DESIGN OF A HYDRAULIC RIVETER

BY

BERNARD CARLYLE VAN PAPPELENDAM

THESIS FOR THE DEGREE OF BACHELOR OF SCIENCE

IN MECHANICAL ENGINEERING

IN THE

COLLEGE OF ENGINEERING

OF THE

UNIVERSITY OF ILLINOIS

JUNE, 1910

UNIVERSITY OF ILLINOIS

May 31 1910

THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

Bernard Carlyle van Pappelendam

ENTITLED Design of a Hydraulic Riveter

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF Bachelor of Science in Mechanical Engineering

O. A. Leutwiler
Instructor in Charge

APPROVED: G. A. Goodenough

HEAD OF DEPARTMENT OF Mechanical Engineering

SPECIFICATIONS.

Maximum rivet 1⅛" diameter, requiring a net pressure of 75 tons.

Accumulator pressure 1500 #/□".

Vertical throat 6 ft.

Distance between jaws 15".

Stroke 4".

Single pressure and single lever operated.

Frame of steel casting having solid ⊢⊣ section.

Allowable stresses:— Tension and compression 12,000 #/□",

Shear 10,000 #/□"

CALCULATIONS

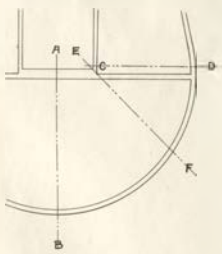

Fig. 1.

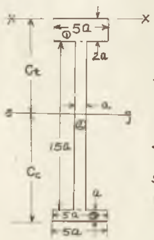

Fig. 2.

Main Frame.

For stresses on the section AB, Fig. 1.

Assume the proportions shown by Fig 2. The section being divided up into the three rectangles marked ①, ② and ③. The following table then

shows the properties. Where A = area, M_{xx} = first moment about xx, I_{xx} = second moment or moment of inertia about xx, and $I_{cg.}$ = same about center of gravity line cg.

Section	A	M_{xx}	I_{xx}	$I_{cg.}$
①	$10a^2$	$10a^3$	$43a^4$	$3.33a^4$
②	$15a^2$	$143a^3$	$1631a^4$	$281.a^4$
③	$5a^2$	$87a^3$	$1530a^4$	$0.42a^4$
Entire	$30a^2$	$240a^3$	$3204a^4$	$1284.a^4$

Then $C_t = M_{xx}/A = 240a^3/30a^2 = 8a$

and C_c = (see Fig. 2) $18a - 8a = 10a$

$M/S_t = I_{cg}/C_t$ so $[150{,}000(72+8a)]/12000 = 1284a^4/8a$

from which $a = 1.9$ inches. The following dimensions (Fig. 2.) were chosen, due partly to the way in which the other sections worked out. web a = 2". 2a = 4". 5a = 12". 15a = 28". a (at bottom) = 3"

Since $S_c = S_t$ and C_c is greater than C_t, this section is all right for compression.

Used the same method as above for section cd (Fig. 1.) and it came out S_c and S_t = 11,750 #/□" with width = 12", depth = 26", web thickness = 2", flange thickness 3".

For the 45° section EF. Assume flanges 3"×12" and web 2"×22" then by Carnegie $I/c = [12\times(28)^3-(22)^3 8]/6\times28 = 106$

and S due to bending, both tension and compression = MC/I

$= [150000(72+(14\times.707))]/106 = 11600$ #/□"

and S due to direct force, both tension and shear = P/A

$= (150000\times.707)/116 = 910$ #/□"

Tension stress (combined) = $S_t = 11600+910 = 12{,}510$ #/□" and the

equivalent stress = $S_t/2 + \sqrt{(S_t/2)^2+(S_s)^2} = 6{,}255+\sqrt{6255^2+910^2}$ = 12,575 #/□" which is all right because the one flange is considerable more than 3" wide when measured along this section.

Area required for pure shear, i.e. on center line of die equals $P/S_s = 150000/10000 = 15$ sq. in. so make it as shown by fig 3, and the section just below this as shown by fig 4.

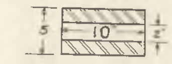

Fig. 3.

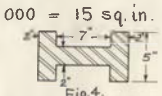

Fig. 4.

For the section three feet below the center line of dies S (due to bending both tension and compression for an assumed section with flanges 2½"×10" and web 2"×16") equals MC/I

$= [150000\times36\times6\times21] \div [(10\times(21)^3)-(8\times(16)^3)] = 11{,}300$ #/□"

and $S_s = P/A = 150000/82 = 1{,}830$ #/□"

so $S_e = S/2 + \sqrt{(S/2)^2+(S_s)^2} = 5650+\sqrt{5650^2+1830^2} = 11{,}570$ #/□"

The Piston and Cylinder.

The net area required equals total force on rivet divided by pressure of water used = 150000/1500 = 100 sq. in. The net area equals the main piston area minus the return piston area. After observing several makes of riveters it was decided to have these areas (i.e. of the two pistons) in the ratio of 1 to 0.09. Then the area of the main piston must be 100/.91 = 110 sq. in. and its diameter 12 inches.

The small piston area is 110 − 100 = 10 sq. in. and the corresponding diameter 3½ in.

Thickness of cylinder walls.

From Meriman $rp/(S-p) = t$

where t = thickness of wall in inches.

r = radius of cylinder in inches.

p = pressure in cylinder in pounds per square inch.

S = allowable tensil stress in walls in pounds per sq. in.

From which, for the main cylinder $t = (6\times1500)/(12000-1500) = 0.85"$. Make it 1.25" for reboring.

For the small cylinder $t = (1.75\times1500)/(12000-1500) = 0.25"$

Keep it ½ inch on account of flaws. This will also permit reboring as that part is thicker. See detail drawing.

Thickness of flat cylinder head.

From Merriman $d = \sqrt{\frac{r^2R}{S}}$

where r and S are as above

d = thickness of head in inches.

R = pressure in cylinder in pounds per square inch.

From which, for the main cylinder head $d = \sqrt{\frac{6^2\times1500}{12000}} = 2.2$ in.

Make it 2¼" the material being steel casting.

For the small cylinder head $d = \sqrt{\frac{(1.75)^2\times1500}{12000}} = 0.4$ = say ¾".

Size and number of bolts for cylinder heads.

For the large head. Using 1¼" studs with 8 threads per in.

The net area = 0.85 sq. in. and the number required $\frac{150000}{15000\times.85} = 12$

Same method shows 6 − ½"×13 thread studs necessary for the small cylinder head.

Forces on the Piston.

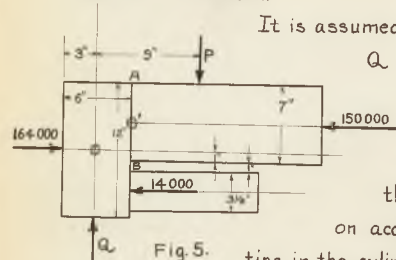

Fig. 5.

It is assumed that the forces P and Q (Fig. 5) act at the center of the surface on which they slide. This assumption, though not true, is safe on account of the piston fitting in the cylinder. The 150000# force is that necessary on the rivet. The 164000# and 14000# forces were obtained by multiplying corresponding piston areas by the accumulator pressure. P = Q (only vertical forces) and by moments about O, $P = [(150000\times2\tfrac{1}{2})-(14000\times3\tfrac{3}{4})]/9 = 35800$#

For section AB S (due to bending alone, both tension and compression) = $MC/I = [(164000\times2\tfrac{1}{2})-(35800\times3)-(14000\times6\tfrac{1}{4})] \div [.098\times7^3] = 6400$

S_c (due to crushing) = $P/A = 150000/38.5 = 3900$#

Max. $S_c = 6400+3900 = 10\ 300$#

Max. $S_t = 6400-3900 = 2\ 500$#

So cast iron is all right.

The Valve.

After comparing with other makes of riveters a 1½" valve was decided upon.

Diameter of valve piston = 2". So with ports 5/16 in. wide and eight guide strips for leather washers, the net area is $(\tfrac{5}{16}\times\pi\times2)-(8\times\tfrac{1}{8}\times\tfrac{5}{16})$ (for ⅛" guide strips) = 1.65 sq. in.

Size of piston stem (Fig. 6) Area = $1.75 = \pi - \pi x^2/4$.

from which $x = 1.3"$ = say 1¼".

Fig. 6.

Fig. 7 is a section through weakest part of valve body. i.e. through center line of ports. The stress $= P/A = [1500\times.7854(3\tfrac{1}{2}^2-2^2)]/[.7854\times(4\tfrac{1}{2}^2-3\tfrac{1}{2}^2)] = 1500$ #/□". So valve is to be made of bronze.

Use "Standard Extra Strong" piping and "Line Pipe" couplings.

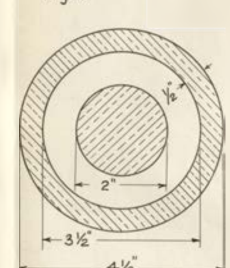

Fig. 7.

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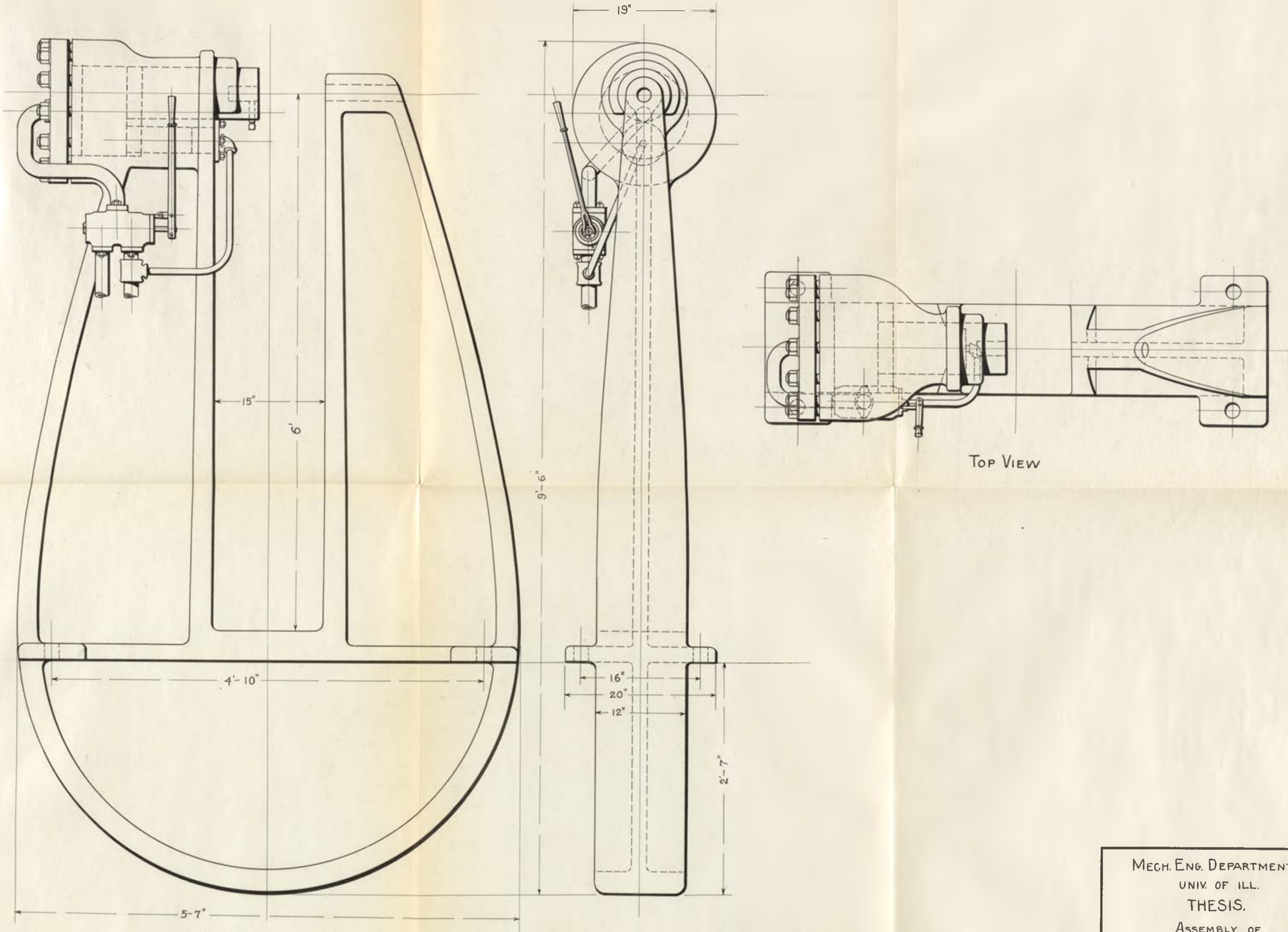
THESIS

CALCULATIONS FOR 6 FT. HYDRAULIC RIVETER.

SHEET NO. 1.

April 18, 1910. B. van Pappelendam



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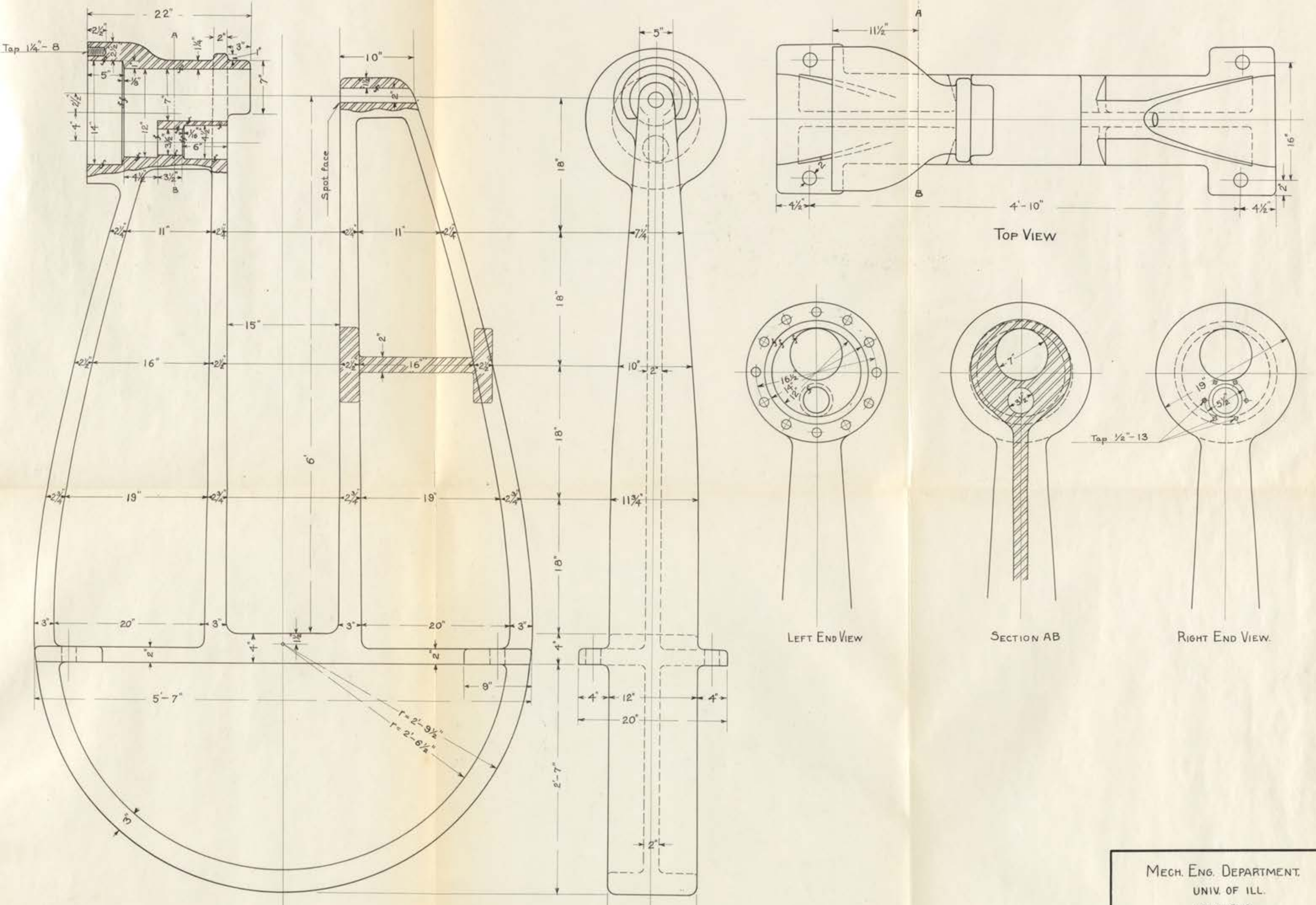
Univ. of Ill.
THESIS.
Assembly of
6 Ft. Hydraulic Riveter.
Sheet No. 2.
Scale = 1/8 size. B. van Poppelendam.



Nº 31. FRAME.

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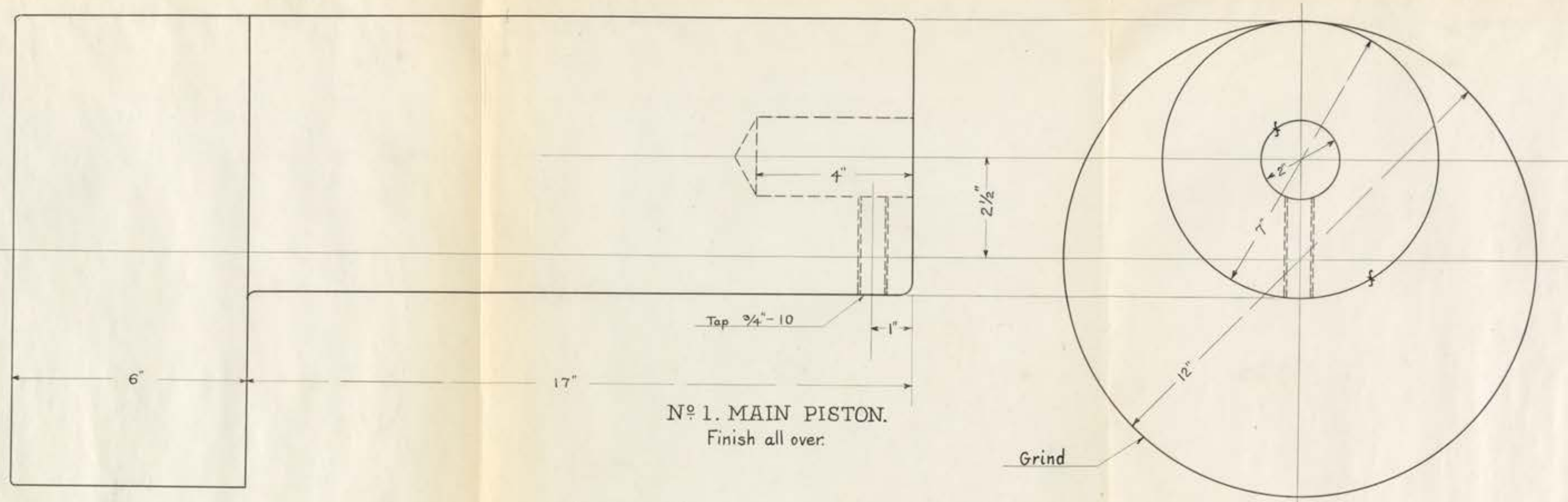
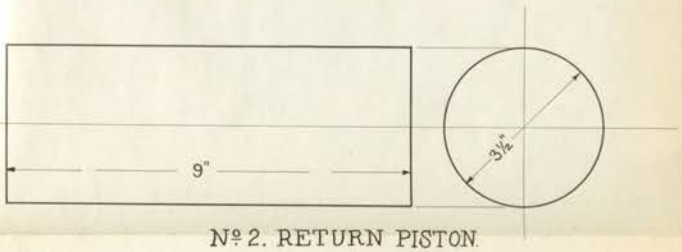
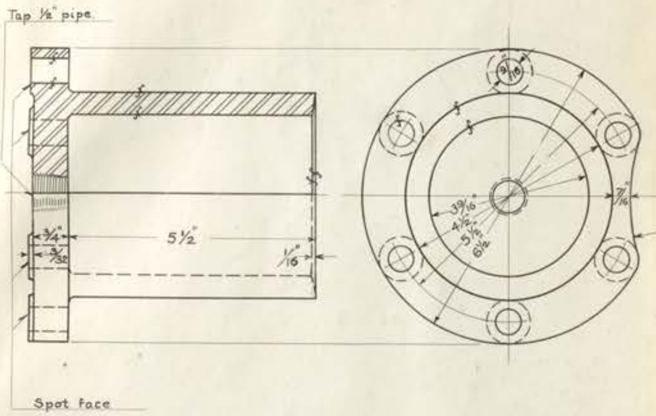
THESIS.
Details of
6 Ft. Hydraulic Riveter.
Sheet No. 3.
Scale:- ⅛ size. B. von Pappelendam.



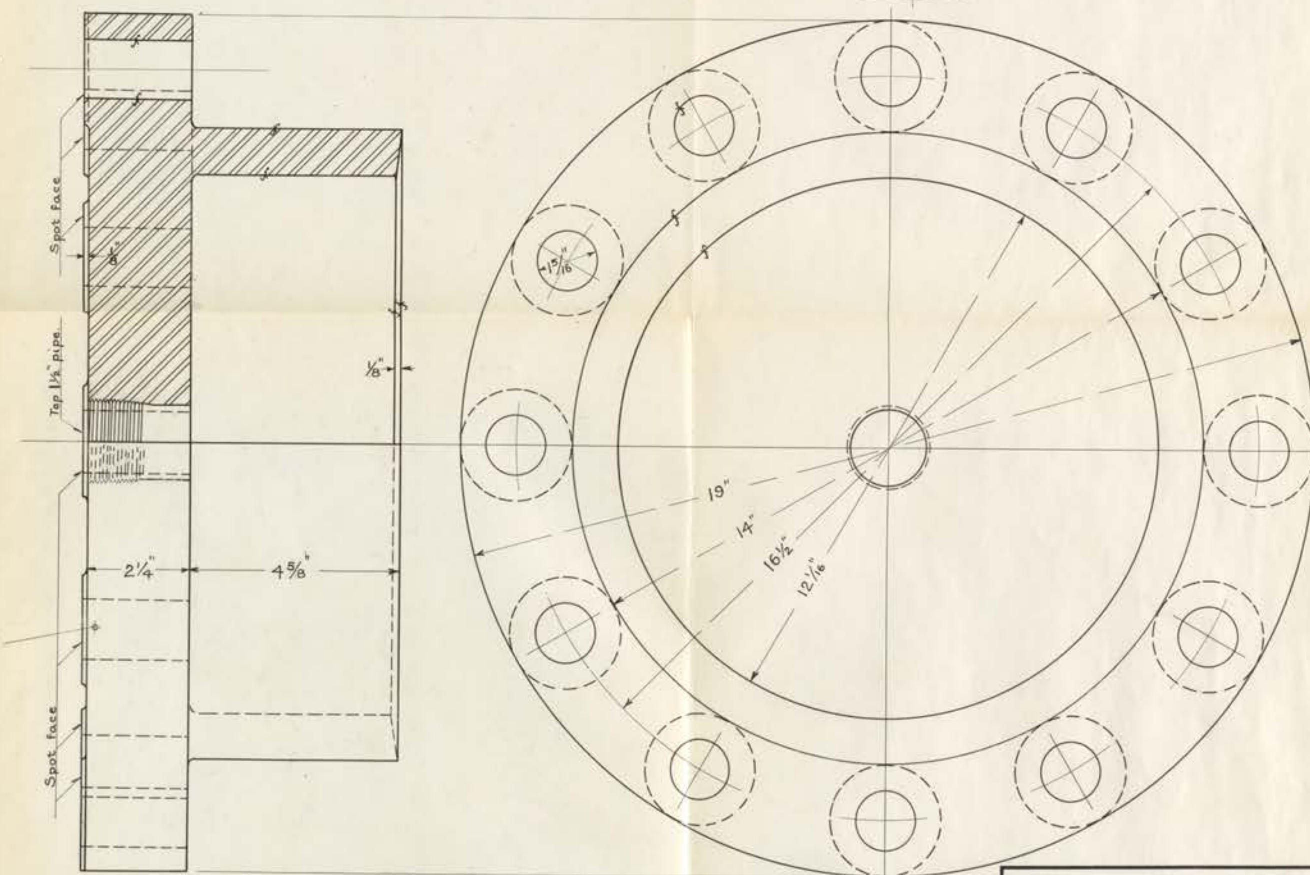
N° 1. MAIN PISTON.
Finish all over.



N° 2. RETURN PISTON.
Finish all over



N° S3. RETURN CYLINDER HEAD.



N° S2. MAIN CYLINDER HEAD.

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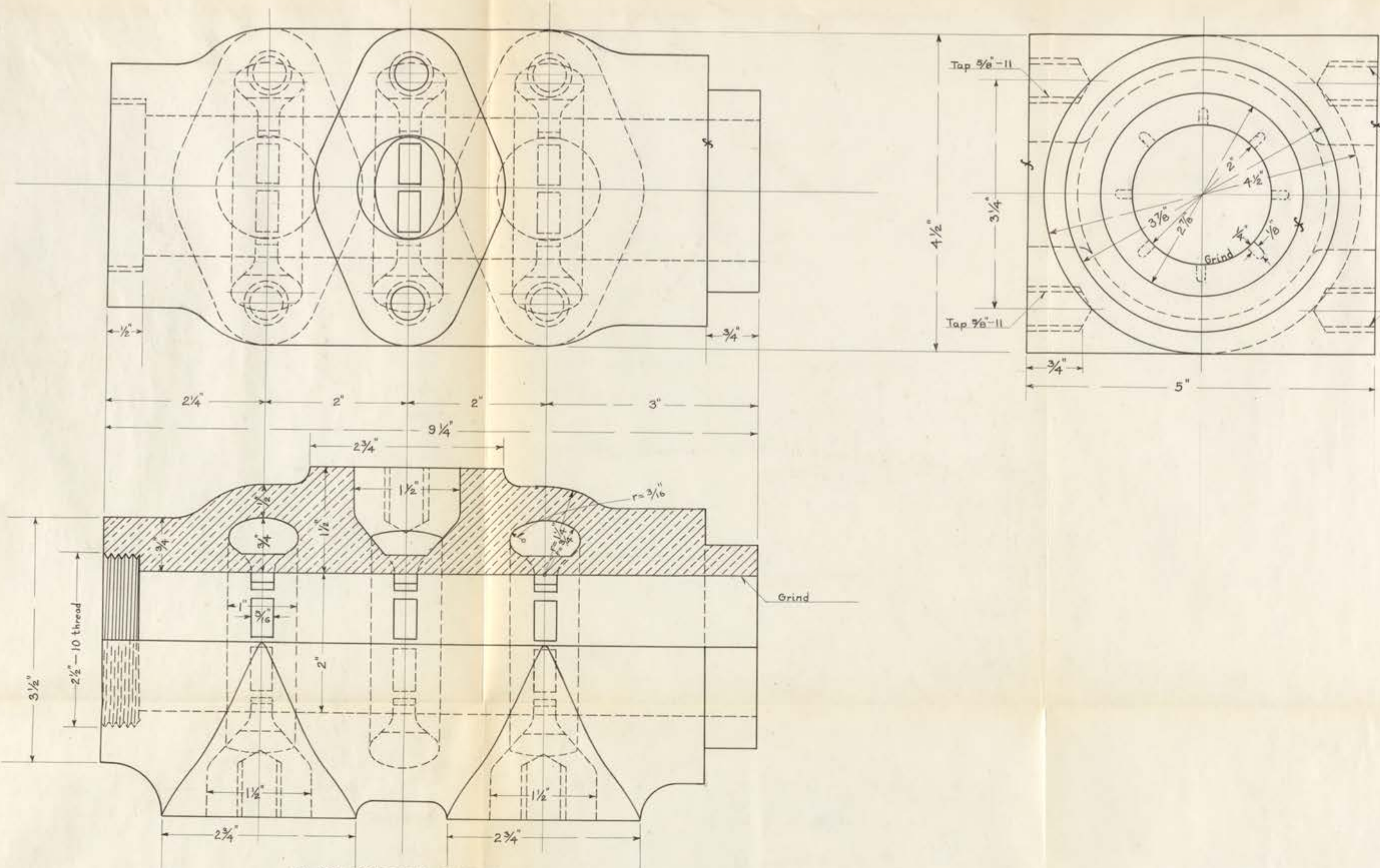
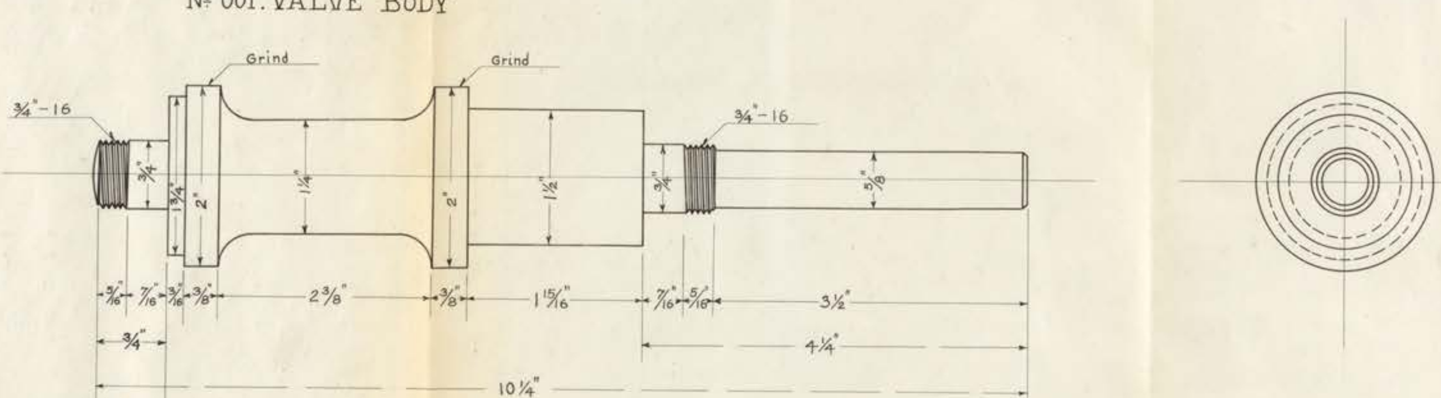
THESIS.
DETAILS OF
6 FT. HYDRAULIC RIVETER.
SHEET NO. 4.
Scale:- ½ size. B. van Pappelendam



Nº 001. VALVE BODY



Nº 002. VALVE PISTON.
Finish all over.

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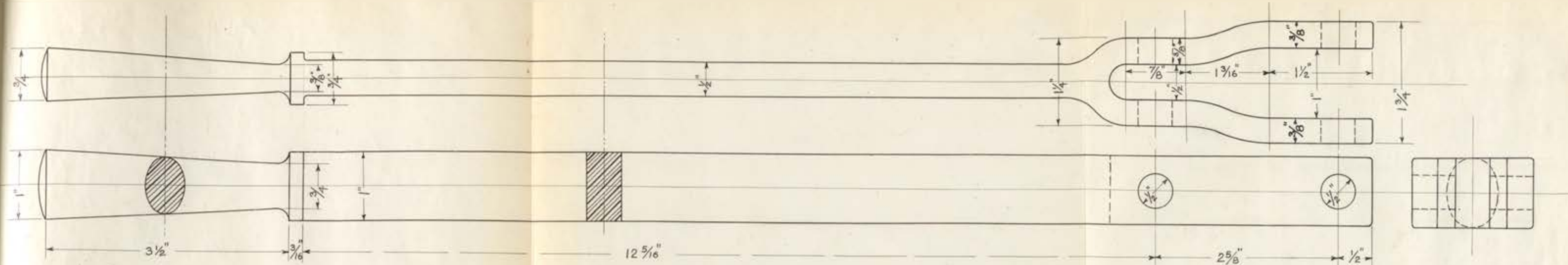
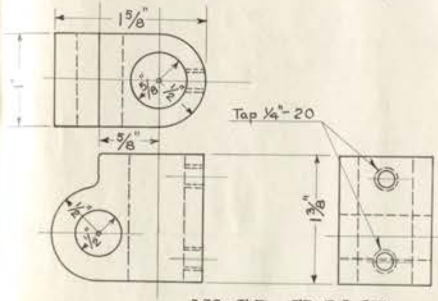
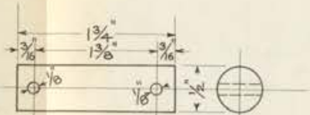
THESIS.
DETAILS OF
6 FT. HYDRAULIC RIVETER.
SHEET NO. 5.
Scale :- Full size. B. van Pappelendam.



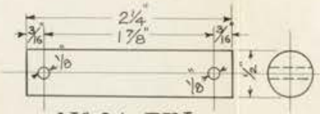
Nº 03. VALVE HANDLE.



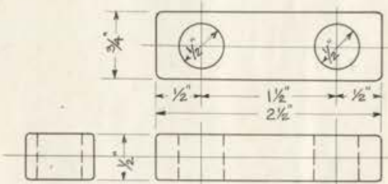
Nº S5. CLAMP.



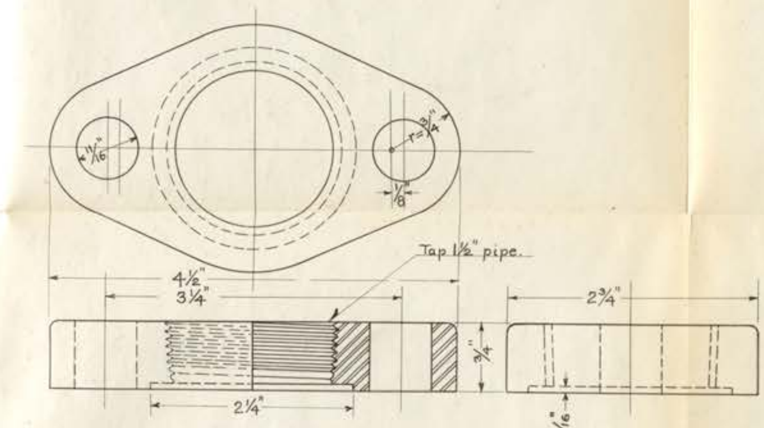
Nº 05 PIN.



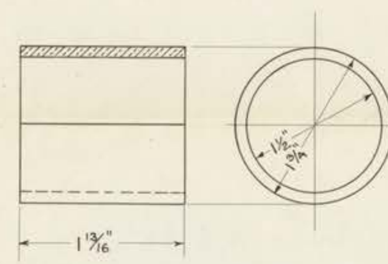
Nº 04 PIN.



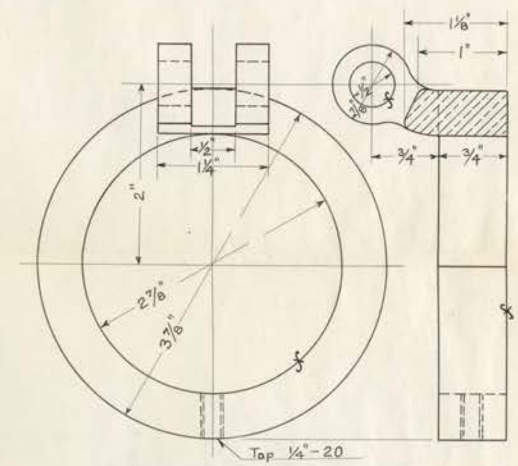
Nº 06 LINK.



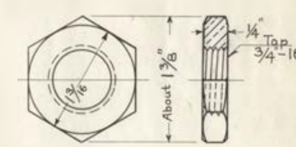
Nº S4. PIPE FLANGE.



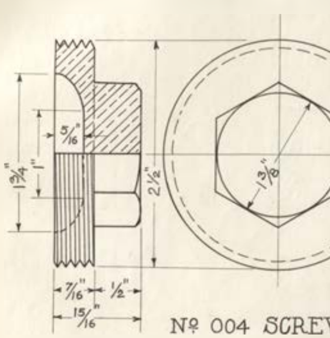
Nº 005 COLLAR
Finish all over.



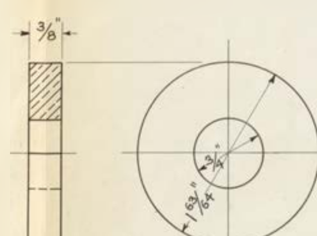
Nº 003 VALVE COLLAR



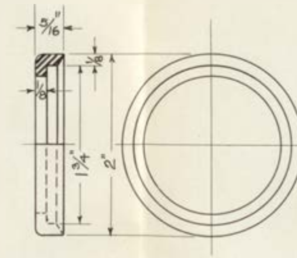
Nº 007 NUT
Finish all over.



Nº 004 SCREW CAP



Nº 006 WASHER.
Finish all over.



Nº 0001 LEATHER WASHER

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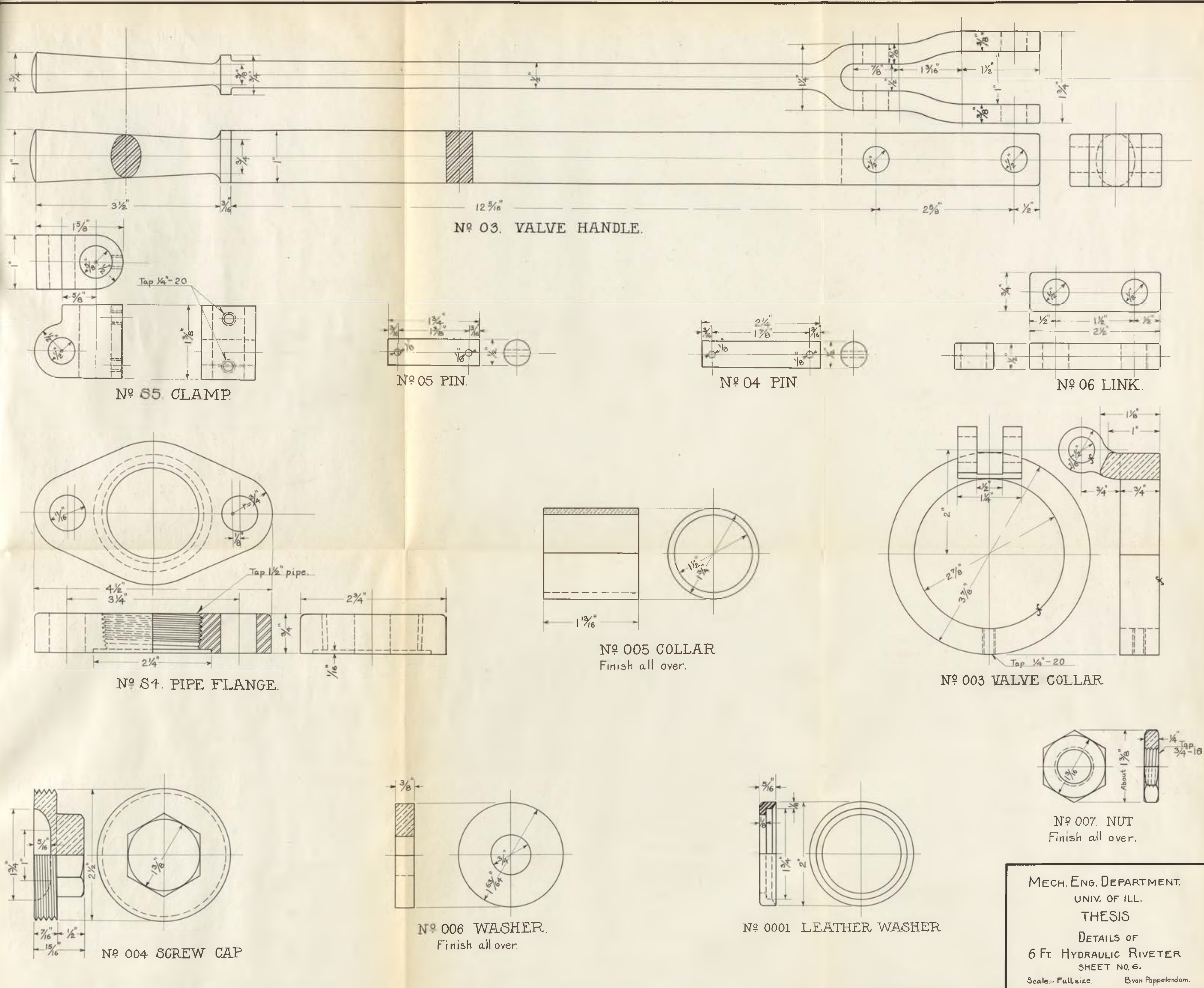
THESIS
DETAILS OF
6 FT. HYDRAULIC RIVETER
SHEET NO. 6.
Scale:- Full size.
B. von Pappelendam.



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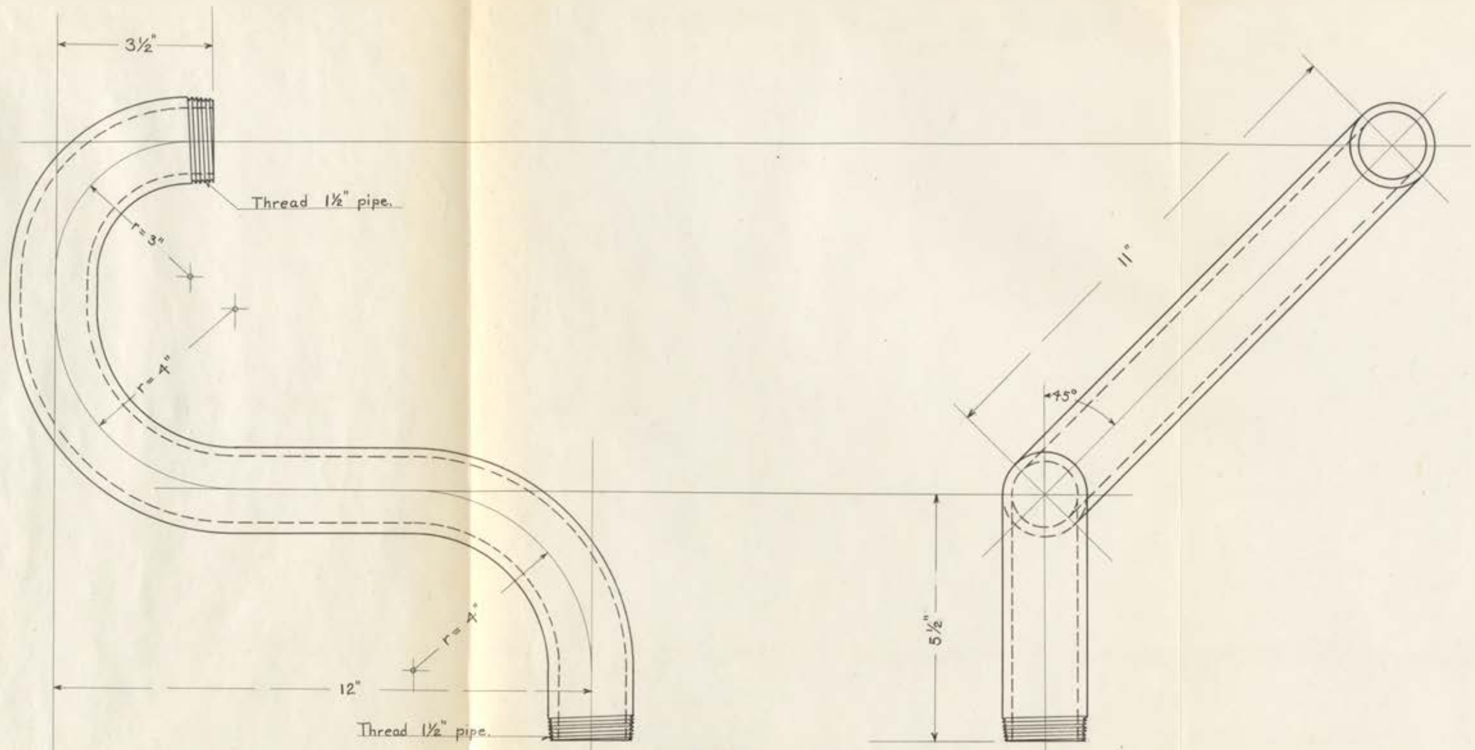
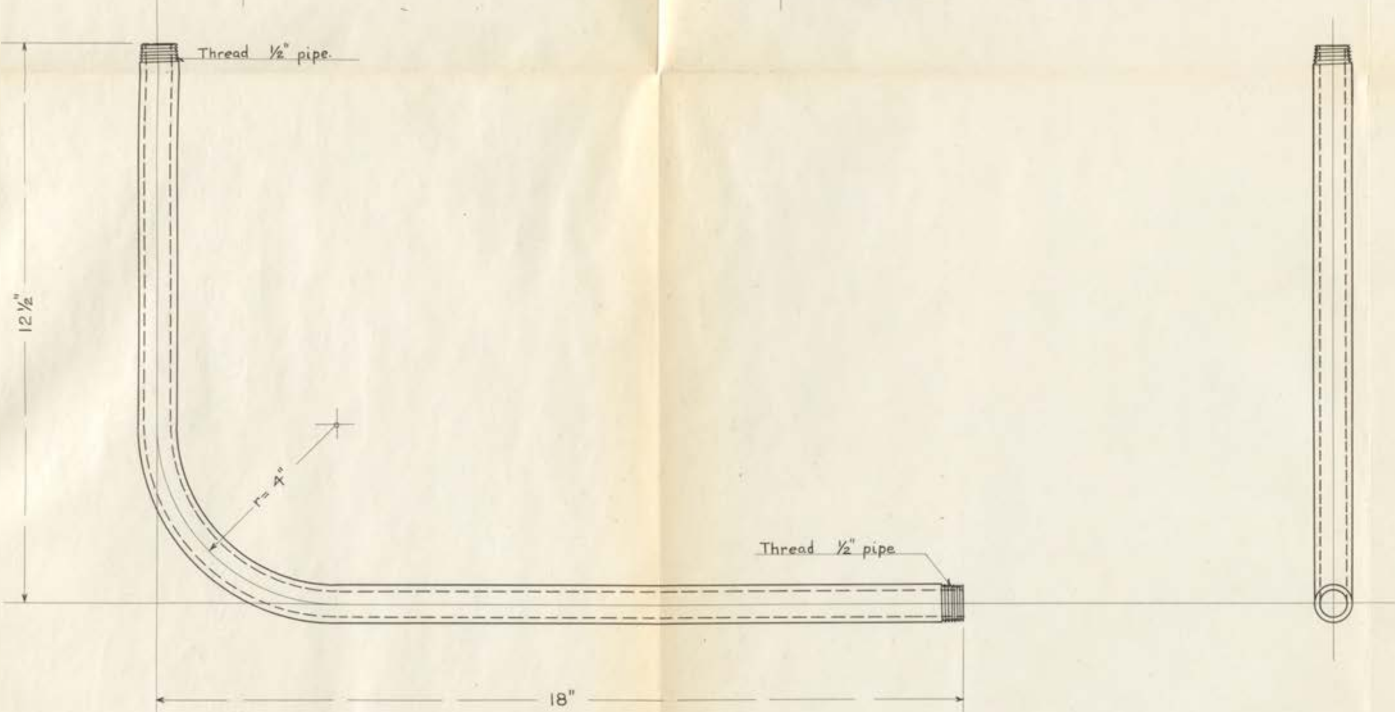
THESIS
DETAILS OF
6 FT. HYDRAULIC RIVETER
SHEET NO. 6.
Scale.- Full size. B. van Pappelendam.



Nº 01 PIPE TO MAIN CYLINDER



Nº 02. PIPE TO RETURN CYLINDER.

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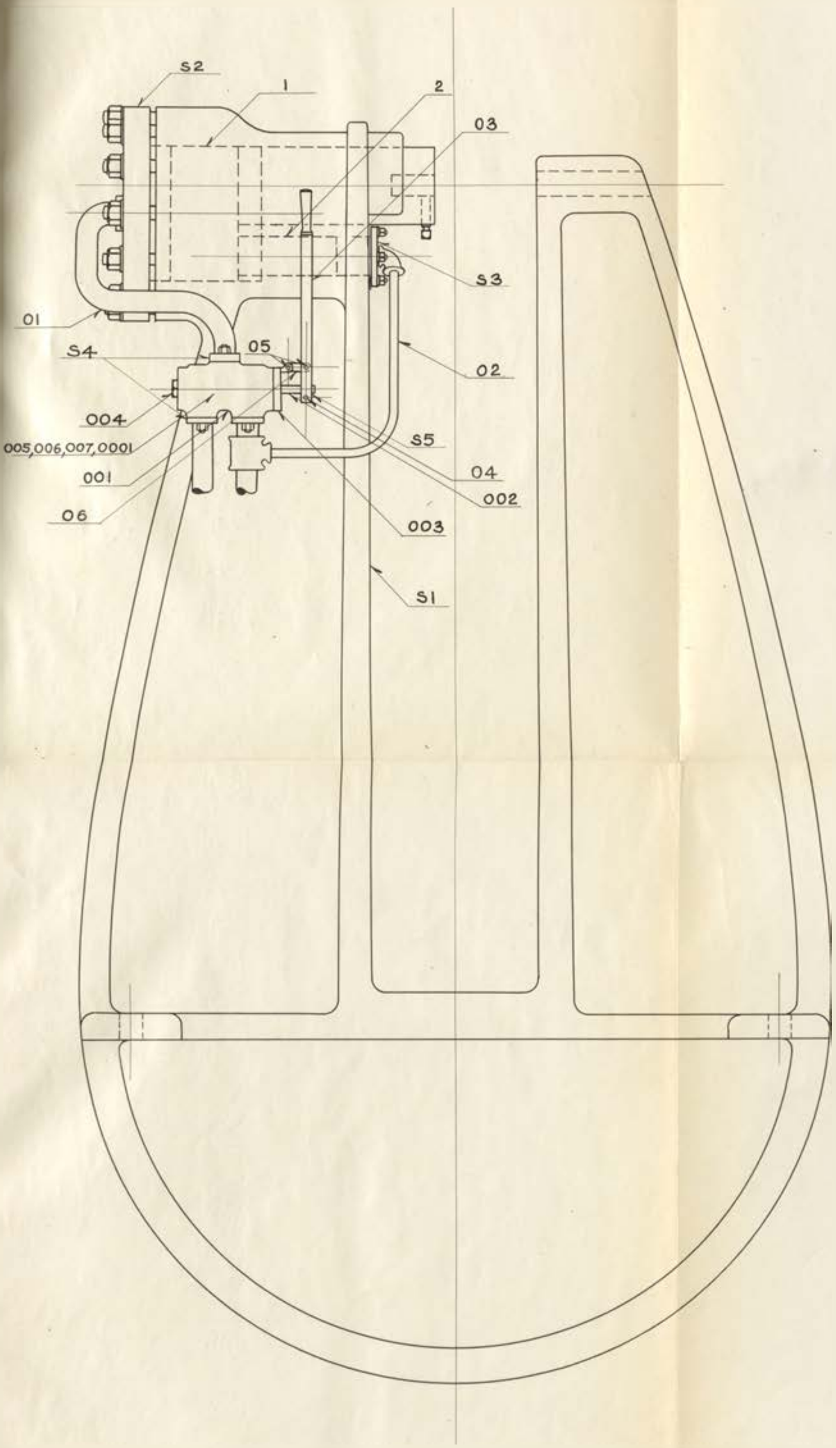
THESIS.
DETAILS OF
6 FT. HYDRAULIC RIVETER.
SHEET NO. 7.
Scale :- ½ size. B. van Pappelendam.



BILL OF MATERIAL.

Number	Name	Material	Sheet No.	No. Wanted
S1	Frame	Steel Casting.	3	1
S2	Main Cylinder Head.	" "	4	1
S3	Return Cylinder Head.	" "	4	1
S4	Pipe Flange.	" "	6	4
S5	Valve Stem Clamp.	" "	6	1
1	Main Piston.	Cast Iron.	4	1
2	Return Piston.	" "	4	1
01	Pipe for Main Cylinder.	Mild Steel.	7	1
02	Pipe for Return Cylinder.	" "	7	1
03	Valve Handle.	" "	6	1
04	Pin.	" "	6	1
05	Pin.	" "	6	2
06	Link.	" "	6	1
001	Valve Body.	Bronze.	5	1
002	Valve Piston.	"	5	1
003	Valve Collar.	"	6	1
004	Screw Cap.	"	6	1
005	Collar.	"	6	1
006	Washer.	"	6	2
007	Nut.	"	6	2
0001	Washer.	Leather.	6	3

STOCK LIST.

Name.	Size.	No. Wanted.
Cotter Pins	1/8" × 3/4"	6
Stud Screws	5/8"-11 × 2 1/4" × 1" × 3/4"	8
" "	1/2"-13 × 2" × 5/8" × 5/8"	6
" "	1 1/4"-8 × 5 3/4" × 2" × 1 1/2"	12
Nuts.	5/8"-11	8
"	1/2"-13	6
"	1 1/4"-8	12
Set Screws (Cup Point)	1/4"-20 × 5/16"	2
" " "	1/4"-20 × 5/8"	1
" " "	3/4"-10 × 2 3/4"	1
Pipe Tee	1 1/2" × 1 1/2" × 1/2"	1
Pipe Elbow	1/2"	1
Nipple (Short)	1 1/2"	1
" "	1/2"	1
Leather Gasket.	2 1/4" × 1 3/4" × 3/32"	4
" "	2 1/2" × 1 3/4" × 1/16"	1

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THESIS.
BILL OF MATERIALS FOR
6 FT. HYDRAULIC RIVETER
SHEET NO. 8.
Scale:- 1/8 size B. van Pappelendam.