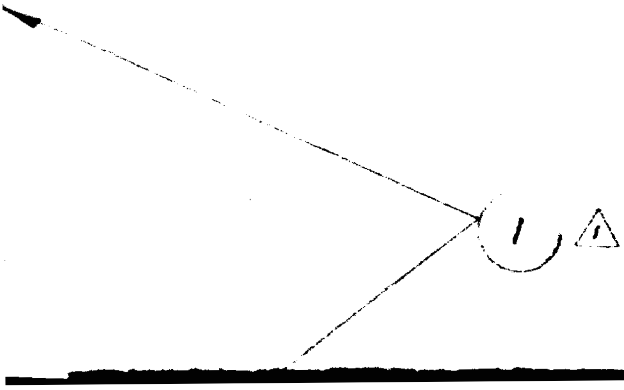
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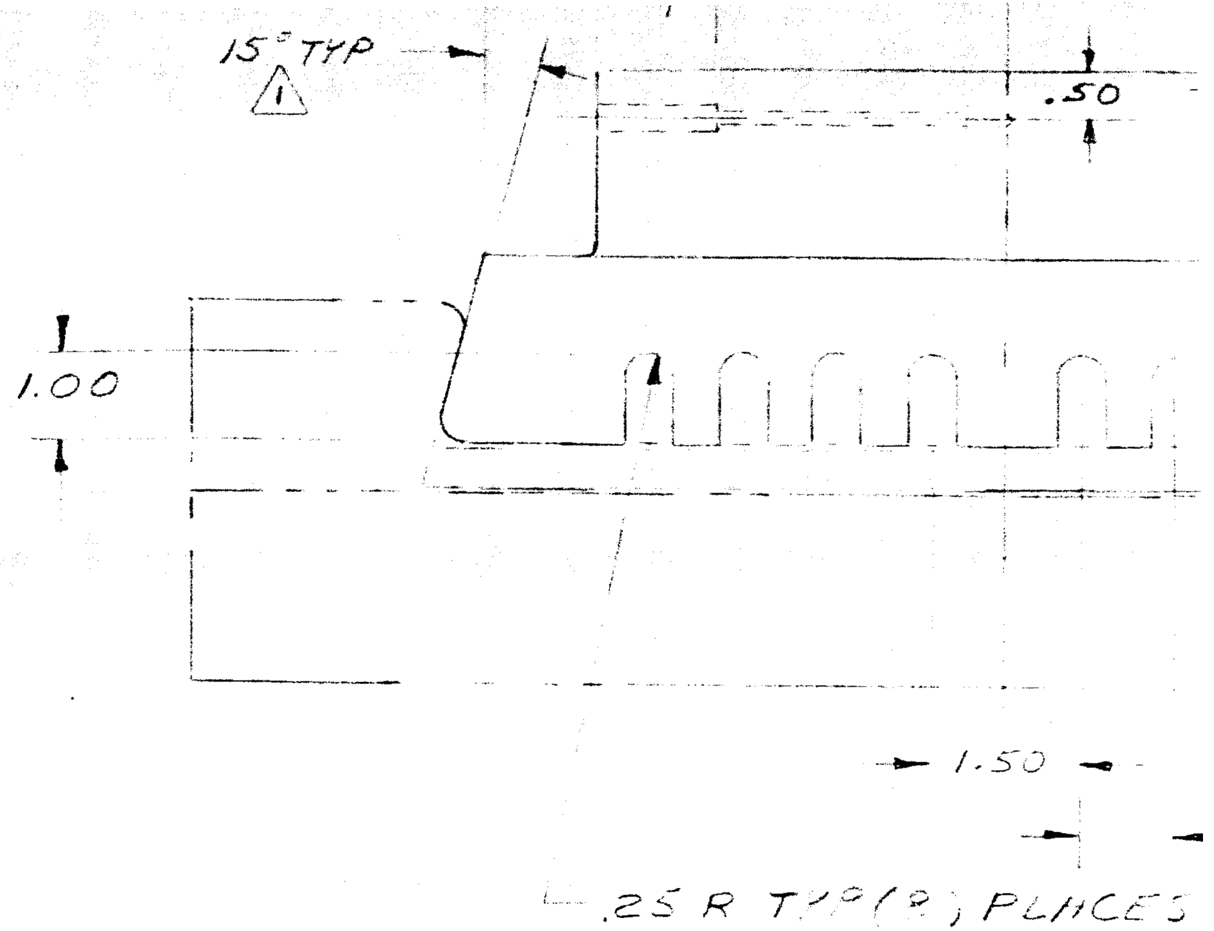
20-09302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.50
1.00
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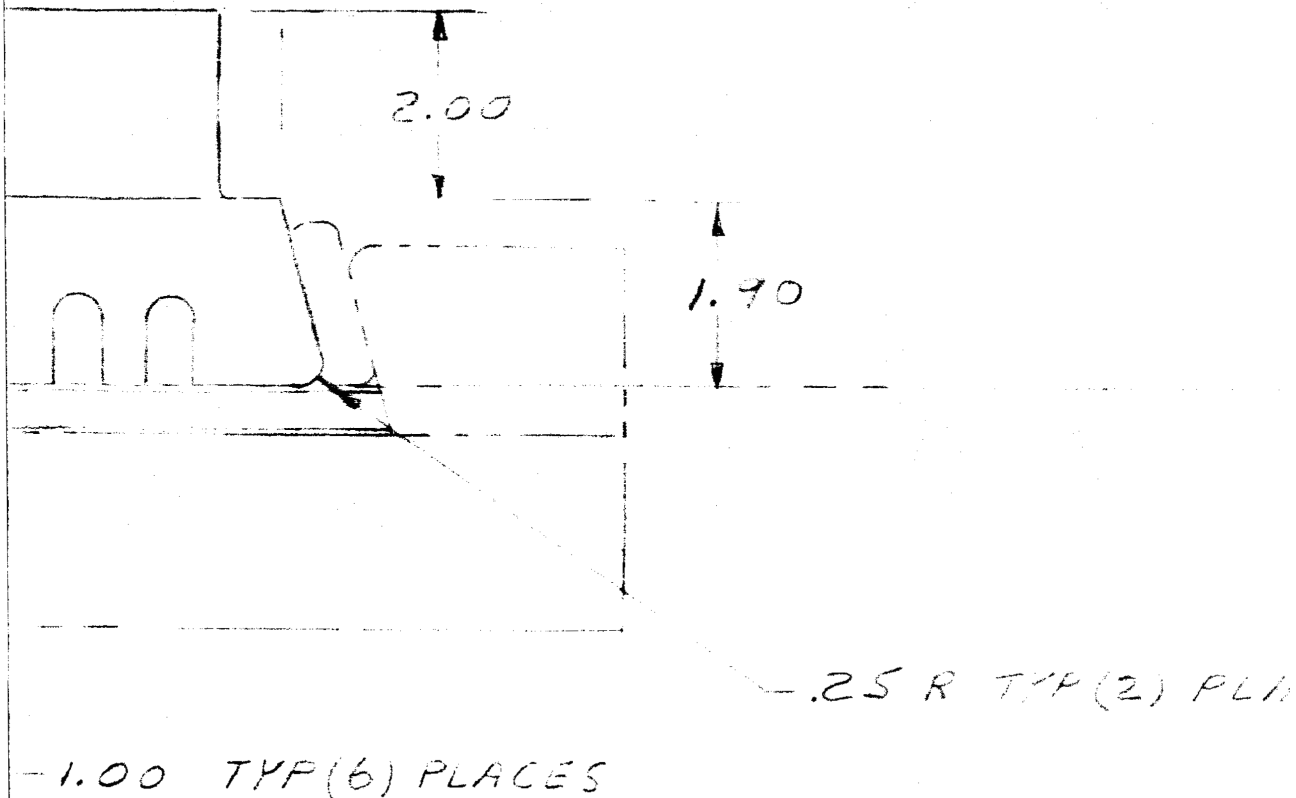
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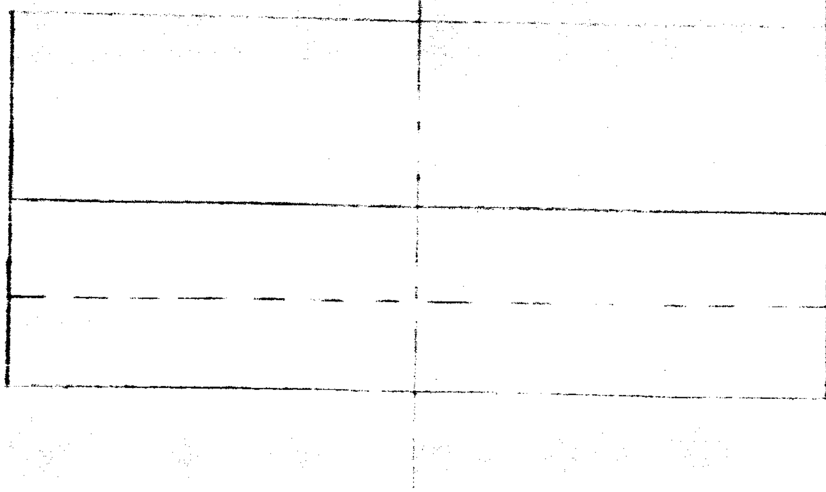
1.00 TYP (6) PLACES



CES

NOTES

1. DET. -1 (2 REQ'D) USE WITH 20-093

1 DIE-FORGING

LET.	CHANGES	DATE	BY	APP.
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NO. REQ.	NEXT ASSEM.

ACT. WT	ISSUE DATE	ISSUE NUMBER
CALC. WT		

DIE -

(USE

9

ITEM NO.	NO. REQ.	SIZE	DESCRIPTION	ARMY	NAVY
1	2	4 X 9 X 12	713C ALLOY INCONEL CASTING		
		MATERIAL		MATERIAL SPECIFICATION	

G = GRIND
// = SMOOTH MACHINE
/ = MACHINE
R/ = ROUGH MACHINE

FINISH

HEAT TREAT

LIMITS UNLESS OTHERWISE SPECIFIED
.X = ± .06
.XX = ± .03
.XXX = ± .005
.XXXX = ± .0005
ANGULAR ± ½°

SCALE ½ SIZE

APPROVED	HW	9-10-65
PRO. ENG.	S. R. Long	9-9-65
STRESS		
CHECKED	[illegible]	9-9-65
DRAWN BY	[illegible]	9-9-65

JOB NO.

HARVEY Aluminum
TORRANCE, CALIFORNIA

HARVEY ENGINEERING LABORATORIES

FORGING
WITH 20-09301)

DWG. NO. 20-09302

FORM 1000H-D—1M—3-52—T-5885

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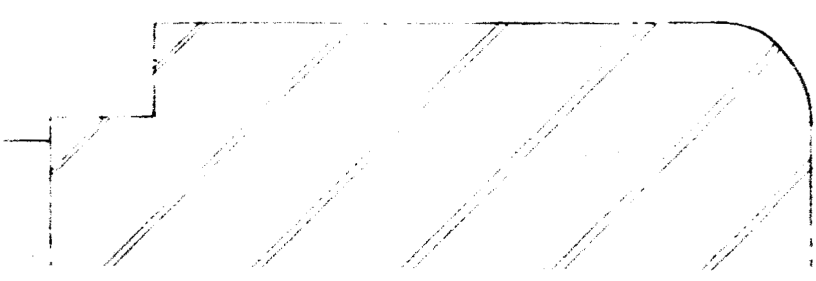
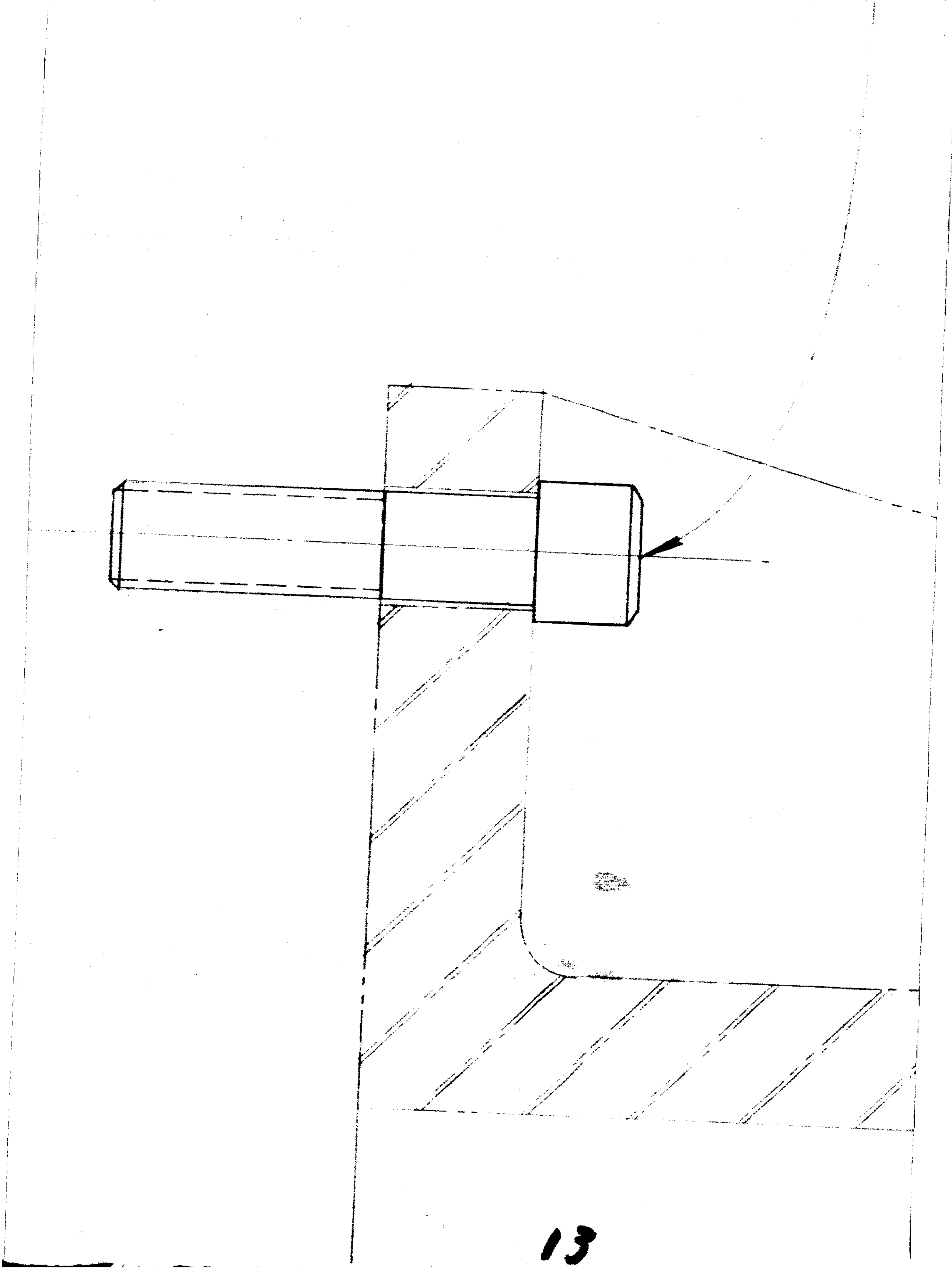
7/3 36/2

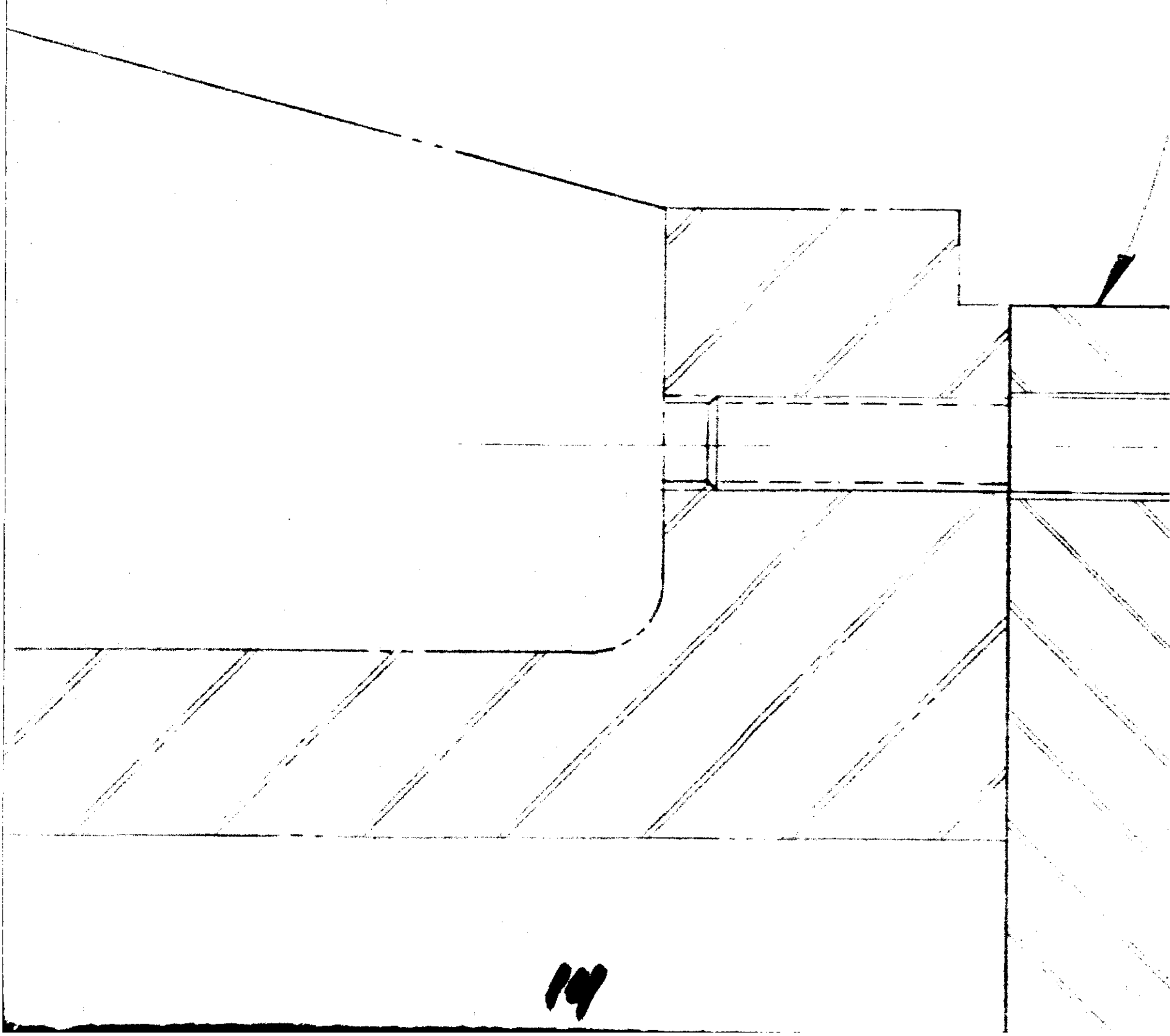
7

23 4/2 23 10

9







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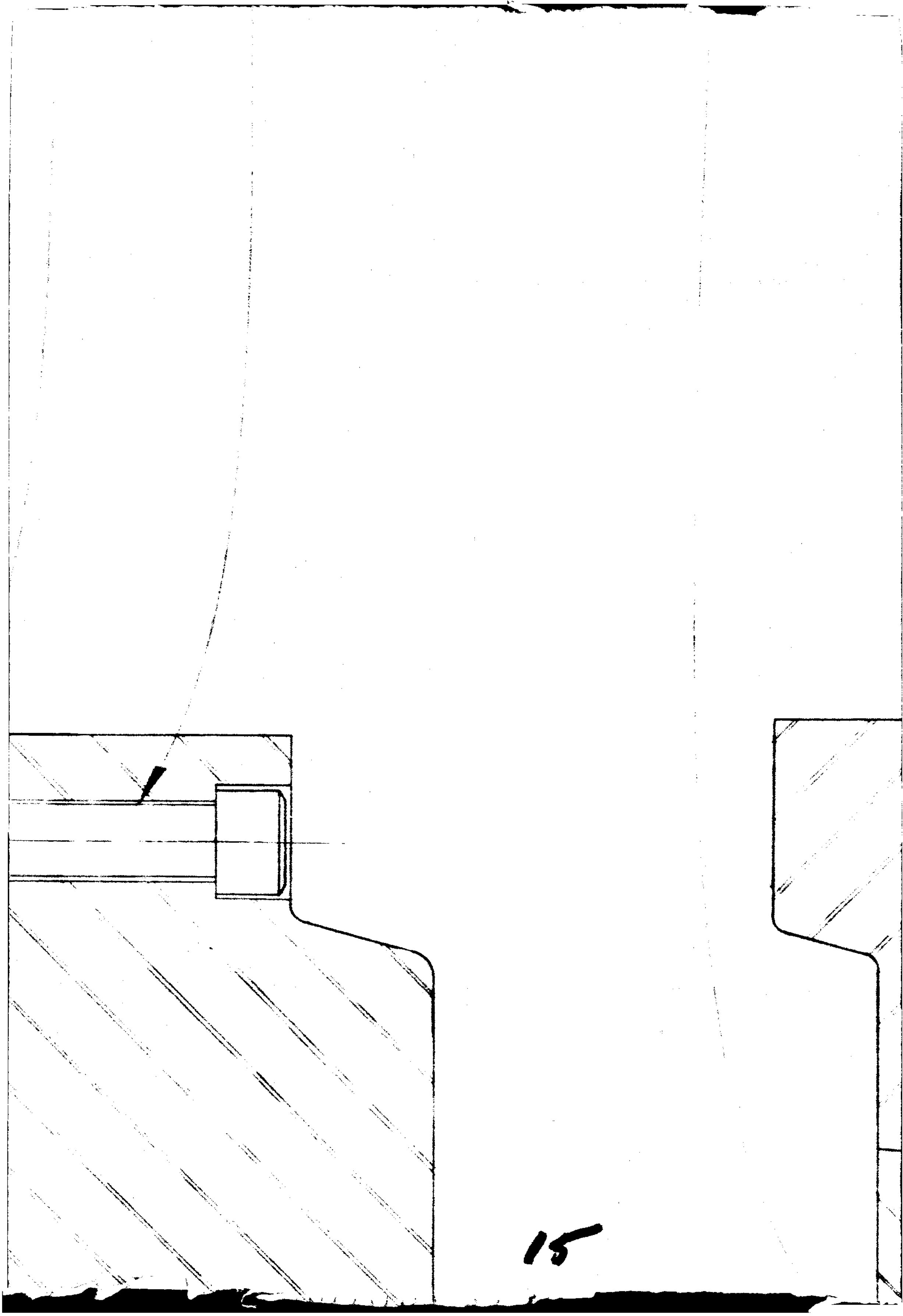
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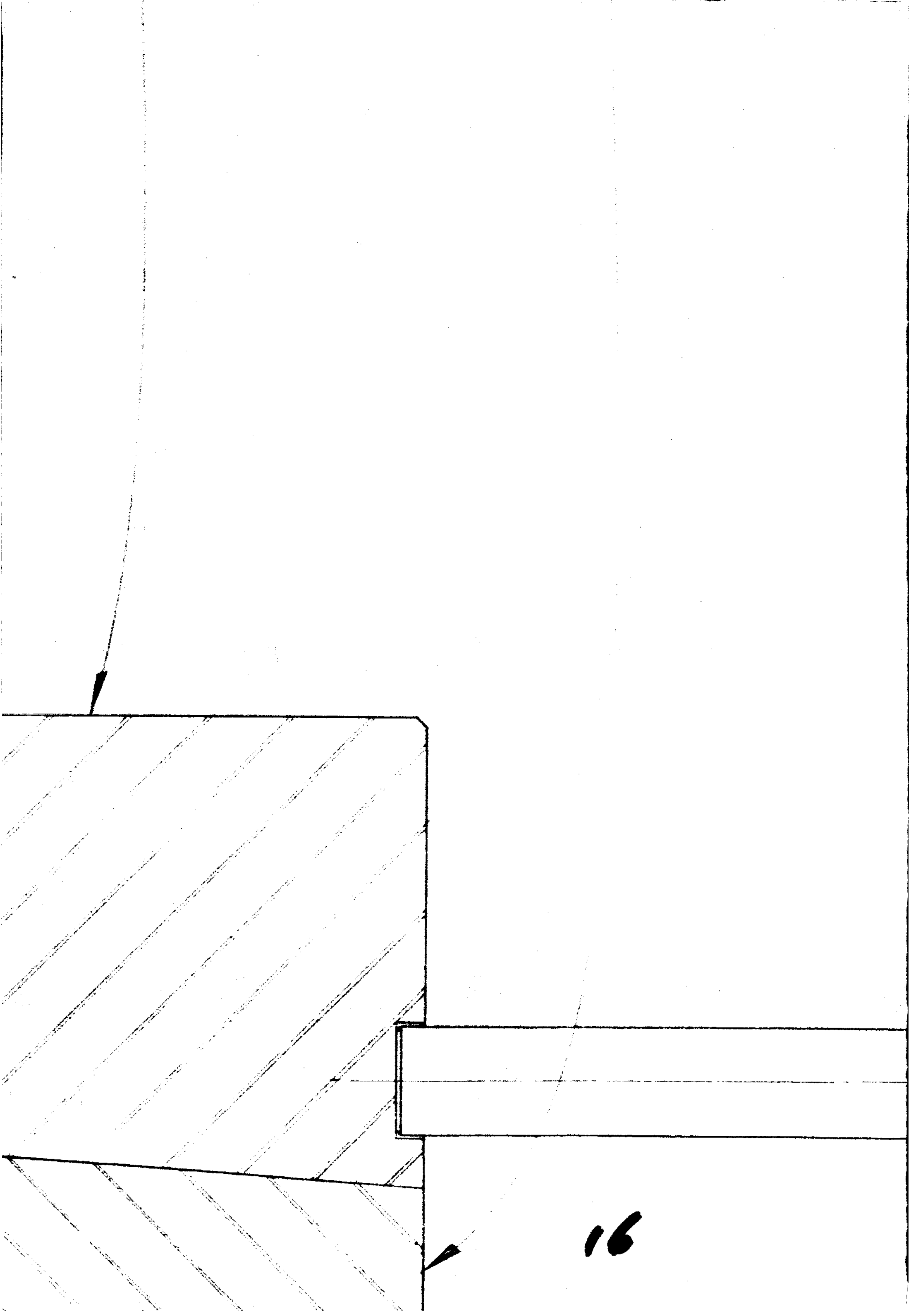
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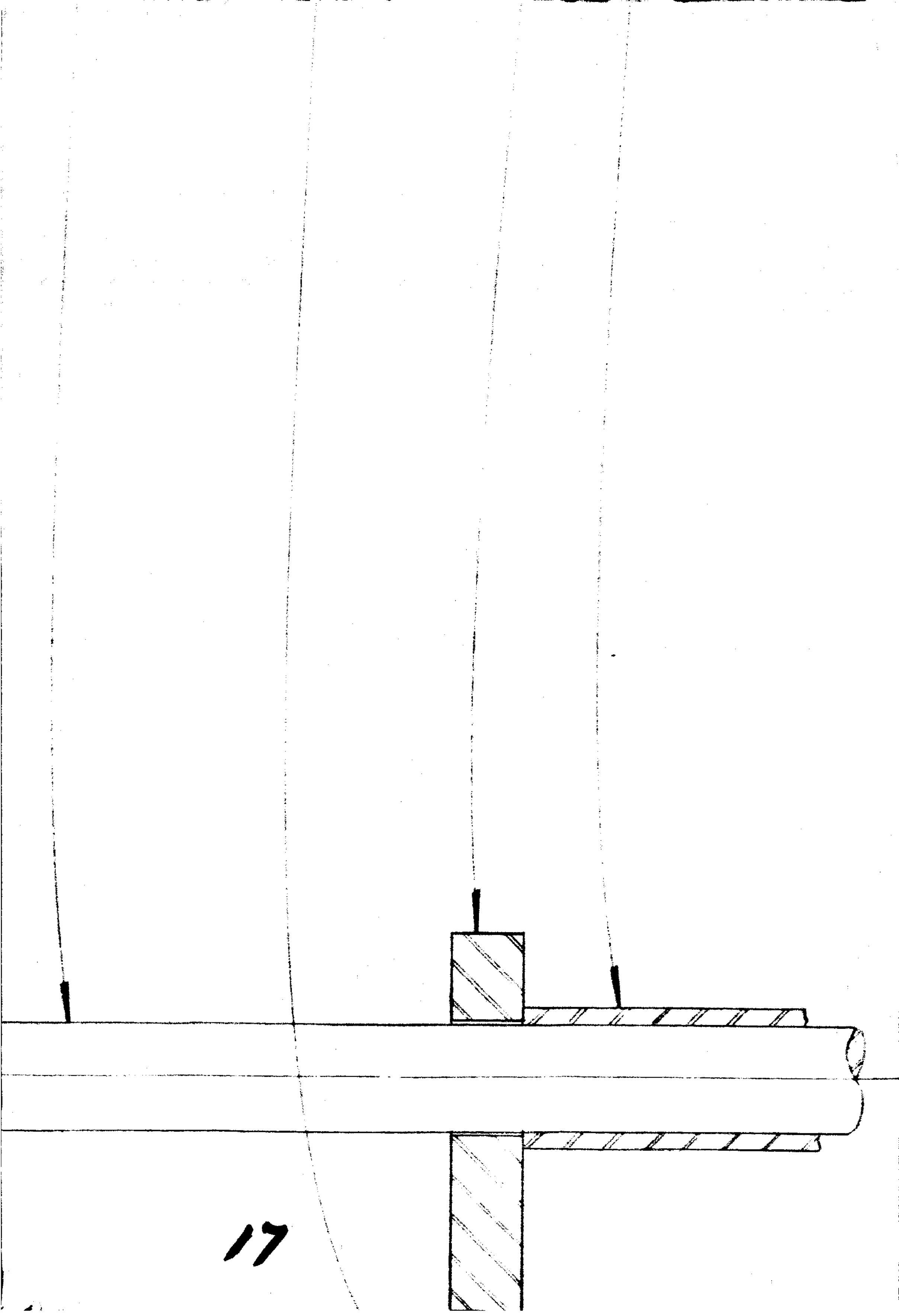

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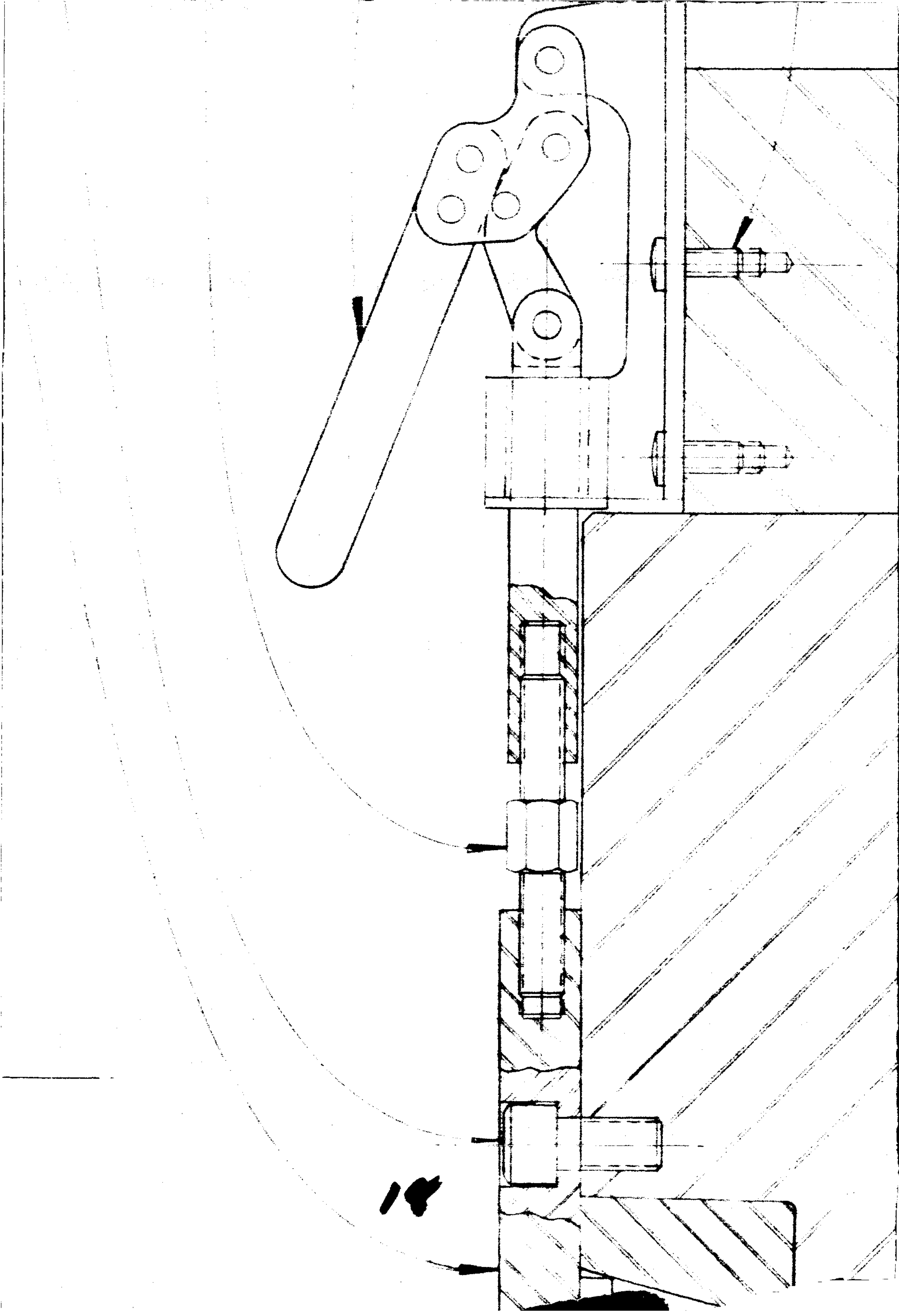

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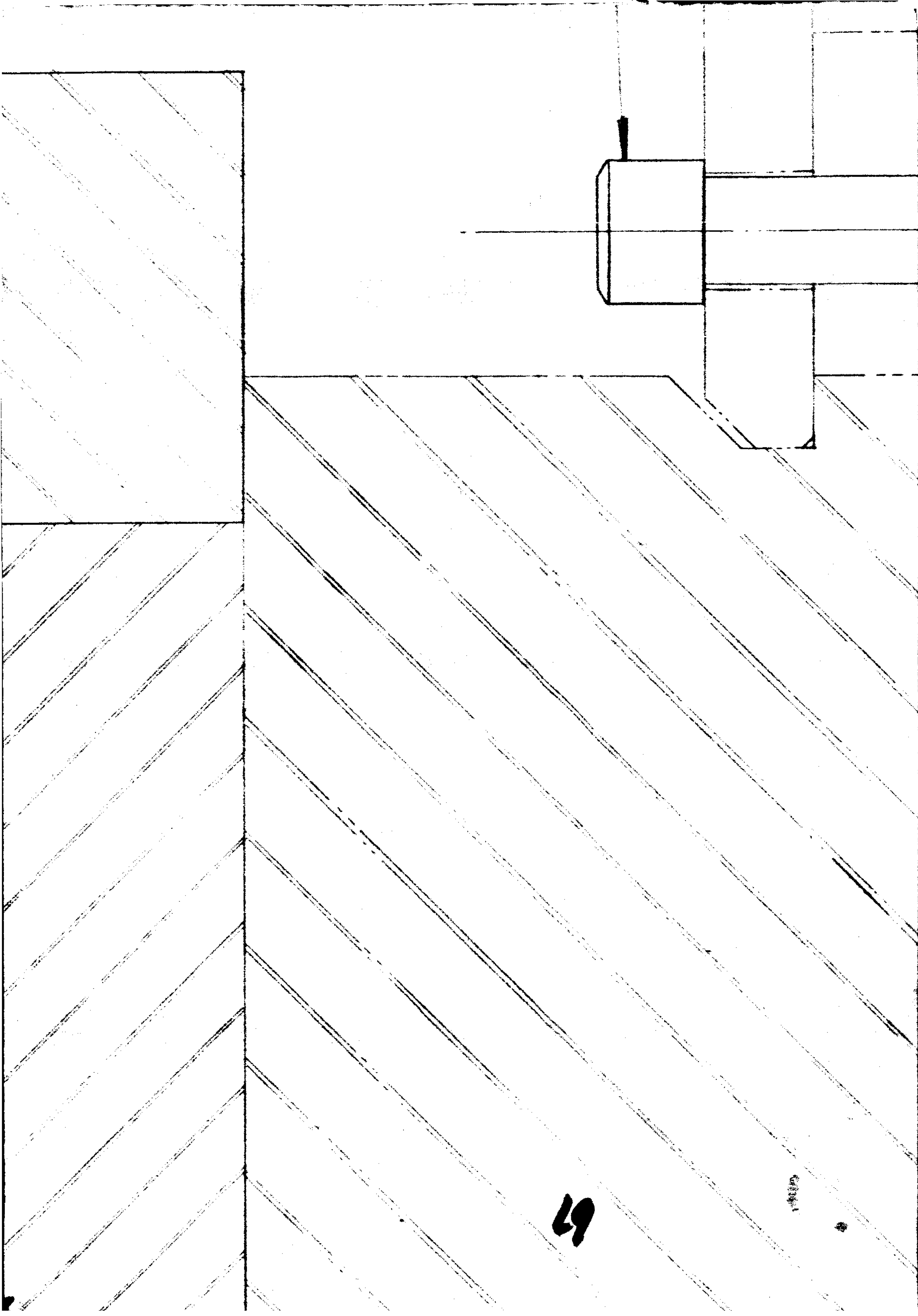

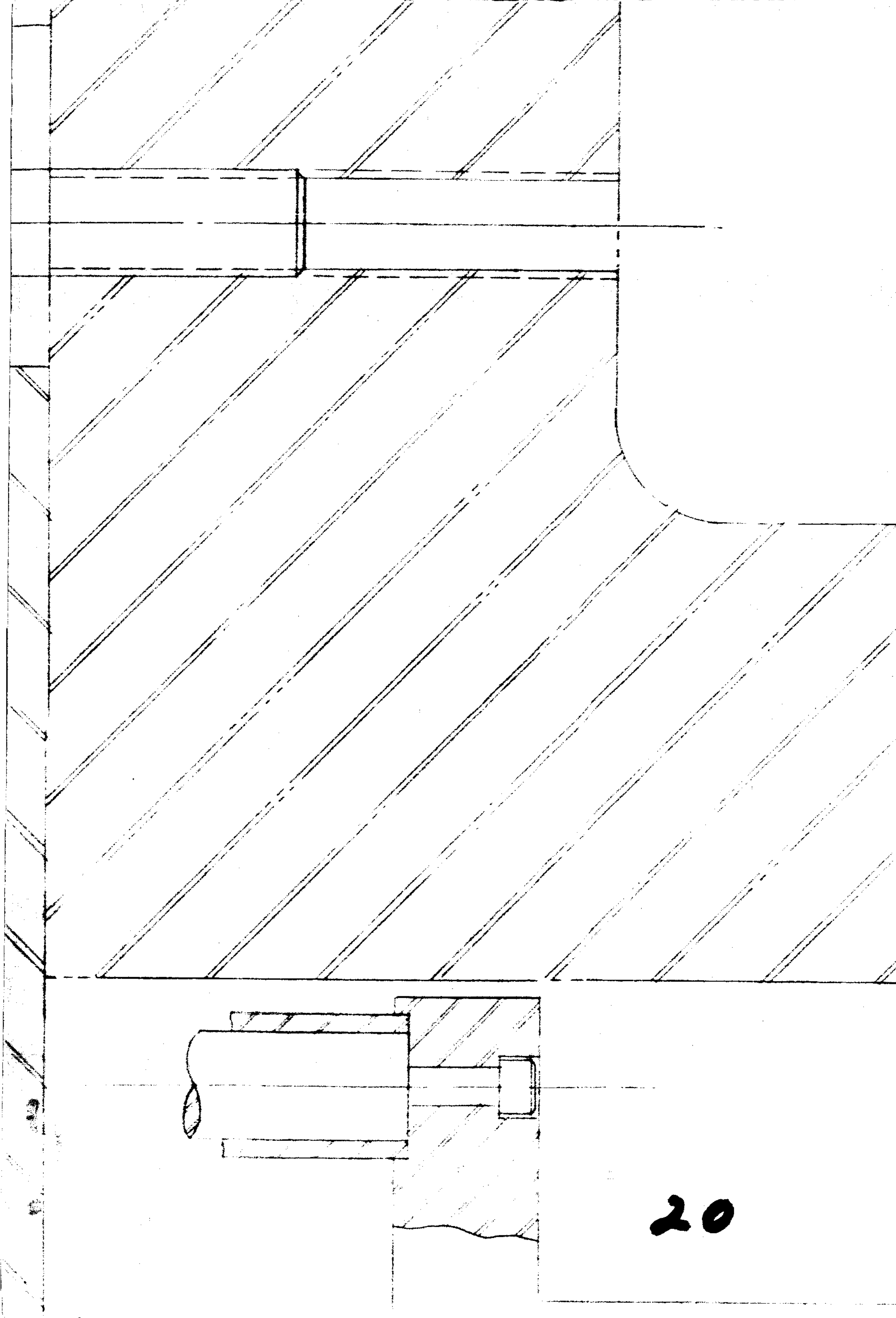

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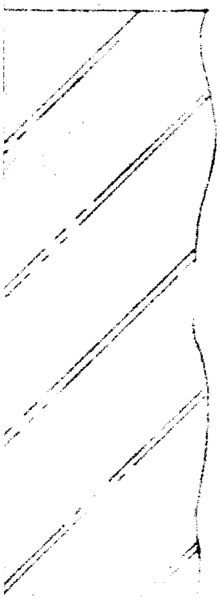
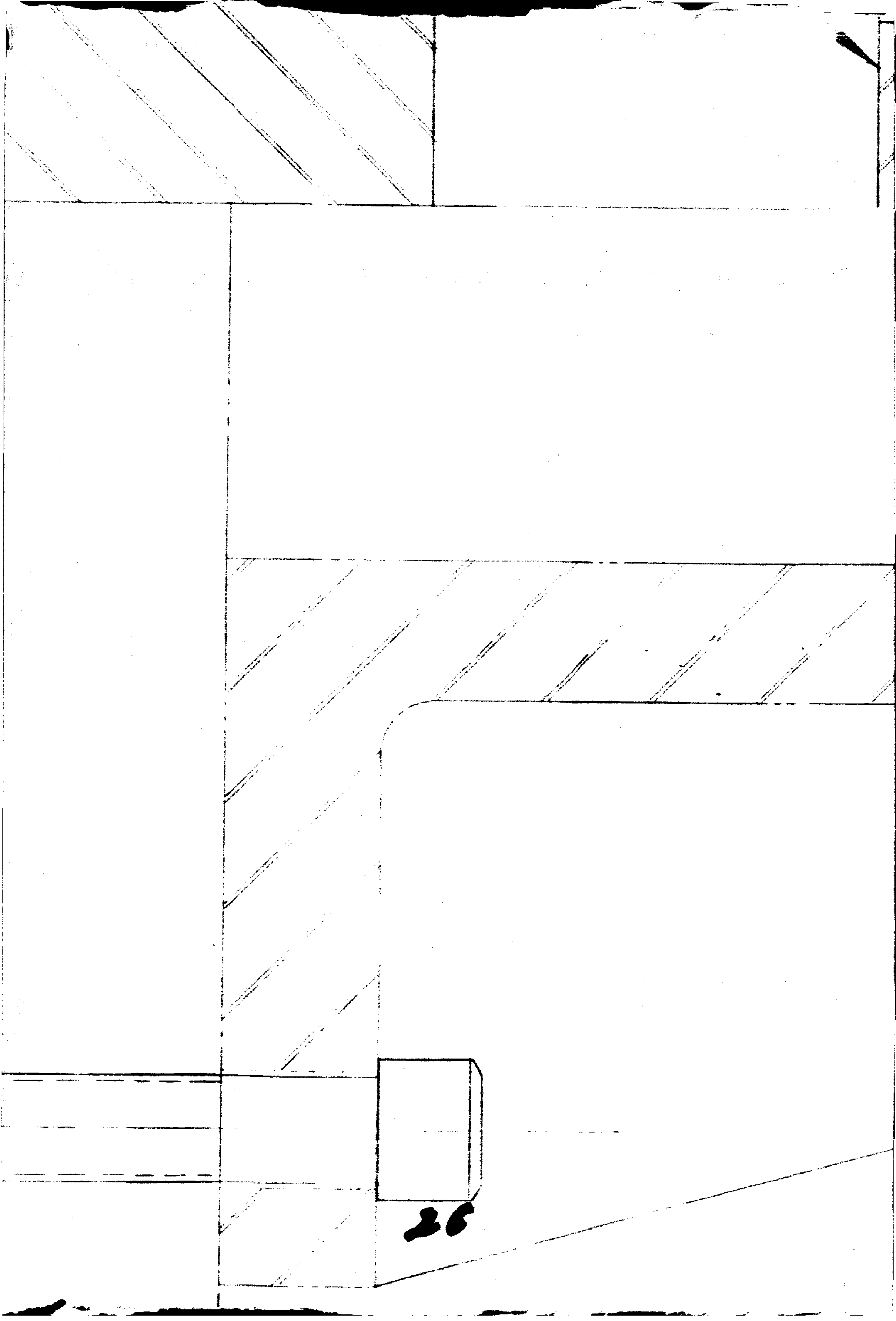
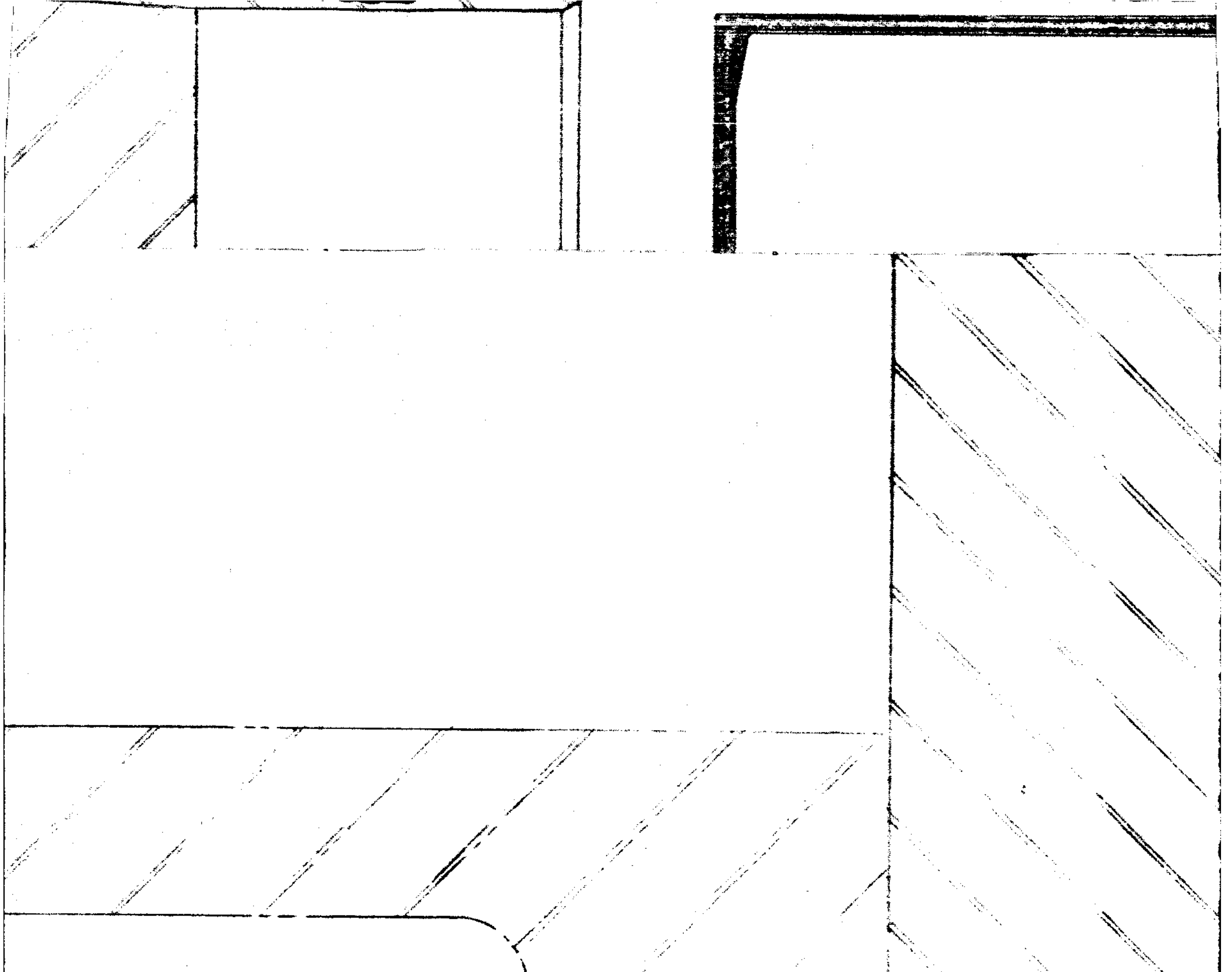
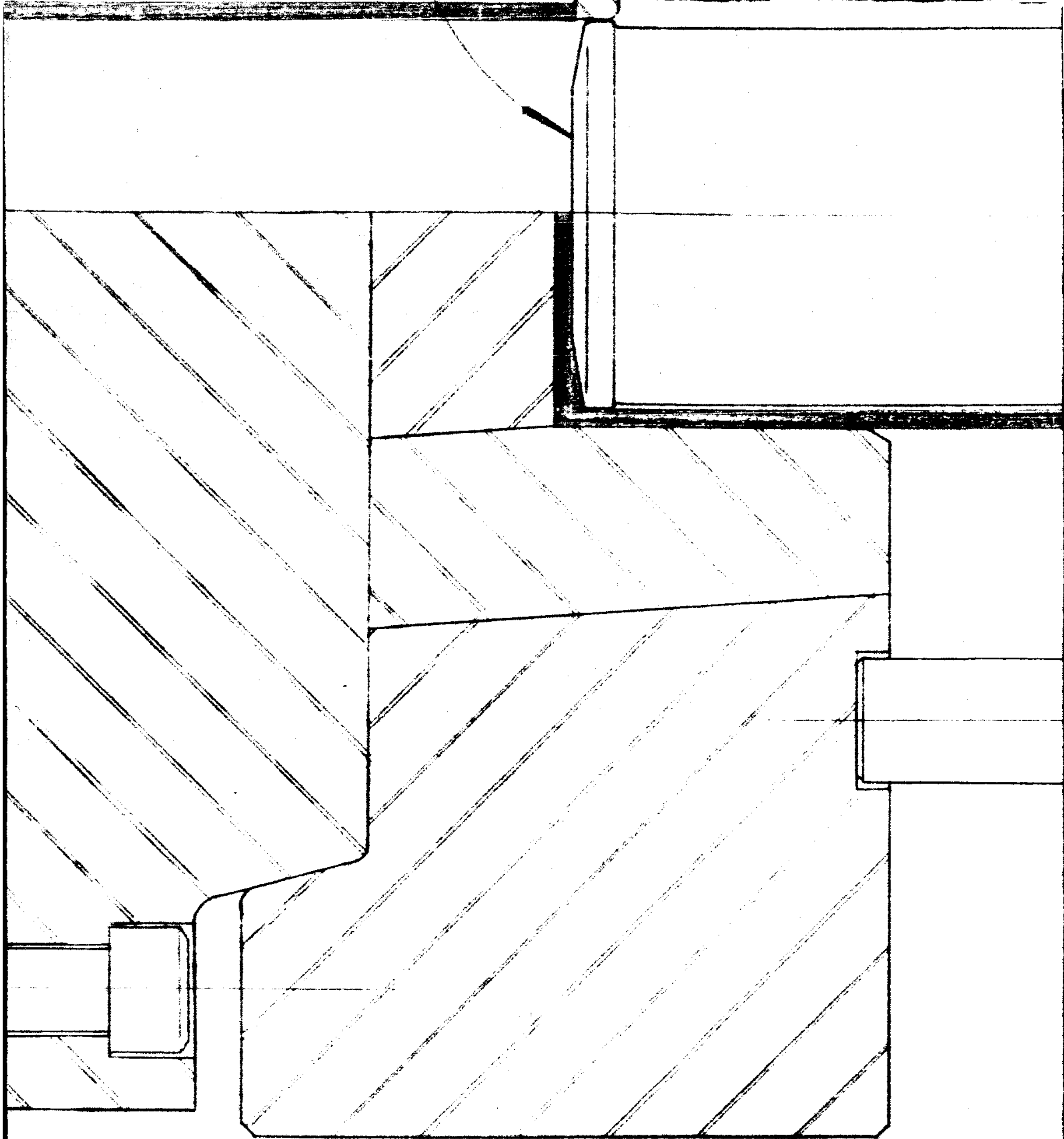


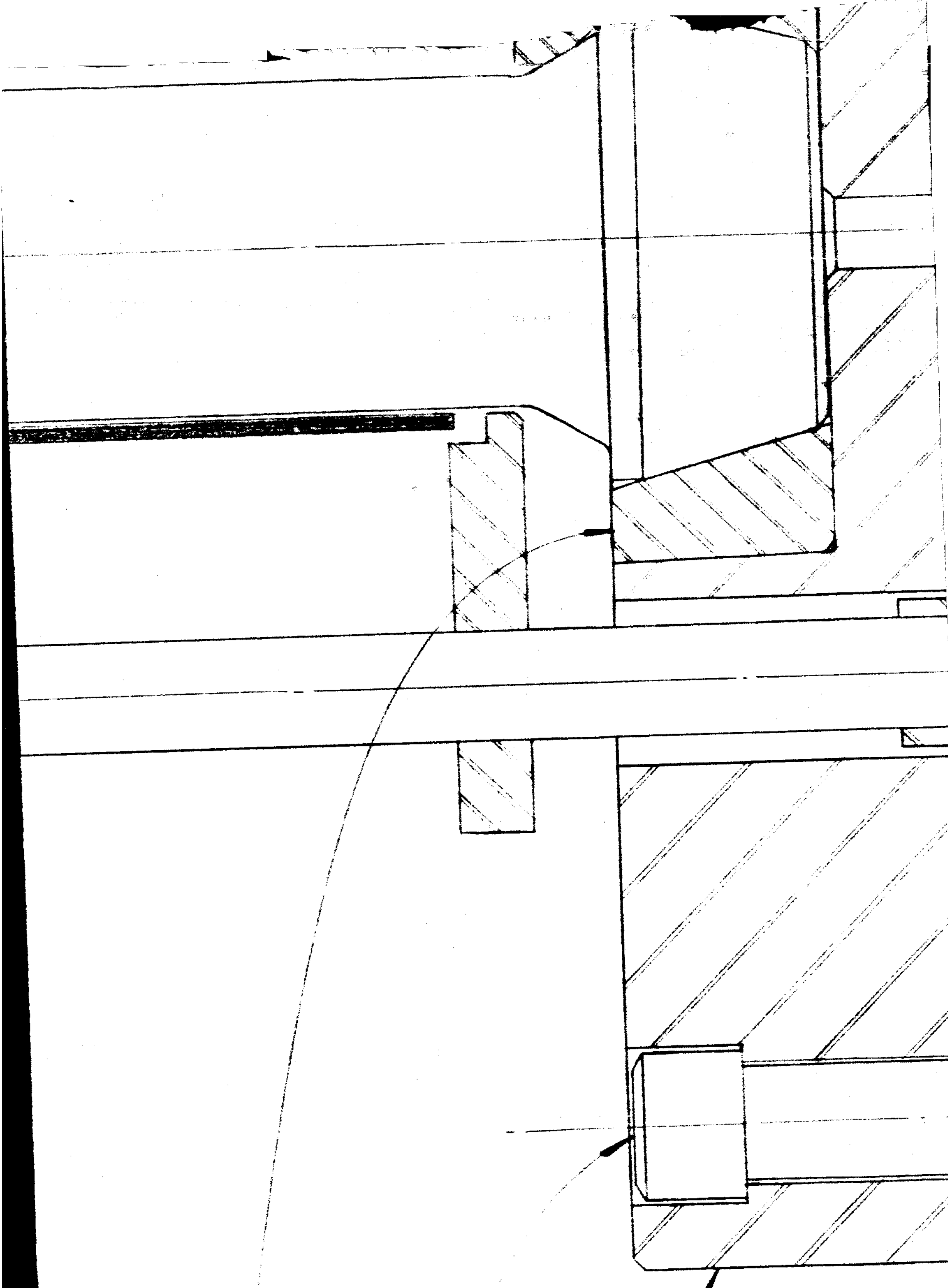


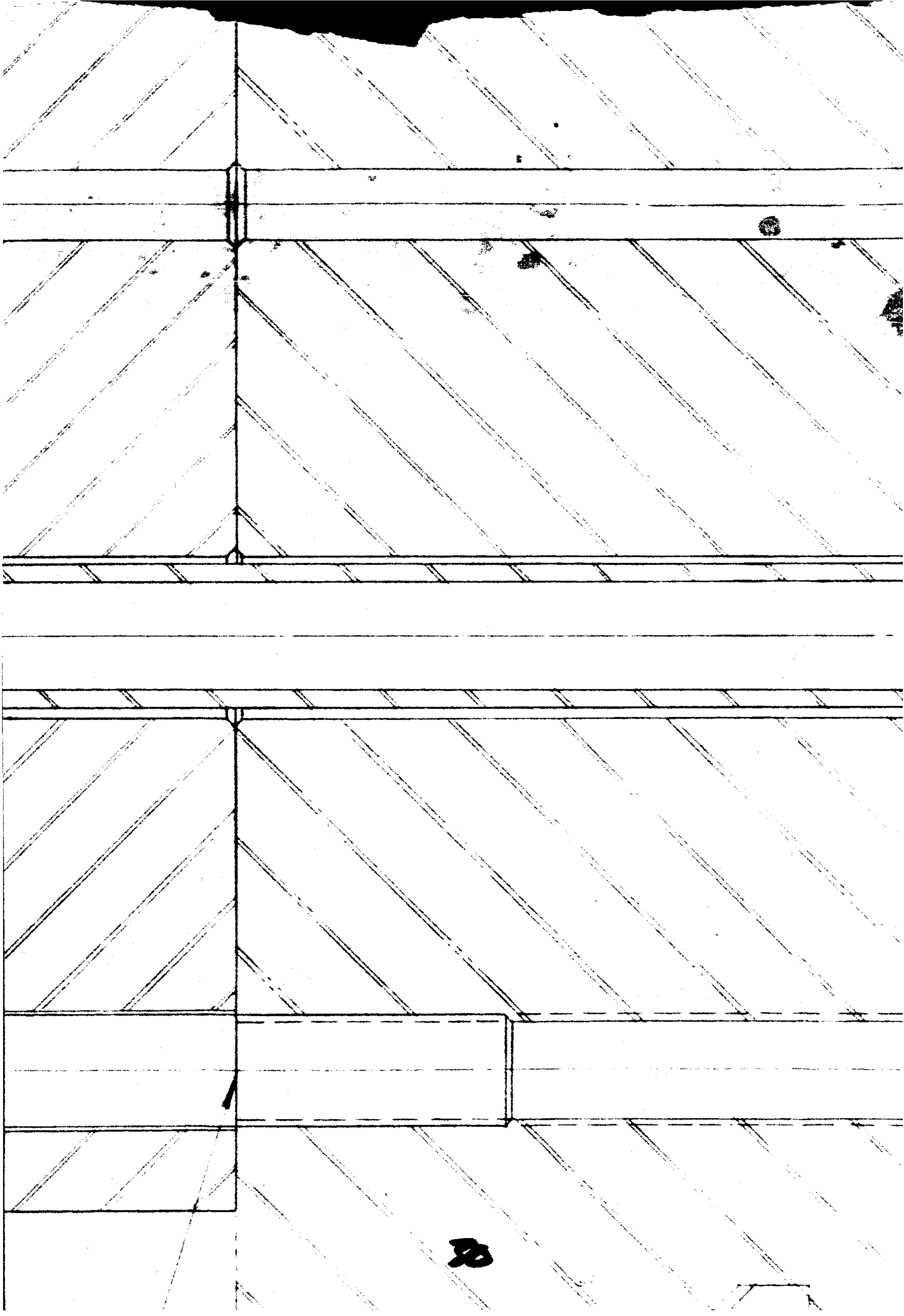
26

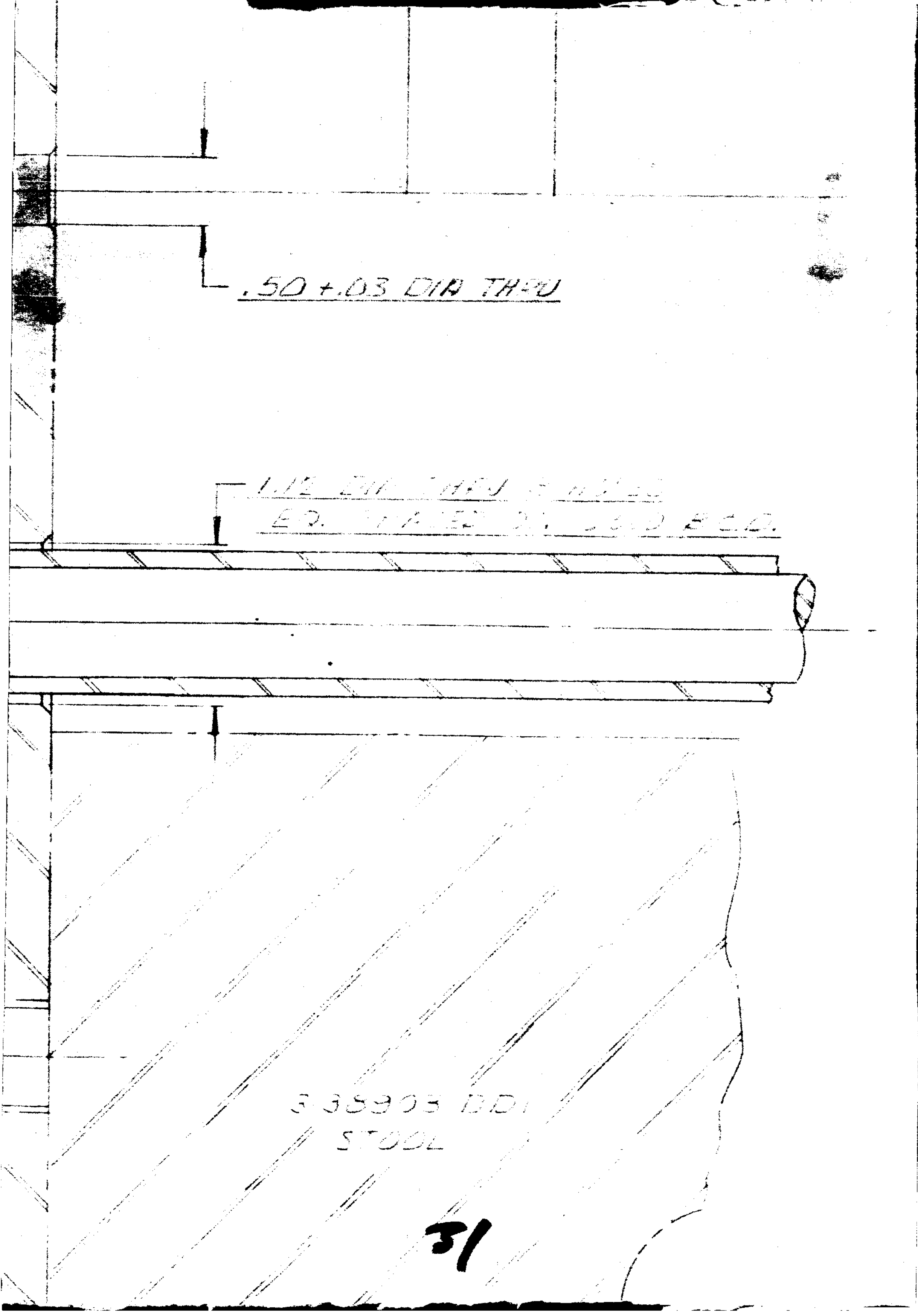




28






.50 +.03 DIA THRU
STOOL

NOTES:

1. FOR EXTRUDING MARAG[illegible] STEEL & TITANIUM (6 & [illegible]LLOY) THE FOLLOW[illegible] APPLIES:

   A. DETAILS -6, -7, -8, -9, -14, -16, & -18 ARE USED.

   B. DETAIL -6 APPLIES WHEN EXTRUDING A CUP WITH .100 WALL, -7 WITH A .150 WALL, -8 WITH A .200 WALL & -9 WITH A .250 WALL.

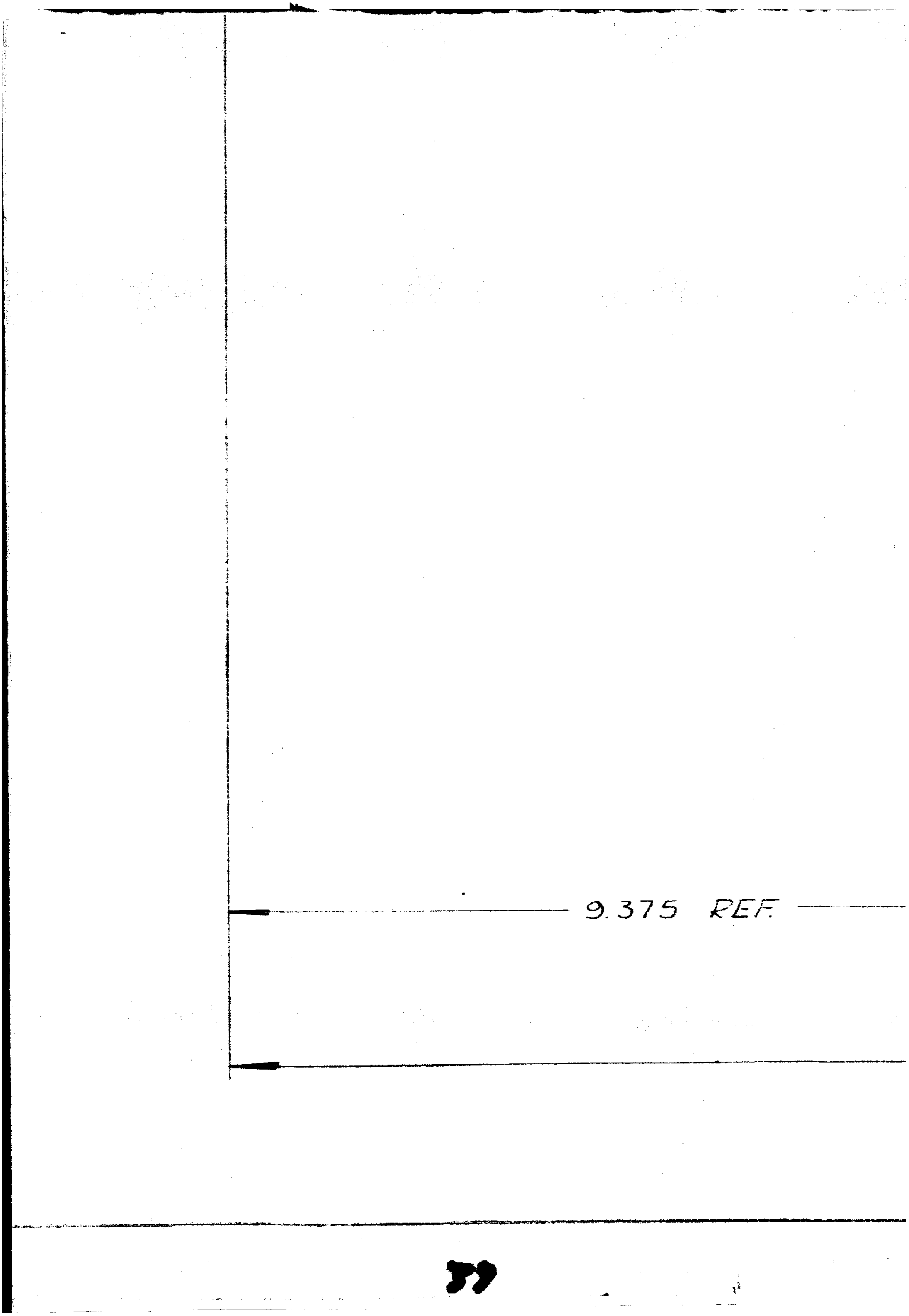
   C. HEAT DET'S -6, -14, -16, & -18 TO [illegible]°F

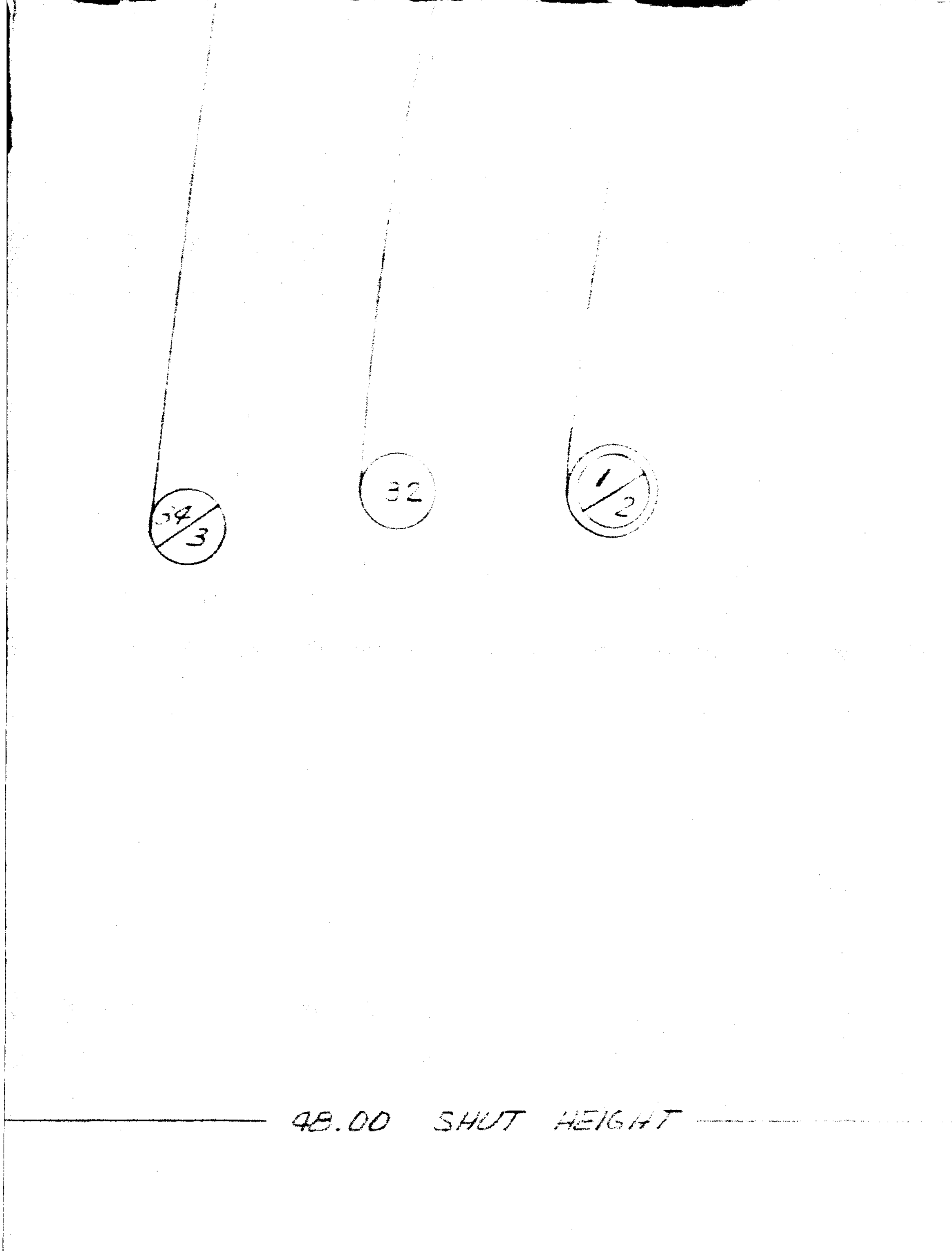
   D. SEAT PUNCH IN NEST & LOCK IN PLACE.

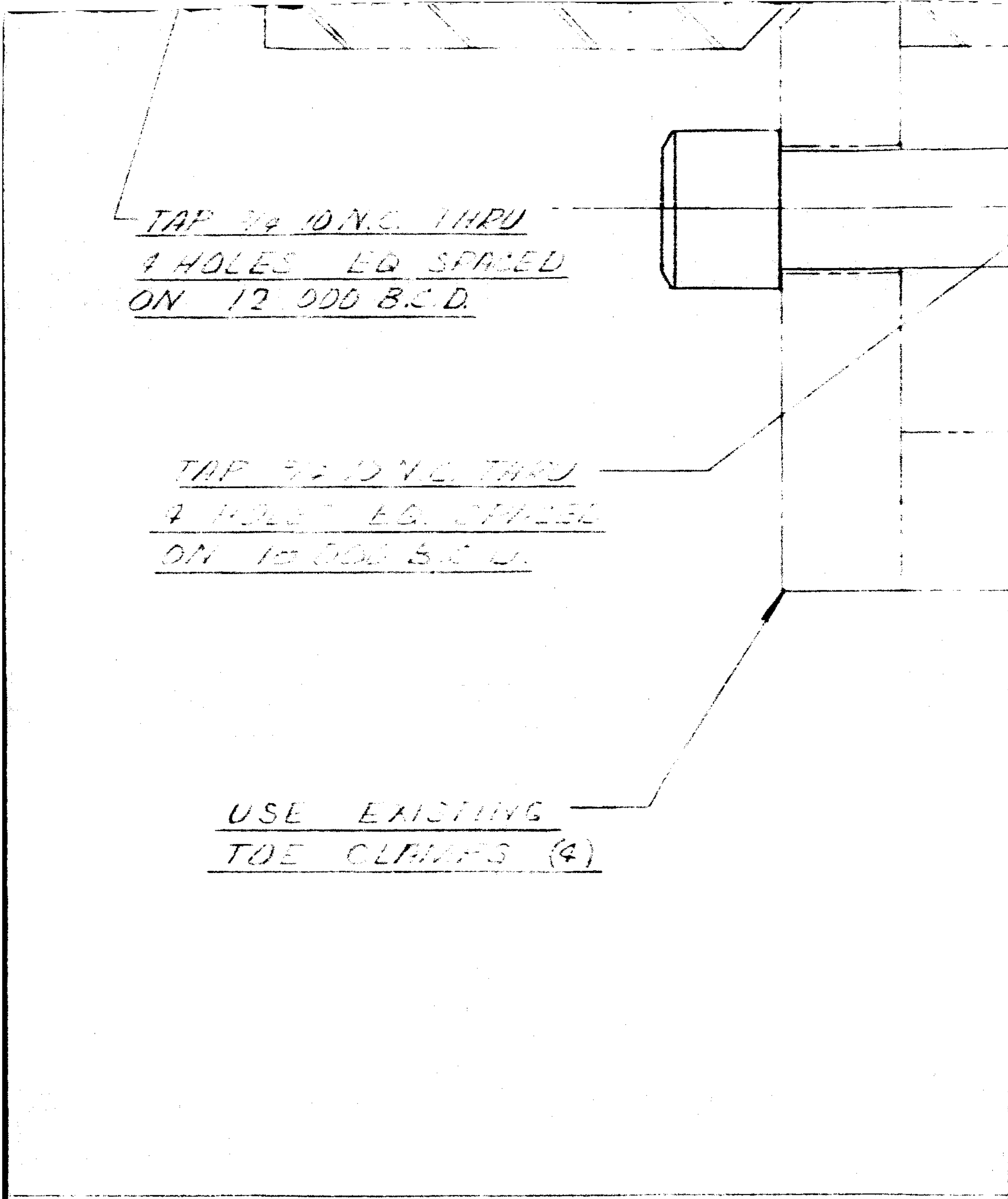
   E. SEAT DIE RETAINER ON STRIPPER RODS.

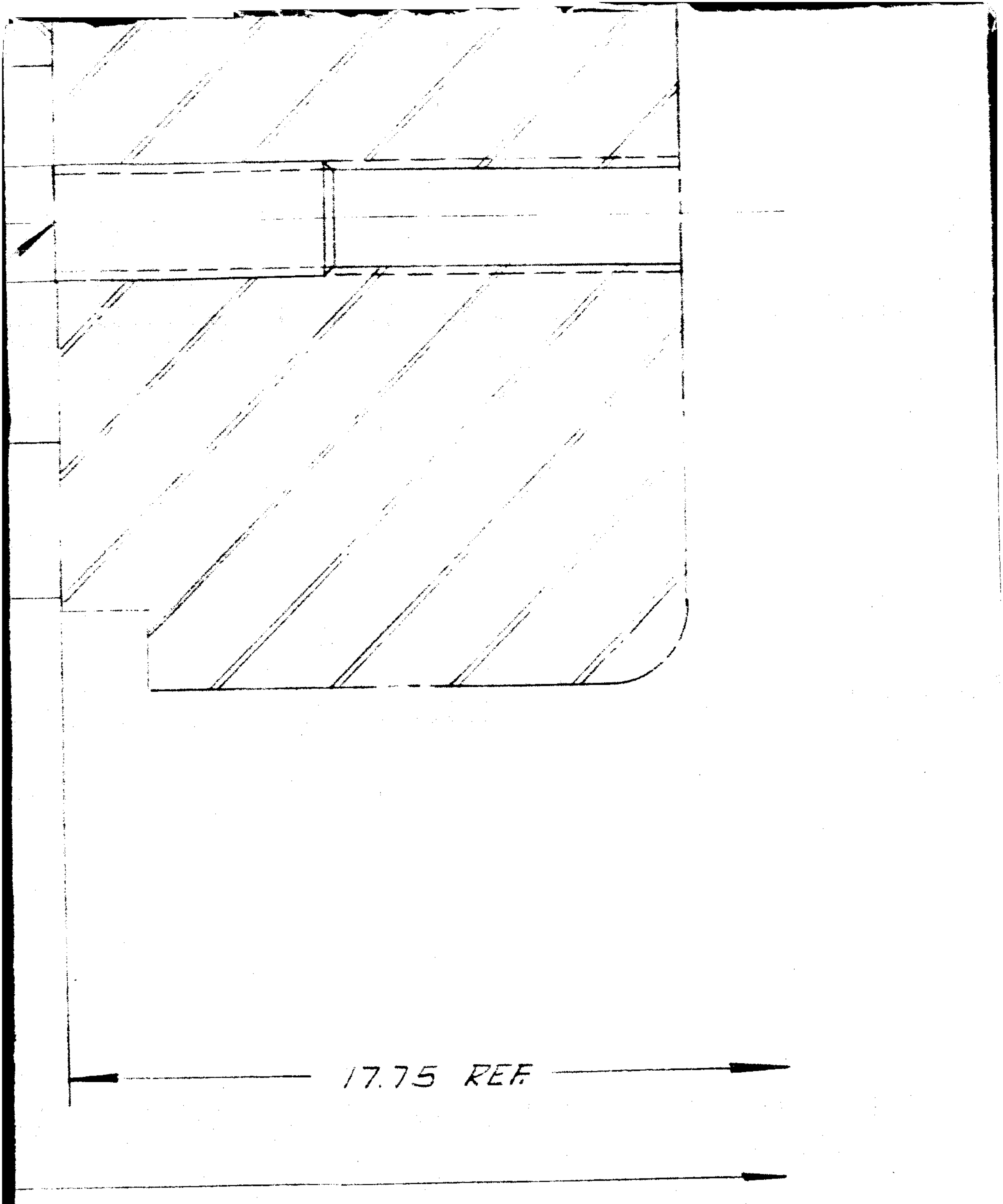
   F. CLOSE PRESS [illegible] LOWER SURFACE OF DIE RETAINER IS APPROX. FLUSH WITH NOSE OF PUNCH & SET CUSHION [illegible] [illegible].

   G. [illegible] DIE [illegible] IN DIE RETAINER, [illegible] BLANK IN & [illegible] IN [illegible] BALL IN PLACE.


9.375 REF.


34/3
32
1/2
48.00 SHUT HEIGHT


TAP 3/4 10 N.C. THRU
4 HOLES EQ SPACED
ON 12.000 B.C.D.
USE EXISTING
TOE CLAMPS (4)



#2

... PLACE THEN EXTRUDE.

2. FOR EXTRUDING ALUMINUM THE FOLLOWING APPLIES:

A. DETAILS -10, -11, -12, -13, -15, -17 & -18 ARE USED.

B DETAIL -10 APPLIES WHEN EXTRUDING A CUP WITH .100 WALL, -11 WITH A .150 WALL, -12 WITH A .200 WALL & -13 WITH A .250 WALL.

C. HEAT DETAILS -10, -11, -12 & -13 TO 800 °F

D. REPEAT 1-D E, F, G, & H OF ABOVE NOTE No. 1

A	SEE E.O.				NO. REQ.	NEXT ASSEM.	MODEL
LET.	CHANGES	DATE	BY	APP.			

ACT. WT	ISSUE DATE	ISSUE NUMBER
CALC. WT		

CUPPIN...

NO. REQ.	SIZE	DESCRIPTION
4	3/4-10NC x 5	[illegible] HD CAP SCR
4	3/4-10NC x 3 1/2	SOC HD CAP SCR.
12	#10-24NC x 1/2	BUTTON HD SCR
[illegible]	MODEL No. 200	[illegible] TOGGLE CLAMP
18	3/8-16NC x 3/4	SOC. HD CAP SCR.
3	1 O.D. x 1/8 WALL AS REQ'D	SHELBY SEAMLESS TUBING
3	3/4 DIA. AS REQ'D	C.R.S.
4	1/2-13 NC x 4	SOC HD CAP SCR.
4	3/4-10NC x 3	SOC. HD CAP SCR.

MATERIAL — ARMY — NAVY — MATERIAL SPECIFICATION

= GRIND
= SMOOTH MACHINE
= MACHINE
= ROUGH MACHINE

FINISH

HEAT TREAT

LIMITS UNLESS OTHERWISE SPECIFIED
.X = ± .06
.XX = ± .03
.XXX = ± .005
.XXXX = ± .0005
ANGULAR ± 1/2°

SCALE 1:1

APPROVED	[illegible]	[illegible]
PRO. ENG.	[illegible]	[illegible]
STRESS		
CHECKED	[illegible]	[illegible]
DRAWN BY	[illegible]	[illegible]

JOB NO.

HARVEY Aluminum TORRANCE, CALIFORNIA

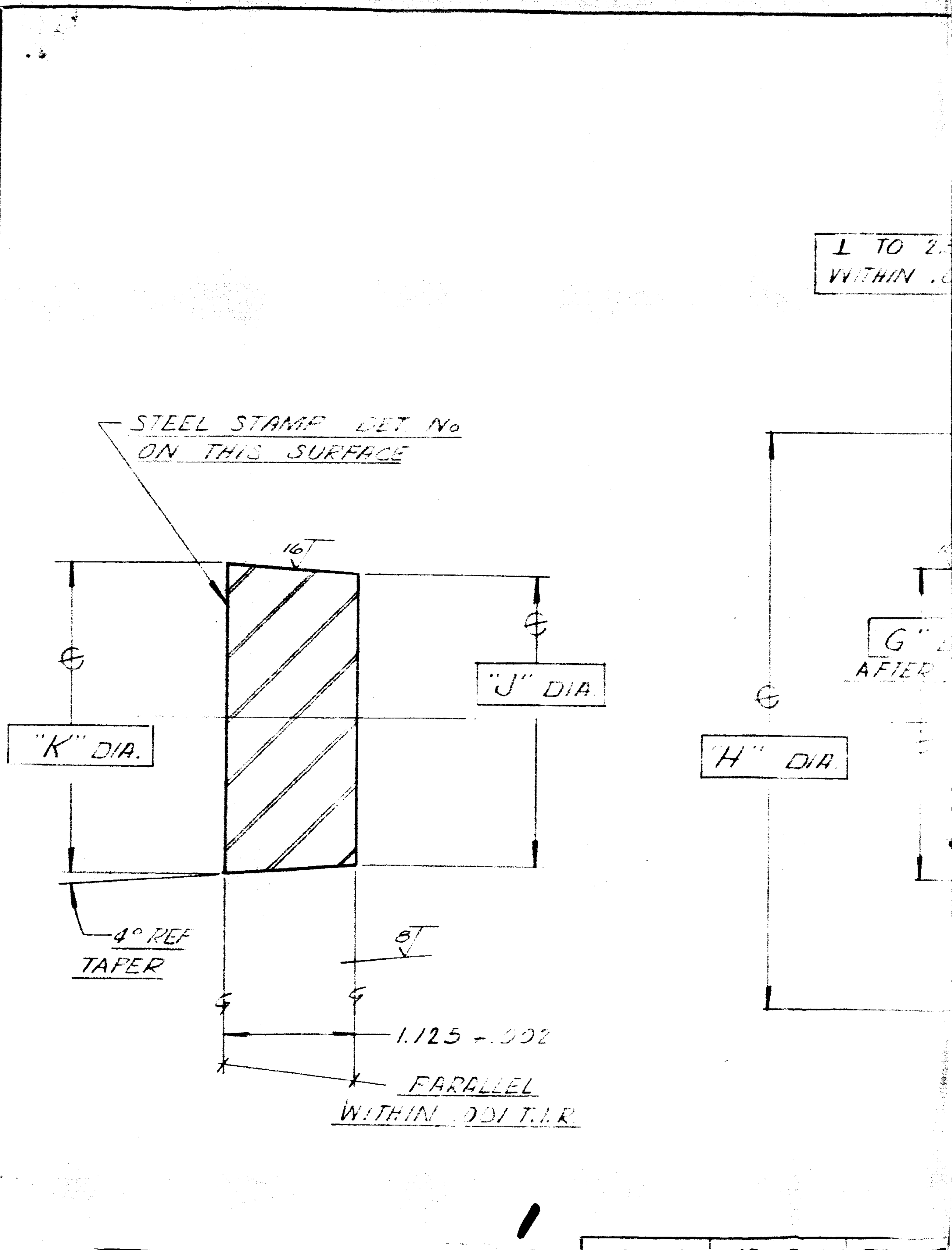
HARVEY ENGINEERING LABORATORIES

DIE

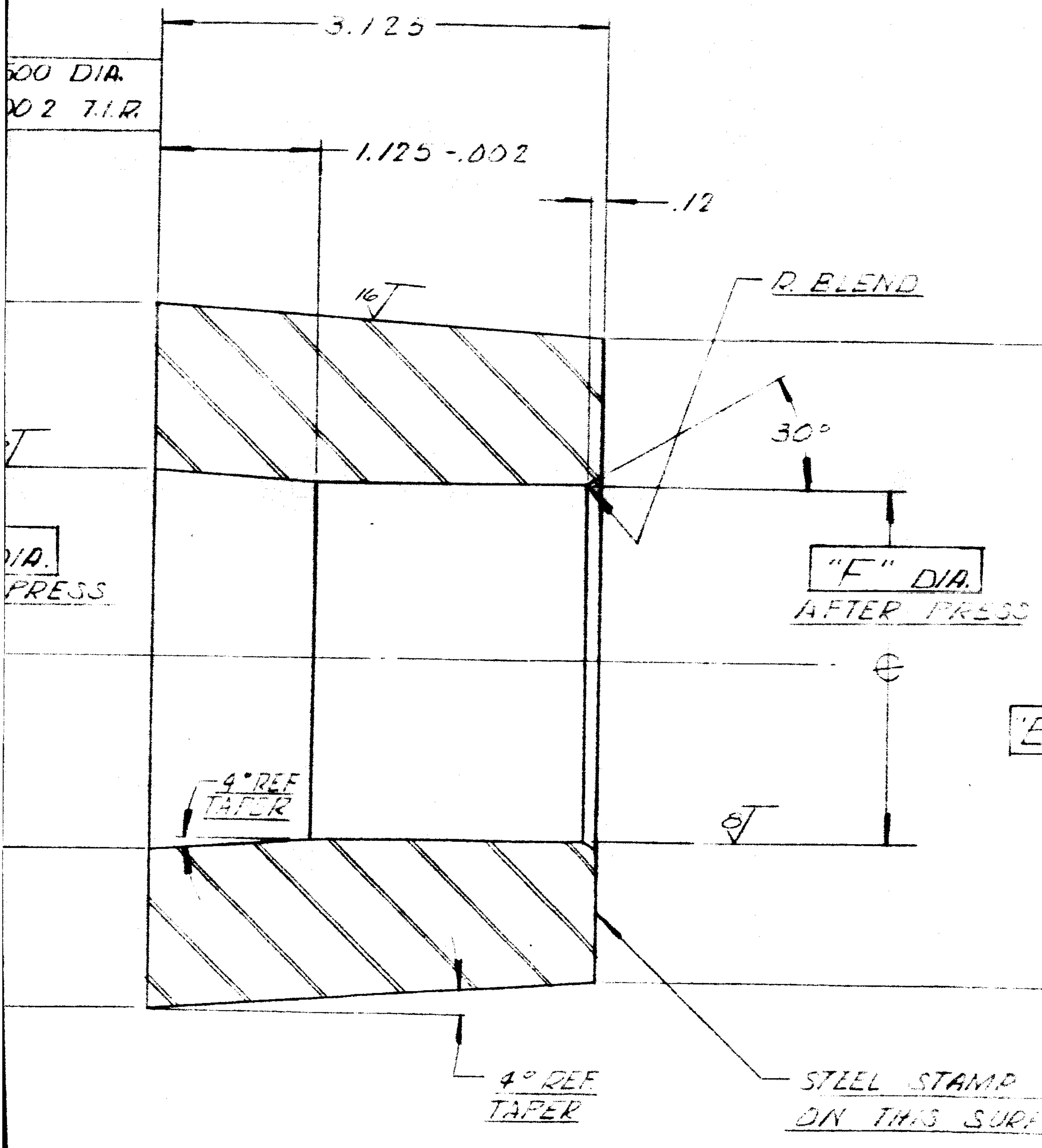
DWG. NO. 20-03303

SHT. 1 OF 4

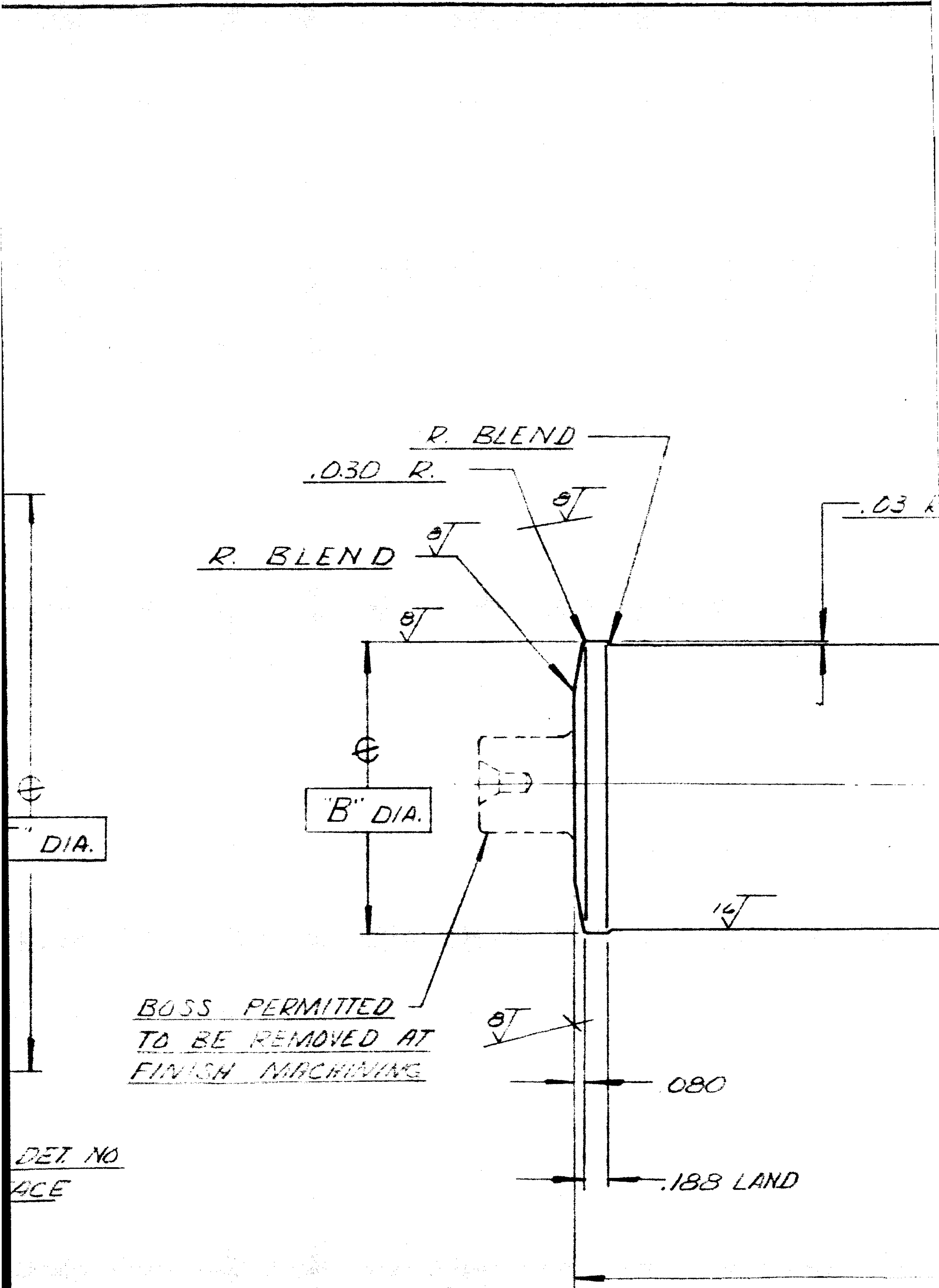
4 Dec 1 AUG 23 ER-0-3

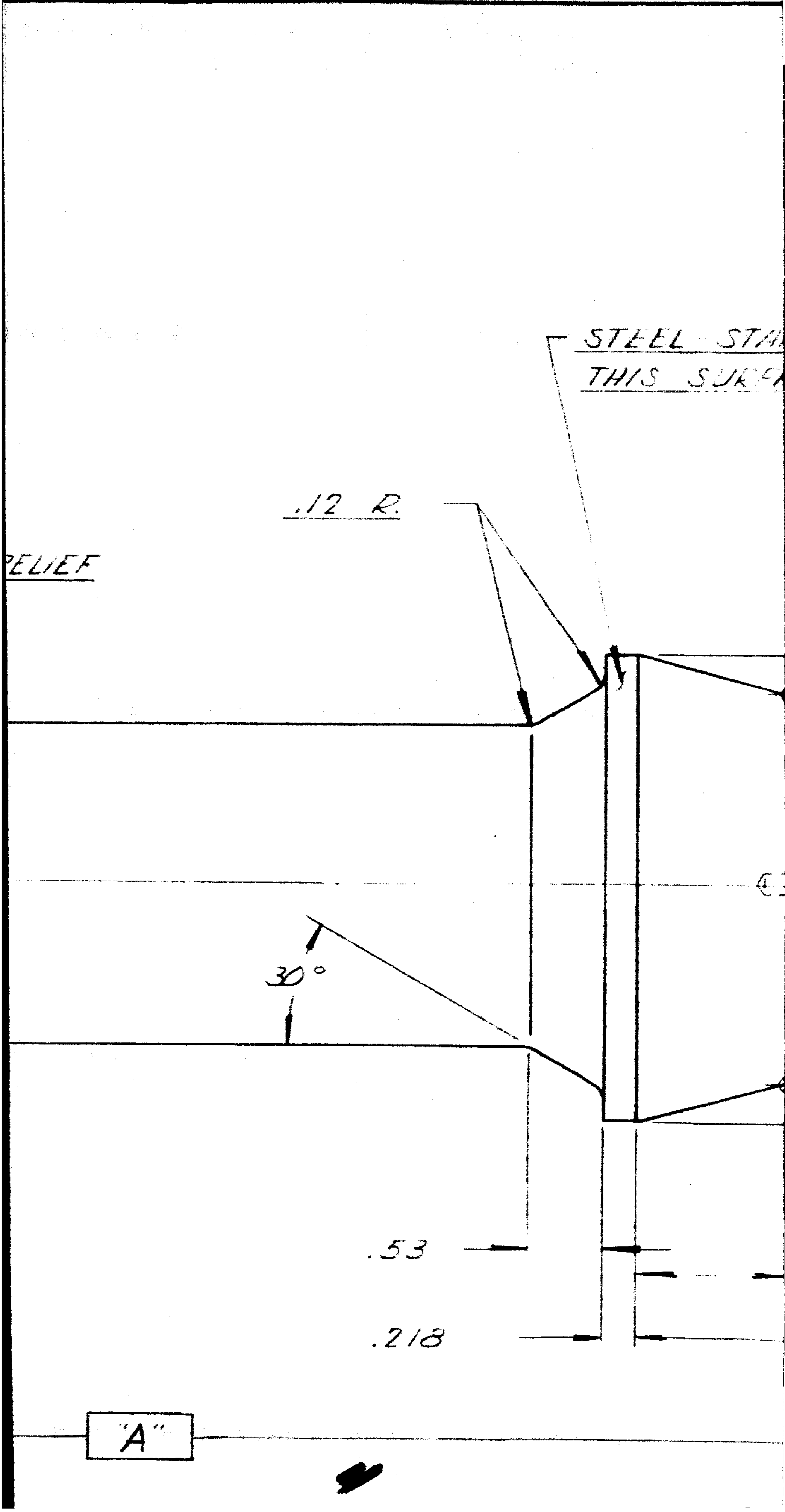


STEEL STAMP DET. No
ON THIS SURFACE
16
"J" DIA.
"K" DIA.
4° REF
TAPER
8
1.125 ±.002
PARALLEL
WITHIN .001 T.I.R
"H" DIA.
AFTER
⊥ TO
WITHIN



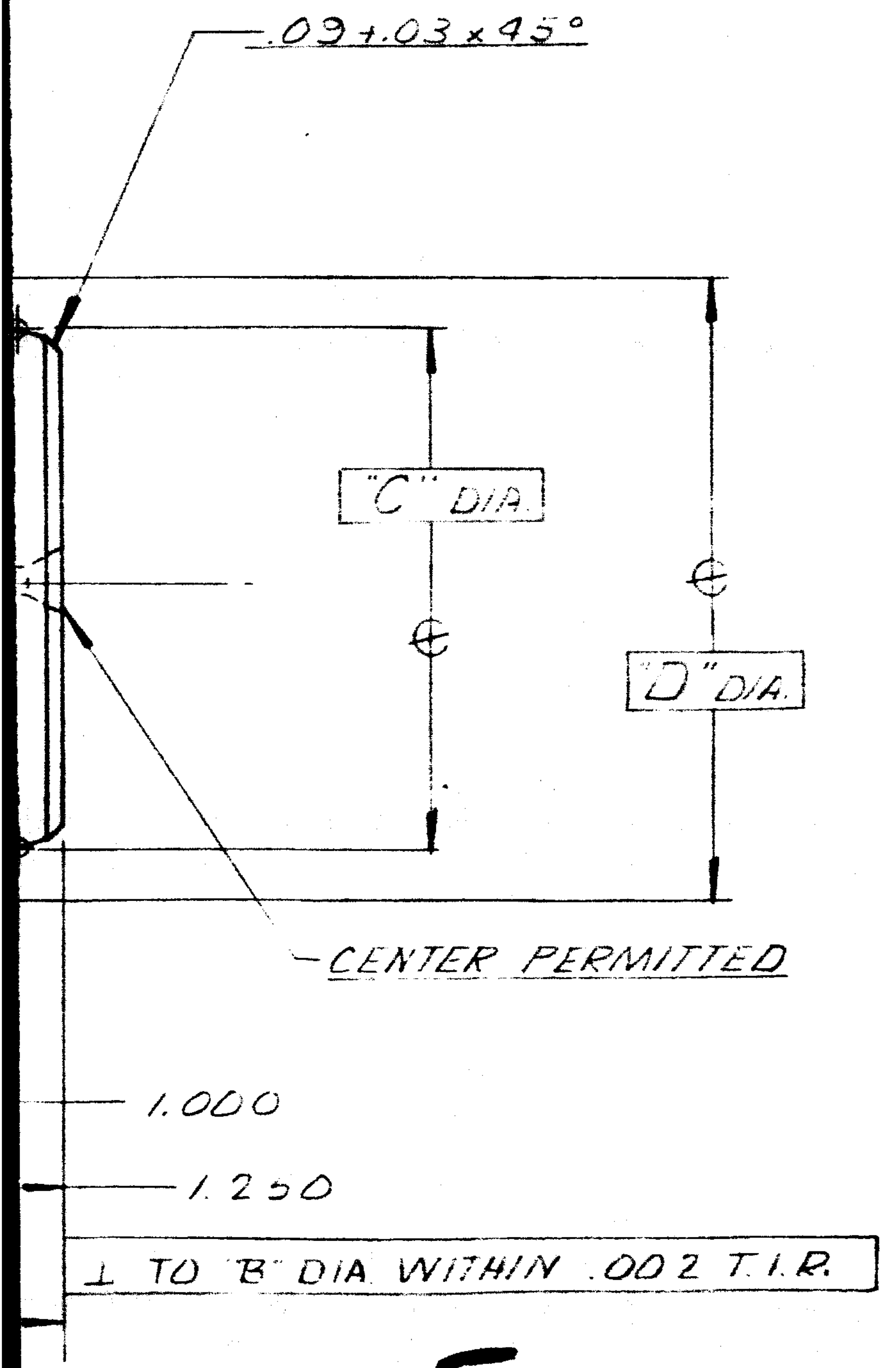
3.125
500 DIA.
002 T.I.R.
1.125 -.002
.12
R. BLEND
16
30°
"F" DIA.
AFTER PRESS
DIA.
PRESS
4° REF
TAPER
8
4° REF
TAPER
STEEL STAMP
ON THIS SURF


R. BLEND
.030 R.
R. BLEND
.03 R
"B" DIA.
DIA.
BOSS PERMITTED TO BE REMOVED AT FINISH MACHINING
.080
.188 LAND
DET. NO
ACE
8
16


STEEL STA
THIS SURF
.12 R.
RELIEF
30°
.53
.218
"A"

20-09303
SHT. 3

MP DET. NO ON
NCE



DASH No.	"J" DIA.	"K" DI
-16	2.977±.001	2.625±.00
-17	2.990±.001	2.648±.00

DET.-16 INSERT BASE

MAT'L: INCONEL 713 "C"

VACUUM CASTING.

DET. -17 INSERT BASE

MAT'L: HARDTEM PREHARDENED
HOT WORK DIE STEEL

DIA'S MARKED THUS ⊖ TO BE
CONCENTRIC WITHIN .001 T.I.R.

DASH No.	E [illegible]
-14	4.929 ±
-15	4.971 ±

DET. - 14 DIE INSERT

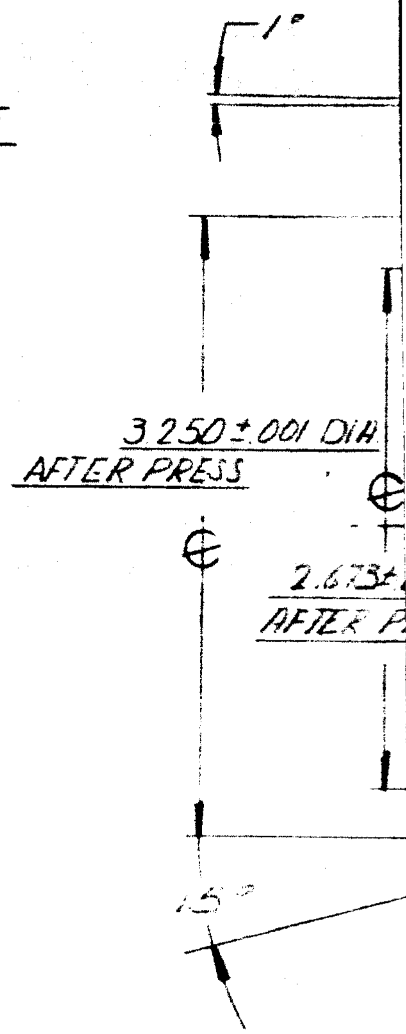
MAT'L: INCONEL 713 "C"

VACUUM CASTING

DET. - 15 DIE INSERT

MAT'L: HARDTEM PREHARDENED HOT WORK DIE STEEL

DIA'S MARKED THUS ⊕ TO BE CONCENTRIC WITHIN .001 T.I.R.



DET. - 34 PUNCH INSERT

MAT'L: INCONEL 713 "C"

VACUUM CAST

DIA'S MARKED THUS ⊕ TO BE CONCENTRIC WITHIN .002 T.I.R.

MACHINE FINISH 16√ ALL OVER

...DIA.	"F" DIA.	"G" DIA.	"H" DIA.
...001	2.461±.001	2.619±.001	4.851±.001
...001	2.484±.001	2.642±.001	4.837±.001

DET. -...

MAT'L ...

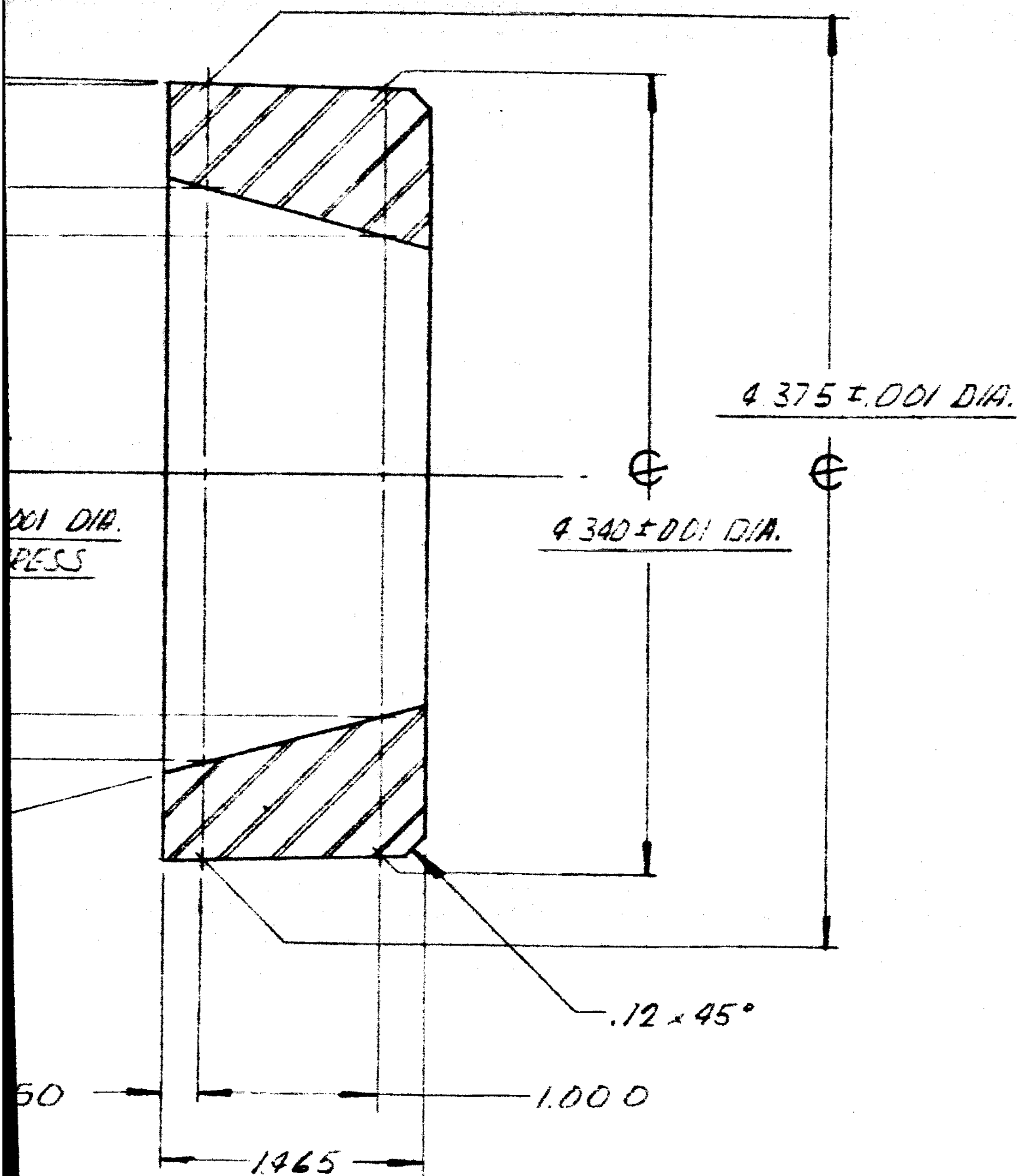
VACUU...

DET. -1...

MAT'L: ...

DIA'S ...

CONCEN...



A

LET.

ACT. W...

CALC. ...

6, -7, -8, & -9 PUNCH
INCONEL 713 "C"
CASTING

-10, -11, -12, & -13 PUNCH
HARDTEM PREHARDENED
HOTWORK DIE STEEL

MARKED THUS Є TO BE
TRIC WITHIN .001 T.I.R.

DASH No.	"A
- 6	8.3
- 7	8.3
- 8	8.2
- 9	8.2
- 10	8.4
- 11	8.3
- 12	8.34
- 13	8.25

ITEM NO.
34
17
16
15
14
13
12
11
10
9
8
7
6

G = G
// = S
/ = M
Rf = R

N

N

CHANGES	DATE	BY	APP.
SEE N.O.C.	[illegible]		

NO. REQ. | NEXT ASSEM. | MODEL

ISSUE DATE | ISSUE NUMBER

T

CUPPING

DIM.	"B" DIA.	"C" DIA.	"D" DIA.
66	2.263 ±.001	2.622 ±.001	3.199 ±.001
7	2.165 ±.001	"	"
7	2.067 ±.001	"	"
8	1.968 ±.001	"	"
5	2.285 ±.001	2.252 ±.001	3.229 ±.001
5	2.186 ±.001	"	"
6	2.086 ±.001	"	"
7	1.987 ±.001	"	"

NO. REQ.	SIZE	DESCRIPTION	MATERIAL SPECIFICATION
1	CAST AS SHOWN		INCONEL 713 "C"
1	3 DIA. x 1 1/2		HARDTEM FX-FINKL HEPPENSTAL
1	CAST AS SHOWN		INCONEL 713 "C"
1	5 1/2 DIA. x 3 1/2		HARDTEM FX-FINKL HEPPENSTAL
1	CAST AS SHOWN		INCONEL 713 "C"
1	3 1/2 DIA. x 9		HARDTEM FX-FINKL HEPPENSTAL
1	3 1/2 DIA. x 9		HARDTEM FX-FINKL HEPPENSTAL
1	3 1/2 DIA. x 9		HARDTEM FX-FINKL HEPPENSTAL
1	3 1/2 DIA. x 9		HARDTEM FX-FINKL HEPPENSTAL
1	CAST AS SHOWN		INCONEL 713 "C"
1	CAST AS SHOWN		INCONEL 713 "C"
1	CAST AS SHOWN		INCONEL 713 "C"
1	CAST AS SHOWN		INCONEL 713 "C"

NO. REQ. | SIZE | DESCRIPTION | ARMY | NAVY
MATERIAL | MATERIAL SPECIFICATION

GRIND
SMOOTH MACHINE
MACHINE
ROUGH MACHINE

FINISH
NOTED

HEAT TREAT
NOTED

LIMITS UNLESS OTHERWISE SPECIFIED
.X = ± .06
.XX = ± .03
.XXX = ± .005
.XXXX = ± .0005
ANGULAR ± 1/2°

SCALE 1:1

APPROVED [signature] [date]
PRO. ENG. [signature] [date]
STRESS
CHECKED [signature] [date]
DRAWN BY [signature] [date]
JOB NO.

HARVEY Aluminum
TORRANCE, CALIFORNIA

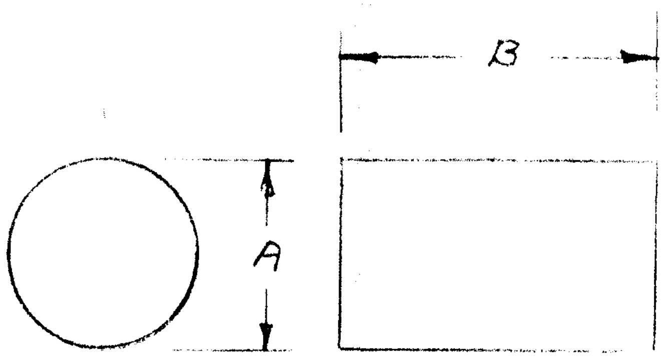
HARVEY ENGINEERING LABORATORIES

DIE DETAILS

DWG. NO. 20-09303
SHT. 3

FORM 1000H-D—1M—3-62—7-5885

20-09304



NO	MATERIAL	A	B
-1	7075-F	2.00	1.50
-2	8-1-1 Ti	2.00	1.50
-3	MARAGING 250	2.00	1.50
-4	7075-F	2.50	1.00
-5	8-1-1 Ti	2.50	1.00
-6	MARAGING 250	2.50	1.00

ITEM NO.	NO. REQ	MATERIAL SIZE	MATERIAL DESCRIPTION	MATERIAL SPECIFICATION ARMY	MATERIAL SPECIFICATION NAVY

G = GRIND
// = SMOOTH MACHINE
/ = MACHINE
Rf = ROUGH MACHINE

FINISH

HEAT TREAT

LIMITS UNLESS OTHERWISE SPECIFIED
.X = ± .06
.XX = ± .03
.XXX = ± .005
.XXXX = ± .0005
ANGULAR ± ½°

SCALE NONE

APPROVED
PRO. ENG.
STRESS
CHECKED
DRAWN BY
JOB NO.

HARVEY Aluminum TORRANCE CALIFORNIA
HARVEY ENGINEERING LABORATORIES

LET.	CHANGES	DATE	BY	APP.

NO. REQ	NEXT ASSEM.	MODEL

ACT. WT
CALC. WT
ISSUE DATE
ISSUE NUMBER

FORGING SLUG

DWG. NO. 20-09304