

Design Report 2

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1. Objective Definitions

Total Cost

The qualitative requirement is that the device should be affordable to produce and purchase. A quantitative equivalent is the total cost in dollars, which includes raw material expenses and fastener costs. This can be determined by itemizing the bill of materials and estimating the fabrication costs for each design. A concept costing \$45 scores higher than one costing \$85.

$$Total\ Cost = \Sigma(Cost\ of\ Stock\ for\ Manufactured\ Parts) + \Sigma(Cost\ of\ OTS\ Parts)$$

Manufacturing Time

The qualitative requirement is that the device should be quick and efficient to produce. A quantitative proxy is the projected manufacturing time in minutes. This can be determined by summing the estimated time required for each fabrication process, accounting for material machinability and thickness. A concept requiring 30 minutes to manufacture scores higher than one requiring 75 minutes.

$$Total\ Manufacturing\ Time = \Sigma(Individual\ Part\ Manufacturing\ Time)$$

Size

The qualitative requirement is that the device should be compact and space efficient. A quantitative proxy is the total volume of the device in cubic inches, or its maximum bounding box dimensions. This can be determined by measuring the length, width, and height of the models. A concept with a volume of 120 cubic inches scores higher than one with a volume of 300 cubic inches.

$$Size = Largest\ Length \times Largest\ Width \times Largest\ Height$$

Part Count

The qualitative requirement is that the device should be easy to assemble and simple to manufacture. A quantitative equivalent is the total number of discrete components, fasteners, and structural parts required to build the complete assembly. This can be determined by walking through the bill of materials for each concept and counting every individual piece. A concept requiring 6 parts scores higher than one requiring 15.

$$Total\ Part\ Count = \Sigma(Manufactured\ Parts) + \Sigma(OTS\ Parts)$$

User Operability

The qualitative requirement is that the device should be intuitive and straightforward for the user to operate. A quantitative equivalent is the number of manual steps required to load the mason jar into its holder, plus a binary penalty score for operational interruptions (such as needing to shut down the machine to change speeds). This can be determined by mapping out the user interaction workflow for each concept and counting the mandatory physical interventions. A concept requiring 2 loading steps with on-the-fly speed adjustment scores higher than one requiring 5 loading steps and a full machine shutdown to change speeds.

$$\text{Total Operational Interventions} = \Sigma(\text{Jar Insertion Steps}) + (\text{Speed Change Penalty})$$

Where the Speed Change Penalty is a binary score calculated as:

- +1 if the machine must be turned off to change speeds (cannot change speeds while the machine is on).
- +0 if the machine allows for on-the-fly speed adjustments while running.

Speed Versatility

The qualitative requirement is that the device should offer a wide range of operational settings to handle different food types effectively. A quantitative proxy is the total number of available speed settings integrated into the device's control mechanism. This can be determined by counting the distinct operational speeds or presets designed into each concept's interface. A concept providing 4 distinct speed settings scores higher than one providing only 2.

$$\text{Total Speed Versatility} = \Sigma(\text{Unique Pulley Step Ratios})$$

2. Weighing Factor Determination

Food Mixer
Jacob Kaercher

Total Cost	Manufacturing Time	Size	Part Count	User Operability	Speed Versatility
A	A	A	A	A	A
	B	B	D	E	B
		C	D	E	F
			D	D	D
				E	E
					F

	Category	Count	%
A	Total Cost	5	33.3
B	Manufacturing Time	2	13.3
C	Size	0	0.0
D	Part Count	4	26.7
E	User Operability	3	20.0
F	Speed Versatility	1	6.7

Matthew Sabag

Total Cost	Manufacturing Time	Size	Part Count	User Operability	Speed Versatility
A	A	A	A	A	A
	B	B	D	E	B
		C	D	E	C
			D	E	D
				E	E
					F

	Category	Count	%
A	Total Cost	5	33.3
B	Manufacturing Time	2	13.3
C	Size	1	6.7
D	Part Count	3	20.0
E	User Operability	4	26.7
F	Speed Versatility	0	0.0

Nicholas Trim

Total Cost	Manufacturing Time	Size	Part Count	User Operability	Speed Versatility
A	A	A	A	A	A
	B	B	B	D	B
		C	D	E	C
			D	E	D
				E	E
					F

	Category	Count	%
A	Total Cost	5	33.3
B	Manufacturing Time	3	20.0
C	Size	1	6.7
D	Part Count	3	20.0
E	User Operability	3	20.0
F	Speed Versatility	0	0.0

Om Patel

Total Cost	Manufacturing Time	Size	Part Count	User Operability	Speed Versatility
A	A	A	A	E	A
	B	B	B	E	B
		C	D	E	F
			D	E	D
				E	E
					F

	Category	Count	%
A	Total Cost	4	26.7
B	Manufacturing Time	3	20.0
C	Size	0	0.0
D	Part Count	2	13.3
E	User Operability	5	33.3
F	Speed Versatility	1	6.7

Objective	%
Total Cost	31.7
Manufacturing Time	16.7
Size	3.3
Part Count	20.0
User Operability	25.0
Speed Versatility	3.3

3. Decision Matrices

Group 1D Decision Matrix

FOOD MIXER			Jacob Kaercher			Matthew Sabag			Nicholas Trim			Om Patel		
Objective	Weighting Factor	Parameter	Mag.	Score	Value	Mag.	Score	Value	Mag.	Score	Value	Mag.	Score	Value
Total Cost	0.32	\$	94.47	4.0	1.3	37.49	10.0	3.2		#####	#####	99.65	3.8	1.2
Manufacturing Time	0.17	Minutes	403.8	8.6	1.4	346.5	10.0	1.7		#####	#####	377.5	9.2	1.5
Size	0.03	Inches³	854.5	1.3	0.0	113.8	10.0	0.3	343.0	3.3	0.1	421.5	2.7	0.1
Part Count	0.20	Parts	57	4.2	0.8	24	10.0	2.0		#####	#####	38	6.3	1.3
User Operability	0.25	Interventions	4.00	7.5	1.9	3.00	10.0	2.5	4.00	7.5	1.9	5.00	6.0	1.5
Speed Variability	0.03	Speed Ratios	3.00	10.0	0.3	2.00	6.7	0.2	2.00	6.7	0.2	3.00	10.0	0.3
Overall value					5.8			9.9			#####			5.9

4. Appendix A: Scoring Justifications & Calculations

Total Cost

The design with the lowest cost after taking the sum of all raw materials, fasteners, and off-the-shelf components earns a score of 10 because it will minimize the cost objective to the best. The scores for the other designs will be calculated based on a proportion to the design with the lowest cost. This is done by dividing the lowest cost by the cost of the current design and multiplying the result by 10. If a design cost is over \$100, it will score a 0, since the design requirements state a budget of \$100 for materials.

Total Cost Score

$$\text{Design Score} = \frac{\text{Lowest Cost}}{\text{Design Cost}} \times 10$$

Example

Lowest Cost = \$37.49 (Matthew's Design)

Jacob's Cost = \$94.47

$$\text{Jacob's Design Score} = \frac{37.49}{94.47} \times 10 = 3.97$$

Manufacturing Time

The design with the lowest manufacturing time will earn a score of 10 since it will best minimize the manufacturing time objective. To obtain the total manufacturing time, the sum of each manufactured part time is taken, which is estimated using the time estimation workbook for each manufacturing tool. Other scores will be calculated using their proportion to the design with the lowest manufacturing time. This is done by dividing the lowest manufacturing time to the manufacturing time of the current design and multiplying by 10.

Manufacturing Time Score

$$\text{Design Score} = \frac{\text{Lowest Manufacturing Time}}{\text{Design Manufacturing Time}} \times 10$$

Example

Lowest Manufacturing Time = 346.5 minutes (Matthew's Design)

Om's Manufacturing Time = 377.5 minutes

$$\text{Om's Design Score} = \frac{346.5}{377.5} \times 10 = 9.18$$

Size

The design with the smallest size, which is calculated by taking the volume of the design, will score a 10, since it minimizes the space required to operate the mixer and provides better user experience. The scores for the other designs will be calculated by dividing the design with the smallest size with the size with the current design and multiplying by 10.

Size Score

$$Design\ Score = \frac{Smallest\ Size}{Design\ Size} \times 10$$

Example

$$Smallest\ Size = 113.8\ in^3\ (Matthew's\ Design)$$

$$Jacob's\ Cost = 854.5\ in^3$$

$$Jacob's\ Design\ Score = \frac{113.8}{854.5} \times 10 = 1.33$$

Part Count

The design with the lowest total part count after taking the sum of all manufactured and off-the-shelf parts will earn a score of 10 since minimizing the part count objective would improve user experience in terms of contracting the mixer design. Other scores are calculated using a proportion between the lowest part count design and the current part count design and multiplying by 10. If a design has a manufactured parts count of less than 4 or greater than 12, it will receive a score of 0, as stated in the project description.

Part Count Score

$$Design\ Score = \frac{Lowest\ Part\ Count}{Design\ Part\ Count} \times 10$$

Example

$$Lowest\ Part\ Count = 24\ parts\ (Matthew's\ Design)$$

$$Om's\ Part\ Count = 38\ parts$$

$$Om's\ Design\ Score = \frac{24}{38} \times 10 = 6.32$$

User Operability

The design with the lowest total operational interventions will receive a score of 10. This total is computed by taking the sum of the jar insertion steps needed to use the mixer design with additional penalties being added to account for adjusting the speed of the mixer. Other scores will be calculated by dividing the lowest total operational interventions by the current design of total operation interventions and multiplying by 10.

User Operability Score

$$\text{Design Score} = \frac{\text{Lowest Operational Interventions}}{\text{Design Operational Interventions}} \times 10$$

Example

Lowest Operational Interventions = 3 interventions (Matthew and Jacob's Design)

Om's Operational Interventions = 5 interventions

$$\text{Om's Design Score} = \frac{3}{5} \times 10 = 6.00$$

Speed Versatility

The design with the greatest number of unique ratios will earn a score of 10 since it will maximize the speed versatility objective and account for the speed adjustment requirement in the project description. Other scores will be calculated by dividing the current design number of ratios to the design with the greatest number of ratios and multiplying by 10. If a design has no speed adjustment ratios, it will receive a score of 0 since it does not meet the speed adjustment requirement in the design description.

Speed Versatility Score

$$\text{Design Score} = \frac{\text{Design Number of Adjustment Ratios}}{\text{Greatest Number of Adjustment Ratios}} \times 10$$

Example

Greatest Number of Adjustment Ratios = 3 speed ratios (Om and Jacob's Design)

Matthew's Number of Adjustment Ratios = 2 speed ratios

$$\text{Matthew's Design Score} = \frac{2}{3} \times 10 = 6.67$$

4A. Cost Calculations

Jacob's Design Cost							
Component (Name and/or Part Number)	Description/Size	Material	Vendor (if applicable)	Cost	Qty.	Justification/Notes	Link (if applicable)
Extended Base (8975K432)	24" x 5" x 0.25" Raw Stock (Machined to 6.0" length for the compact 15" belt drivetrain layout).	Aluminum 6061 T6	McMaster Carr	\$9.53	1.00	Area = 6*5 = 30 sq in. 24" x 5" x 0.25" = \$38.10 \$38.10/120 = 0.3175 0.3175 * 30 = \$9.53 Forms the lower tier deck. Features an integrated belt-tensioning tab and pre-drilled edge holes to anchor the mixer enclosure lid hinge. Two 0.10" deep x 0.43" wide 1.750" Long parallel slots milled into top surface, for dual T-bolt clamping mechanism securing bearing housing	https://www.mcmaster.com/products/8975k432/
Modified Flywheel	1.500" OD x 0.450" Thick	Mild Steel	Existing Air Engine	\$0.00	1.00	Flywheel modified with V groove, no additional material purchased	N/A
Custom Sliding Bearing Housing (9008K46)	Machined from 1.5" x 1.5" Aluminum Square Bar 4" long piece	6061-T6 Aluminum	McMaster Carr	\$7.20	1.00	Prorated from 8 ft length (\$172.96 / 96" x 4"). Features wide milled base for horizontal sliding belt tensioning. Bearing bore centered at 0.5" height within 1.0" tall housing. Housing height machined down from 1.5" stock to 1.0" so that pulley middle step groove aligns with flywheel centerline at 1.5" above extended base. Two 11/32" wide bearings stack to 0.688" total, fitting within 1.0" housing with adequate wall material. Two 0.281" clearance holes drilled through base face to accommodate T-bolt shafts from clamping sets positioned 0.375" from front and back edges of housing base face.	https://www.mcmaster.com/products/9008k46/
Threaded Mason Jar Lid	Wide Mouth (86mm/3.4in)	Food-Grade Tinplate	Amazon	\$0.50	1.00	\$35.99 for pack of 72 = \$0.50 per count. Food safe, protects against splashing. Lid modified by drilling 11/16" center hole to allow 5/8" shaft clearance while retaining enough material to prevent passage of 1" blade hub	https://www.amazon.com/dp/B0CYP6MTXL/ref=sspa_dk_detail_0?pd_rd_j=B0CYP6MTXL&pd_rd_w=owxG1&content-id=amzn1.sym.4f5afe61-a551-4f21-a495-c7c4f2997a96&pf_rd_p=4f5afe61-a551-4f21-a495-c7c4f2997a96&pf_rd_r=ZC9AZJA4KG598XP3F0YJ&pd_rd_wg=yk8Hb&pd_rd_r=49ed7ab4-076c-4e58-a3e8-2851e0b717a9&sp_csd=d2lkZ2V0TmFtZT1zcF9kZXRhaWxfdGhlfWFOaWM&th=1
Mixer Blade Assembly (8992K507)	Single piece 304 SS blade/hub assembly, machined from 1.250" x .250" flat bar stock (8992K507), 2.500" LG. Hub section Ø1.000" x .250" with Ø.625" bore and 10-32 tapped radial hole. Blade sections .875" x 1.000" extending from each side of hub, curved profile milled in.	304 Stainless Steel	McMaster Carr	\$1.86	1.00	\$8.92/12 x 2.50 = \$1.86. Hub and blades machined from same flat bar stock. Hub circular profile milled from 1.250" wide stock giving adequate machining allowance above Ø1.000" hub diameter.	https://www.mcmaster.com/products/bar-stock/multipurpose-304-stainless-steel-bars~/width~1-1-4/?s=304+stainless+steel+bar+stock

Wood Cupholder Bracket	U-shaped bracket, ~8" total pine stock, wraps around 0.75" x 3.5" wood rail; circular bowl recess cut into base to cradle mason jar; 1/4-20 tapped hole through bracket face for hand knob clamping	Pine Wood	Home Depot	\$0.00	1.00	Cut from existing 1x4 pine board (line 15), prorated cost included in wood stand entry. U-shaped profile wraps around right side wood rail with 1/4-20 tapped hole through bracket face. Hand knob screw threads through and presses against rail face to clamp at desired height, threaded mechanism resists vibration loosening. Pine selected for strength to support mason jar load. Circular bowl recess cradles jar base and prevents lateral movement during operation.	https://www.homedepot.com/p/WeatherShield-1-in-x-4-in-x-8-ft-Ground-Contact-Pressure-Treated-Board-Southern-Yellow-Pine-Lumber-253915/206973928?MERCH=REC_-rv_typeahead_rr_-206973928_-2_-n/a_-n/a_-n/a_-n/a_-n/a
V- Belt	3L150 FHP V-Belt, 15 in Outside Length, 3/8 in Top Width, 7/32" Thickness, 1 Ribs	Gum Rubber	Zoro	\$6.19	1.00	3L150 FHP V-belt selected for 15" center-to-center drivetrain layout. Gum rubber construction provides high friction coefficient on V-groove surfaces for positive power transmission. 3/8" top width matches flywheel and stepped pulley groove geometry	https://www.zoro.com/dayton-3l150-fhp-v-belt-15-in-outside-length-38-in-top-width-732-thickness-1-ribs-3l150/i/G0931061/
3 Stepped Pulley	2", 3", 4" OD Steps, 5/8" Bore	Zinc	Ace Hardware	\$19.99	1.00	Chicago Die Cast zinc die-cast 3-step pulley provides three discrete speed ratios using 2", 3", and 4" diameter steps. Speed ratio relative to flywheel changes with each step, enabling variable mixing speeds without disassembly. 5/8" bore matches mixer shaft diameter.	https://www.acehardware.com/departments/hardware/chain-and-rope/pulleys/22840
Pulley Key (98870A130)	3/16" x 3/16"	Low Carbon Steel	McMaster Carr	\$0.26	1.00	\$2.62/10 = \$0.26 3/16"x3/16" key selected to match keyway geometry on 5/8" mixer shaft and stepped pulley bore	https://www.mcmaster.com/products/98870a130/
Mixer Shaft	5/8" Dia Keyed Shaft, 8" Used from 18" Stock	303 Stainless Steel	Zoro	\$17.86	1.00	\$80.39/36 * 8 = \$17.86 303 stainless steel selected for corrosion resistance and machinability; keyed profile transmits torque from pulley to blade assembly.	https://www.zoro.com/zoro-select-keyed-shaft-316x332-ss-zshk-625-36000-303su/i/G605970682/?variantSelection=Keyway+Length
Sealed Ball Bearings	5/8" ID x 1-3/8" OD x 11/32" width	Chromium Steel	Amazon	\$3.44	2.00	\$17.19 for pack of 10, \$17.19/10 * 2 = \$3.44 Provides smooth rotation for the drive system Chromium steel races selected for hardness and wear resistance under radial and axial loads.	https://www.amazon.com/uxcell-R10-2RS-8-inchx1-3-8-inchx11-Bearings/dp/B0824VXKH4/ref=asc_df_B0824VXKH4?tag=bingshoppin&a-20&linkCode=df0&hvadid=80883033958777&hvnetw=o&hvqmt=e&hvbmt=be&hvdev=c&hvlocint=&hvlocphy=73122&hvtargid=pla-4584482510900774&mscldid=28109efc702a11159060f4dfdc229069&th=1

Custom Split Clamping Shaft Collar (1610T11)	1.0" OD × 1.5" Length, 5/8" bore, split clamp style with 10-32 tapped transverse hole	6061-T6 Aluminum	McMaster Carr	\$3.55	1.00	1 1/2" = \$3.55 Machined from 6061-T6 aluminum round stock with longitudinal split cut through one side and 10-32 tapped transverse hole through split. Thumb screw (see knurled hand screw entry) threads through split to close collar and grip shaft. Positioned above bearing housing, bottom face rests on housing top face to set shaft height at each pulley step. Loosen thumb screw to slide shaft up/down to desired pulley step, retighten to lock. Split clamp design provides uniform clamping force around shaft circumference, more secure against vibration than set screw or star knob.	https://www.mcmaster.com/products/rods/material~6061-aluminum/diameter~1/length~1-1-2/
T-Track Bolt Clamping Set	1/4-20 × 2" T-bolt, star knob, washer	Carbon Steel, Plastic	Amazon	\$2.25	2.00	\$8.99 / 8 * 2 = \$2.25 Slot cut into top surface of extended base, T-bolt slides in from side with head captured in slot and shaft pointing upward through bearing housing clearance hole. Star knob with washer threads down from above onto bearing housing top face, clamping housing firmly to base. Loosen knob to slide housing for belt tensioning, retighten to lock.	https://www.amazon.com/yukata-Hardware-T-Track-Woodworking-Fixtures/dp/B0FQJBBV1P/ref=pd_rhf_dp_s_ci_mcx_mr_d_scc1_2_2/131-7765142-8251065?pd_rd_w=Xin20&content-id=amzn1.sym.c2ce25da-4d17-4f37-af20-bde98a9f0bcd:amzn1.symc.d3391730-f670-41da-8b34-61787b3edb82&pf_rd_p=c2ce25da-4d17-4f37-af20-bde98a9f0bcd&pf_rd_r=HA4FWDRG7VBGSZYPD9X&pd_rd_wg=rm3KD&pd_rd_r=00590da8-9852-4597-93b2-db4005327370&pd_rd_i=B0FQJBBV1P&psc=1
Hand Knob Screw	1/4-20 × 1" thread, plastic knob with steel insert	Carbon Steel, Plastic	Amazon	\$0.80	1.00	\$7.99 / 10 * 1 = \$0.80 Threads through wooden cupholder bracket into tapped 1/4-20 holes in wood rail. Replaces pull pin for height indexing, threaded connection resists vibration loosening better than clearance-fit pin.	https://www.amazon.com/MroMax-Threaded-Clamping-Replacing-Umbrella/dp/B0DKT28HZ6/ref=pd_ci_mcx_mh_mcx_views_0_image?pd_rd_w=jQiqv&content-id=amzn1.sym.781fe6e1-9487-4a74-b81e-5a879e5ec2733Aamzn1.symc.c3d5766d-b606-46b8-ab07-1d9d1da0638a&pf_rd_p=781fe6e1-9487-4a74-b81e-5a879e5ec273&pf_rd_r=0F302J279ABVD58J4CSB&pd_rd_wg=468pR&pd_rd_r=baf211dc-1687-49bc-af0a-d9077536aa51&pd_rd_i=B0DKT28HZ6&th=1
Wood Support Stand	1 in. × 4 in. × 8 ft.	Pine Wood	Home Depot	\$1.41	1.00	Entire board = \$3.34 using 12.25" walls, 4" top and bottom, (40.5/96) * \$3.34 = \$1.41 Pine 1×4 (actual 0.75"×3.5") Side rails include 3 pre-drilled and tapped 1/4-20 holes spaced 0.5625" apart for cupholder height indexing.	https://www.homedepot.com/p/WeatherShield-1-in-x-4-in-x-8-ft-Ground-Contact-Pressure-Treated-Board-Southern-Yellow-Pine-Lumber-253915/206973928?MERCH=REC_-rv_typeahead_rr_-206973928_-2_-n/a_-n/a_-n/a_-n/a_-n/a
Rubber Feet	0.95" Diameter Screw On Rubber Feet	Rubber	Amazon	\$1.07	4.00	Pack of 60 costs \$15.98 15.98/60 * 4 = \$1.07. Reduces vibration along the counter or desk space.	https://www.amazon.com/Screw-Rubber-Fee-Furniture-Protector/dp/B0B9YFKHXR/ref=sr_1_7?crid=1ONDOAPA2HX75&dib=eyJ2IjoiMSJ9.nkYnETtPeJdCIOWUghguSfc8BB0pe7z7P9QXVfnsZpdjhr6wX1PUI75HnGzJ4o_HlyrJVsxYAmKe6AgHILZi9ih4yOTOMXWPFgnZSiac84F34yomVve3cmfLAJ-5L7yqTI6lc_7wVJiYjKGLkf9xOLkx5aZ6Okn0t9LkEqMHceYj_N6iFG1sdciefnSAVxHPPXO8yfCSsKklPWeB6lu-kr7JuRJeIW4a5mpEKt2Zn41iO3DwheWJTCmycv5Dw7XQYBtd0q7hEYMu92klGuVIDHrsaxFVQXS-b3nZbM48.rSHf-7gFxFkq93HgqQlB1i_xlRjZHQ09XG_vl0ptOo4&dib_tag=se&keywords=rubber%2Bfeet%2B60%2Bpack&qid=1783176943&srefix=rubber%2Bfeet%2B60%2Bpac1%2Caps%2C152&sr=8-7&th=1

3D Printed Cover	Custom curved enclosure, printed to fit over pulley/belt assembly; integrated hinge hole for nail pivot pin; optimized profile for clearance over all three pulley steps	PETG Plastic	Amazon	\$0.38	1.00	\$0.31/oz × 1.23oz (35g) = \$0.38. PETG selected for impact resistance and heat deflection temperature of 70-75°C. Custom printed profile provides precise clearance over pulley and belt assembly. Integrated Ø.140 nail hinge hole allows cover to pivot open for belt access without removal from machine.	https://www.amazon.com/Filament-Toughness-Dimensional-Accuracy-Printers/dp/B0FKGQ2B8J/ref=sr_1_1_sspa?crid=HPVMMKYUJ3T31&dib=eyJ2IjoiaMSJ9.Cf_yqermQcYEB8nlsQT4aqFXZ4sY5oRgIXQY3NNAJ8khW-kiiZWthd6_gebSsaHjRvqCPA02uFika0Q01RUOCyODswnpWEAmidxYOga8tyYjNIN7Dwl_AtZPfsNijWBHizsoFX-ZyNYM3M7KWYfUntJtZtkUWUeAE9TRVhRfnJX0Aw2X-leuw_rfZy44s-JXwxhGUq9It_CNtp1vnEeKGtzO4R1aW5ZFQtG8sKzWwqMgZKeKjp_lecspvEJeynEASbqUdWCN0ie7Cw8XhRIJNlsg9KvPYGDn1yf0Gy2zO8.U9pgnLa-77nl8_jejbrH8peFujnnax13FMBXNNQ6ps&dib_tag=se&keywords=petg%2Bfilament&qid=1783176986&s=industrial&srefix=petg%2Bfilament%2Cindustrial%2C142&sr=1-1-spons&sp_csd=d2lkZ2V0TmFtZT1zcF9hdGY&th=1
Knurled Hand Screw	#10-32, 5/32" Head Height, 3/8" Length	18-8 Stainless Steel	Zoro	\$3.94	2.00	\$9.85/5 *2 = \$3.94 (1) Blade hub secured to shaft via 10-32 knurled thumb screw threaded into tapped radial hole in hub, bearing on shaft keyway flat for positive retention against centrifugal forces. (2) Split shaft collar clamp secured via same spec thumb screw threading through split to close collar around shaft.	https://www.zoro.com/zoro-select-thumb-screw-10-32-thread-size-round-plain-18-8-stainless-steel-532-in-head-ht-38-in-lg-wftsss14/i/G1154325/
V-Ring Shaft Seal (VA16-NBR)	VA type, 16mm shaft diameter, Buna-N rubber	NBR (Buna-N) Rubber	123 Bearing	\$0.95	1.00	Stretch-fit onto rotating shaft above lid inner plate. Active sealing lip contacts stationary lid face during operation to seal shaft clearance hole and prevent splatter.	https://www.123bearing.com/seals/seal/v-ring/va16-nbr
Nail	Zinc Plated Common Nails 1/8" x 3-1/8" (3 x 80 mm), Flat Round Head Construction and Woodworking Nails	Zinc	Amazon	\$0.17	1.00	Pack of 100 = \$16.99 \$16.99/100 = \$.17 Functions as a hinge pin for the pivoting PETG cover. Inserted through aligned holes in the base and cover, allowing rotation for access to internal components.	https://www.amazon.com/Galvanized-Construction-Common-Woodworking-Plated/dp/B0DS6PYH42/ref=sr_1_1?crid=TO6YHU3ME3Y5&dib=eyJ2IjoiaMSJ9.nm0xqVfeHCx9MnS9jVZBENLgCmVhd586u-8kfoSroVtkiUplBZQj1MrX5fTwr5GITT_EQ8NoflrPDgmKYLy4YmH3KldvFmerT-eHMQwwUYce_VncCCG76a9FTWKGBs2Zyl0VG_a5u1ldN8QTqQgKZN-gyJ1cRZgaO9AjfSEPFGL7v-R0Rp2A88det6Qxh_162dyTVRe8qMk_zLjfdW8b4T3HxK58hEa7K2GoqbEQlhGalkexZlGoINH7xHaTYTYp3cMRs-jTKQnSn5fGFNfMoOLd1PuavX2GFRU8pTQs.TF4puMuWyzgouu8Dv1tXKB4I8DzTF3Pdyx2y4dGI9ck&dib_tag=se&keywords=1%2F8%22%2Bnail%2B3%22%2Blong&qid=1780716634&s=industrial&srefix=1%2F8%2Bnail%2B3%2Blong%2Cindustrial%2C23&sr=1-1&th=1
Aluminum 90° Angles (8982K61)	3" × 3" × 1/4" thick wall,	Aluminum 6061 T6	McMaster Carr	\$9.23	1.00	\$22.16/12 × 5 = \$9.23. Cut from 1ft stock to two 2.5" lengths. 3" leg height creates ~2.625" drop from existing air engine base down to extended base, positioning flywheel centerline at correct height above extended base so small pulley step groove aligns with flywheel center. Aluminum 6061 selected to match base material and minimize galvanic corrosion.	https://www.mcmaster.com/products/8982k61/
Pan Head Phillips Screws (91772A194)	#8 × 1/2" pan head screws	18-8 Stainless Steel	McMaster Carr	\$0.32	3.00	\$10.86/100 * 3 = \$0.32 Used to secure corner bracket to wood block and air engine base	https://www.mcmaster.com/products/91772a194/

Button Head Hex-Drive Screws (92949A240)	10-24 × 3/8"	18-8 Stainless Steel	McMaster Carr	\$0.55	6.00	\$9.16/100 * 6 = \$0.55 Used to fasten 90° angle brackets to aluminum base and wood block	https://www.mcmaster.com/products/92949a240/
Hex Nuts (90480A011)	10-24 Hex Nut	Zinc-Plated Steel	McMaster Carr	\$0.14	6.00	\$2.33/100 * 6 = \$.14 Mating nuts for button head cap screws where tapping is not feasible	https://www.mcmaster.com/products/90480a011/
Phillips Flat Head Wood Screws (90031A201)	#8 × 1-1/4"	Zinc-Plated Steel	McMaster Carr	\$0.77	9.00	\$8.51/100 * 9 = \$0.77 Assembles pine wood box frame and secures side rails to top and bottom blocks	https://www.mcmaster.com/products/90031a201/
General Purpose Washers (90107A011)	#10 flat washers	Stainless Steel	McMaster Carr	\$0.21	4.00	\$5.28/100 * 4 = \$0.21 Distributes clamping load under button head screw heads at aluminum angle joints	https://www.mcmaster.com/products/90107a011/
Wood Coating	Mineral oil, food-safe, 2oz used	Mineral Oil	Amazon	\$0.70	2.00	\$44.99 / 128 * 2 = \$0.70 Applied to pine wood support stand to prevent moisture absorption and mold growth in food preparation environment.	https://www.amazon.com/food-grade-mineral-oil-for-cutting-board-wood/dp/B07Q1DSV8B/ref=sr_1_2_sspa?adgrpid=1334809525690964&diib=eyJ2IjoiMSJ9.LZ0OrMrH4hzSxgtYusJoy6KC1AliW3d4dnKxD2vVC_qmmeG-GEk38O3MSZijhRAvxk8Qn2zLnayn_Zu8-MBetMpDV456G3Zr-1Tx64C5bgFPClavePEtFTF9Rws3tsltzMD1sDMKJLDbCWGt3QbOlXWlbflkkTaQofC3-7ShoXwuFCH0wVzIqC_rAvzcmo_nN8d7Zc413b-hxibtKI3W9Wf3TyFJppdUF50X8Q3LFTBXHgXaADvbGwhGbfnSkS1UImvdnOiezzA9ttEuIEShCt_fxNeY9I2zw5P29yLKUY.i_YXEB_YlhHIVgNzUWCAu8Cp7GekQVAfcl0Srj6KbS0&diib_tag=se&hvadid=83425867017444&hvbmt=be&hvdev=c&hvlcphy=45310&hvnetw=o&hvmqmt=e&hvtargid=kwd-83426651506035%3Aloc-190&hydadcr=19372_13612536&keywords=cutting%2Bboard%2Boil%2Bby%2Bhoward&mcid=a3c60cacf33b310d900e49b6c2fc6fe3&msc_lkid=d28cbf96d8131396523ad5ab48a2947a&qid=1782419727&rdc=1&sr=8-2-spons&sp_csd=d2lk22V0TmFtZT1zcF9hdGY&th=1
Corner Bracket (15705A45)	1-1/2" × 1-1/2" Zinc-Plated Steel, 2 holes, No. 10 straight	Zinc-Plated Steel	McMaster Carr	\$1.20	1.00	1-49 = \$1.20 Connects top wood block to underside of existing air engine base. Straight No. 10 holes accommodate both 10-24 button head cap screws (into aluminum base) and #8 wood screws (into wood block) from existing fastener set.	https://www.mcmaster.com/products/15705a45/
Total Price:				\$94.47			

Matthew's Design Cost							
Component (Name and/or Part Number)	Description/Size	Material	Vendor (if applicable)	Cost	Qty.	Justification/Notes	Link (if applicable)
Base	7.5" x 2.5" x 0.625	6061 Aluminum	McMaster Carr	\$9.12	1.00	8ft x 2.5" x 0.625" ~ \$116.65; 116.65 / 8 / 12 x 7.5 = \$9.12	N/A
Shaft	Diam 0.75" x 1.813"	6061 Aluminum	McMaster Carr	\$0.60	1.00	Diam 0.75" x 12ft ~ \$47.55; 47.55 / 12 / 12 x 1.813 = \$0.60	N/A
Platform Support	Diam 0.25" x 1.4"	6061 Aluminum	McMaster Carr	\$0.30	2.00	Diam 0.25" x 12ft ~ \$15.41; 15.41 / 12 / 12 x 1.4 = \$0.15	N/A
Lid Platform	Diam 3.6" x 0.5"	3D Printed PETG	Amazon	\$0.14	1.00	Volume (CAD) = 21.31 cm³; (Conservative 40% infill) 21.31 x 0.4 x 1.27 g/cm³ x 1kg/1000g x \$124/10kg = \$0.14	N/A
Lid Adapter	OD 3.5" ID 3.25" x 0.5	6061 Aluminum	McMaster Carr	\$1.13	1.00	OD 3.5" ID 3.25" x 6ft ~ \$161.91; 161.91 / 6 / 12 x 0.5 = \$1.13	N/A
Lid (OTS01)	Thread 86-460, 3.375" x 0.5" Tall	Stainless Steel	Fillmore Container	\$0.75	1.00	N/A	https://www.fillmorecontainer.com/86-ct-gold-wide-mouth-plastisol.html
Belt (6082K51) (OTS02)	Wd. 0.25" x Th. 0.03" x 14" Long	Buna-N	McMaster Carr	\$14.00	1.00	Total base length desired 12", air engine 4.5", max safe distance for shaft + both platform supports: x. 14" belt goes around modified flywheel diam and around largest shaft diam, and creates a triangle to determine length needed from flywheel to shaft centers for 14" belt. further away = less angle for belt. 14 = 2l + 0.5πD + 0.5πd; y = 0.5(D - d); l = (14 - 0.5π(D + d))/2; x = sqrt(l² - y²); D = 1.4; d = 0.375; ---> x = 5.377"	https://www.mcmaster.com/products/belts/flat-belts-1-outer-circumference-14/color-black-1/width-1-4-1/
Tensioner Arm	Diam 0.875" x 0.625"	6061 Aluminum	McMaster Carr	\$0.32	1.00	Diam 0.875" x 8ft ~ \$48.30; 48.30 / 8 / 12 x 0.625 = \$0.32	N/A
1.25" Screw (6-FMPP-10C125) (OTS03)	10-24 Thread	Stainless Steel	Marine Bolt Supply	\$0.30	1.00	\$0.30 per unit x 1 = \$0.30	https://marineboltsupply.com/products/size-10-24-x-1-1-4-type-316-stainless-steel-phillips-drive-pan-head-machine-screws
1" Screw (6-FMPP-10C100) (OTS04)	10-24 Thread	Stainless Steel	Marine Bolt Supply	\$0.54	2.00	\$0.27 per unit x 2 = \$0.54	https://marineboltsupply.com/products/size-10-24-x-1-type-316-stainless-steel-phillips-drive-pan-head-machine-screws
0.5" Screw (6-FMPP-10C050) (OTS05)	10-24 Thread	Stainless Steel	Marine Bolt Supply	\$0.40	2.00	\$0.20 per unit x 2 = \$0.40	https://marineboltsupply.com/products/size-10-24-x-1-2-type-316-stainless-steel-phillips-drive-pan-head-machine-screws?variant=42275532603454
Bearing (BB-R6-ZZ/1) (OTS06)	OD 0.875" ID 0.375" x 0.281" Tall	Chrome Steel	PGN Bearings	\$2.60	4.00	\$0.65 each x 4 = \$2.60	https://pgnbearings.com/products/r6-zz-ball-bearing-3-8x7-8x9-32?variant=20475623473265&country=US&currency=USD&utm_medium=product_sync&utm_source=google&utm_content=sag_organic&utm_campaign=sag_organic
Spacer (WBB511839) (OTS07)	0.375" ID x 0.625" OD x 0.031" Tall	Low Carbon, Full Hard Steel	Global Industrial	\$1.15	1.00	\$11.50 pack x 10/pack = \$1.15	https://www.globalindustrial.com/p/38-inch-id-x-58-inch-od-x-0031-inch-steel-arbor-shim-pack-of-10
Nut (0000-103719) (OTS08)	Diam 0.375" x 0.130"	Stainless Steel 18-8	ASMC Industrial	\$0.17	1.00	Price per Piece: \$0.1620 = \$0.17	https://www.asmc.net/10-24-coarse-thread-hex-machine-screw-nut-stainless-steel-18-8/#
Oster Drive Pin (OS-070) (OTS09)	0.394" x 0.394" x 0.75"	Zinc-Plated Carbon Steel	Goodman's	\$0.79	1.00	N/A	https://www.goodmans.net/i/2599/square-drive-pin-for-oster-osterizer-blenders-shor.htm
Oster Blade Cutter (OS-010) (OTS10)	Diam 2.59" x 2.2" Tall	304 Stainless Steel	Goodman's	\$4.69	1.00	N/A	https://www.goodmans.net/i/2588/blender-blade-cutter-for-oster-osterizer-blenders.htm
Food Grade Silicone Sealant (FGSASI502W-T)	Area = π((3.38/2)² - (1.95/2)²) Height = 0.05"	ASI 502 Food Grade Silicone Sealant	TechnologyLK	\$0.49	1.00	2.8 oz = 79.3787 g, 1.02 g/cm³, π(R2 - r2) = Area, (R1 = 3.38/2", r2 = 1.95/2"), glue thickness 0.05"; π((3.38/2)² - (1.95/2)²) x 0.05" = 0.299 in³ = 4.90 cm³ (R2 = 1.345", r2 = 1.295", glue height 1/16"; π((1.345)² - (1.295)²) x 0.063" = 0.027 in³ = 0.443 cm³ (R3 = 0.975", r2 = 0.925", glue height 0.035"; π((0.975)² - (0.925)²) x 0.098" = 0.030 in³ = 0.492 cm³ 4.90 + 0.443 + 0.492 = 5.835 cm³ x 1.02 g/cm³ x \$6.42/79.3787g = \$0.4814	https://www.technologylk.com/white-food-grade-silicone-sealant-28-oz-squeeze-tube-lk-figsasi502w-t.htm
Total Price:				\$37.49			

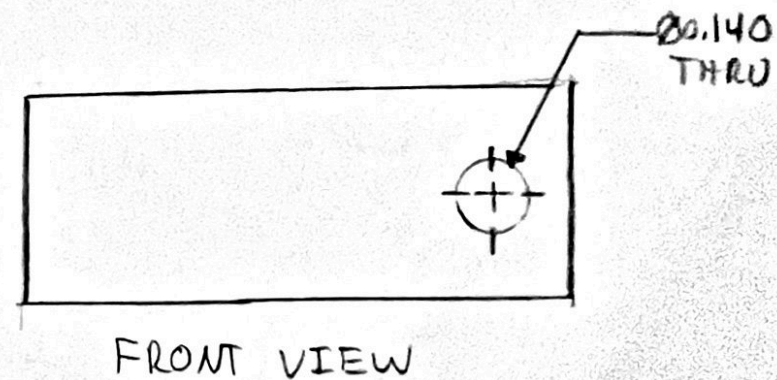
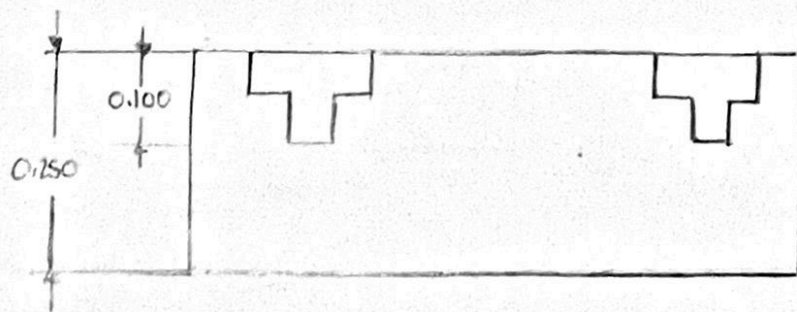
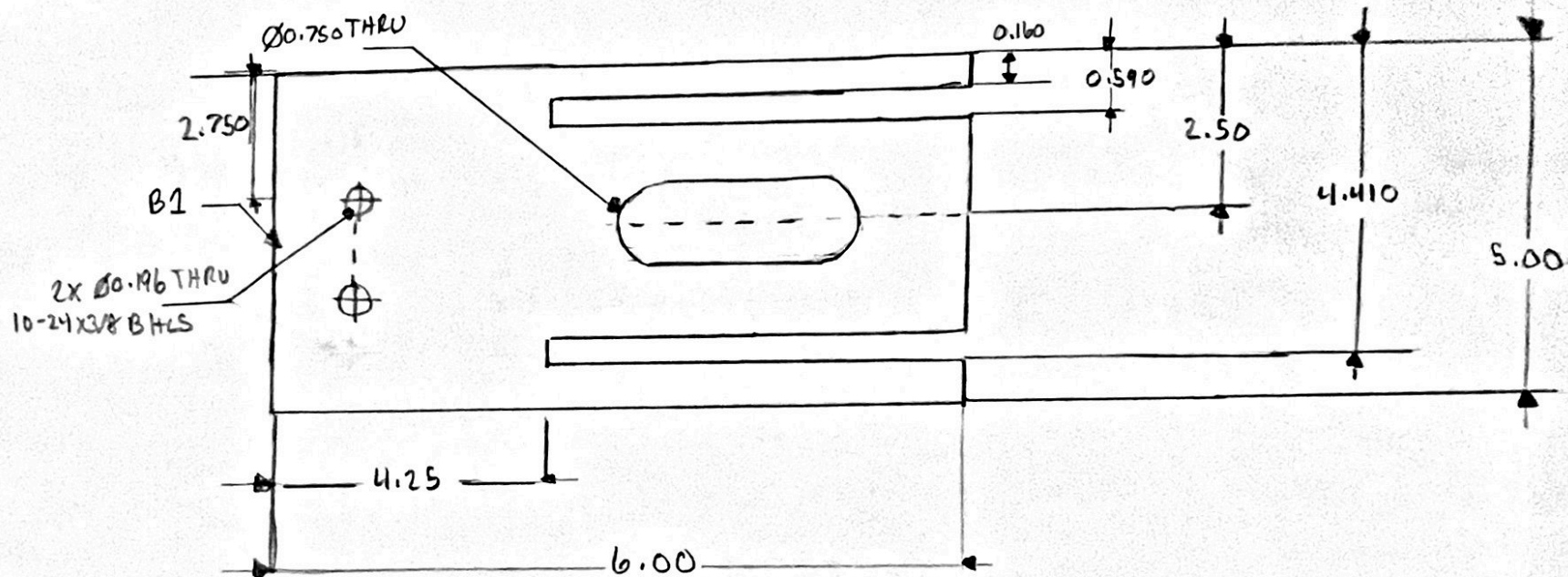
Om's Design Cost							
Component (Name and/or Part Number)	Description/Size	Material	Vendor (if applicable)	Cost	Qty.	Justification/Notes	Link (if applicable)
Base Plate (P1)	1/8" x 4" Aluminum Rectangle Bar 6061-T6511-Extruded; 11" x 4" x 0.125"	6061-T6 Aluminum (Manufactured)	Online Metals	\$12.06	1.00	6061-T6 aluminium provided hight strength-to-weight ratio and excellenet machinability [ASM, 2019]. Bandsaw to get net shape and mill machine for surfacing and drilling. Price of beam for 12" is \$12.06	https://www.onlinemetals.com/en/buy/aluminum/0-125-x-4-aluminum-rectangle-bar-6061-t6511-extruded/pid/1131
Air Engine Mounting Legs (P2)	5/8" Carbon Steel Round Bar A36 Hot Rolled; ø0.625" x 36"	A36 Low Carbon Steel (Manufactured)	Online Metals	\$8.67	4.00	All 4 legs are manufactured using lathe machine for surfacing, drilling, and threading. A36 low carbon steel is a reliable material that offer high sturdiness and structure. Design requires four 7" mounting legs, which is 28" total. A 36" cost \$8.67, which leaves 8" remaining	https://www.onlinemetals.com/en/buy/carbon-steel/0-625-carbon-steel-round-bar-a36-hot-rolled/pid/10238
Stepped Pulley 1 (OTS01)	300-62 Lathe Motor 4 Step Puley with inner diameter of 0.5"	Aluminum Alloy (OTS)	Taig Tools	\$15.00	1.00	Diameter of pulley levels: 2", 2.5", 3.5", and 4"; Pulleys are applicable for the load transfer from the air engine to the mixer while accounting for the speed adjustment requirement	https://taigtools.com/product/part-300-62-lathe-motor-4-step-pulley/
Stepped Pulley 2 (P3)	300-62 Lathe Motor 4 Step Puley with inner diameter of 0.5"	Aluminum Alloy (OTS + Manufactured)	Taig Tools	\$15.00	1.00	OTS part manufactured to included a space for a washer to maintain rotation and for a snap ring to contrain the mixing utensil with the pulley	https://taigtools.com/product/part-300-62-lathe-motor-4-step-pulley/
Support Rod (P4)	1/2" Carbon Steel Round Bar A36 Hot Rolled; ø0.5" x 12"	A36 Low Carbon Steel (Manufactured)	Online Metals	\$4.50	1.00	A36 Carbon steel is a widely used structural-grade steel that is best of rits high durability, cost-effectiveness, and manufacturability	https://www.onlinemetals.com/en/buy/carbon-steel/0-5-carbon-steel-round-bar-a36-hot-rolled/pid/10236
Hinge Platform (P5)	5/8" x 4" Carbon Steel Rectangle Bar A36 Hot Rolled; 12" x 4" x 0.625"	A36 Low Carbon Steel (Manufactured + CNC)	Online Metals	\$11.76	1.00	CNC manchine is used for the manufacturing of this components due to the complex geometry with the threading and the hinged section; Original Price of Beam: \$23.51 for 12"; New Price o Beam: \$4.50 for 5" based on custom cost calculator	https://www.onlinemetals.com/en/buy/carbon-steel/0-625-x-4-carbon-steel-rectangle-bar-a36-hot-rolled/pid/10086
Hinge Attachment (P6)	ELEGOO PLA Plus Filament 1.75 mm; 7" x 4" x 0.625"	3D Printing PLA (Manufactured)	Amazon	\$5.06	1.00	3D Printing PLA used due to complex geoemetry and not at risk of wearing down due to moving components; \$0.41/ounce = \$14.46/kg; PLA density: 1.25 g/cc = 0.02 kg/in ³ ; Hinge attachment dimensions: 7" x 4" x 0.625"; cost: (7)(4)(0.625)(0.02)(14.46) = 5.06	https://www.amazon.com/ELEGOO-Filament-Stronger-Dimensional-Accuracy/dp/B0C14M5HR9/ref=sr_1_2_sspa?crid=1Y7AHCCAP70IT&dib=eyJ2IjoiaMSJ9.qh2rz7FE4c8knlRHtYOGtZ55PCeCq6DCqo-1TOzavqcMw6jTeKLnk4jiitRABc0JmLTVdJBIBhQlQgaMDYcvfCPjTe4x-SdX89DQOMGrEb89gYE7fbdEFySmXwkwYtmF8i0Iho9zZiITxBejDxnHOPf0vI2HK9gSeeOuXK8it4GddjdFXOr2K8tkj_fGaRz6uyHJ1_bdDub6F7D6m1Kk_ONh-rJwvcY2n-lj7RRww.dNICvLXJkWAjXpBF-DdUz4_L_VDe0oIhp745qNz0c&dib_tag=se&keywords=3d%2Bprinting%2Bpla&qid=1780876910&srefix=3d%2Bprinting%2Bpl%2Caps%2C258&sr=8-2-spons&sp_csd=d2lk2ZV0TmFtZT1zcF9hdGY&th=1
Mixing Attachment (P7)	Hand Mixer Beaters Attachments for Hamilton Beach Beaters; 3"D x 1"W x 2"H	304 Stainless Steel (OTS + Manufactured)	Amazon	\$3.99	1.00	OTS component that is manufactured to have a groove in the rod for the snap ring to be placed for contraining rod to pulley	https://www.amazon.com/Mixer-Beaters-Attachments-Hamilton-Beach/dp/B0CYWKLJR/ref=sr_1_5?dib=eyJ2IjoiaMSJ9.Z4UGTGOMJ4Izrlws4Eo3cA4mFfL8ZzcGbZyueWJhegbuMMzQ41QfdtBT81VjVC-0JF1uouW104BISMOfIx_gHcmG6Zx_ZyFWgYBsw-a_PSms3sZKqRp04JO7lrXM_9QQ2_4BSDSbxq3YpWnygU4k6wVGrAEMWcWKz8GoK6gkEwnicm92TytjVnW2y4lwGpmfXnQ51mLuaDzQq8TEvQpQqWQDRcvCgrvwCZmeEiUVAgDO-_KRL4L7Me0vsXRZPF6Ri6MJkOL81aeNDwfYsGdpH1y1SjWjdmLYmT9DWrYco.UkxOyqXzG9eqA6hQoAboXQfmJD2XW6V88YAYkRtX1y4&dib_tag=se&keywords=hand+mixer+attachments&qid=1780865827&sr=8-5
V-Belt (OTS02)	Dayton V-Belt: A, Industry Number A18, 1 Ribs, 20" Outside Length, 1/2" Top Width, 5/16" Thick	Neoprene (OTS)	Imperial	\$3.43	2.00	Neoprene is highly elastic, so it also the greatest tension between the flywheel and the pulleys to maximize the gear ratio that corresponds to the speed adjustment	https://www.imperialsupplies.com/browse/power-transmission/industrial-belts/v-belts?featured-product=9104402&campaignid=11123738119&adgroupid=167775291254&creative=717730949701&matchtype=&network=g&device=c&keywordd=&utm_source=google&utm_medium=cpc&utm_campaign=Google_PLA_-_Web_Priced_Pilots&gad_source=1&gad_campaignid=11123738119&g_braid=0AAAAADLSQ5U8wwUON_yldVmC9jIFVgbc5&clid=Cj0KCQjwrZTRBhDSARIsAHidYffngBIOLsOAvxhYwDmkJSYdsK8raAdzcep81JM0ODCCOQE45mVy1gaAktJEALw_wcB

Flanged Sleeve Bushings (OTS03)	Dry-Running Nylon Sleeve Bearing; 1/4" Shaft Diameter, 3/8" Long, 1/2" Flange OD	Nylon (OTS)	McMaster Carr	\$0.79	5.00	Nylon has high corrosion resistance and vibration damping for when the the air engine is applied. It is placed at the bottom of the base plate where the socekt screws will be inputted	https://www.mcmaster.com/6389K627/
Steel Socket Head Screws (OTS04)	Black-Oxide Alloy Steel Socket Head Screw; 10-24 Thread, 1" Long	Black-Oxide Alloy Steel (OTS)	McMaster Carr	\$0.20	9.00	Socket head screws are made of black-oxide alloy steel for enhancing corrosion resistance and wear resistance. These screws are used to connect the mounting legs to the air engine base and the base plate, as well as connecting the suport rod to the base plate	https://www.mcmaster.com/91251A247/
Washer (OTS05)	18-8 Stainless Steel Washer; 1/2" Screw Size, General Purpose, 0.531" ID, 1.250" OD	18-8 Stainless Steel (OTS)	McMaster Carr	\$0.21	4.00	18-8 stainless steel is useful because it is affordable under a budget contrain and has high durability. Washer are for pulleys to prevent grinding and maintaining the rotation of the pulleys	https://www.mcmaster.com/92141A033/
Round Head Screw (OTS06)	Passivated 18-8 Stainless Steel Pan Head Phillips Screw; 10-24 Thread, 1" Long	18-8 Stainless Steel (OTS)	McMaster Carr	\$0.21	2.00	Round headed screws used to connect the hinge contraption to the side of the base plate. Material of 18-8 stainless steel is exceptional for affordability, durability, and corrosion resistance	https://www.mcmaster.com/91772A247/
Threaded rod (OTS07)	Grade B7 Medium-Strength Threaded Rod; 1/2" 13 Thread Size, 3" Long	Steel (OTS)	McMaster Carr	\$2.69	1.00	Thread rod use to contrain the first step pulley to the support rod by an intereference fit throught the stepped pulley, and then threaded into the support rod to stabilize the pulley	https://www.mcmaster.com/98750A103/
Snap Ring (OTS08)	External Retaining Ring; 1/4" OD, 15-7 PH Stainless Steel	15-7 PH Stainless Steel (OTS)	McMaster Carr	\$1.06	1.00	The snap ring is applicable to contraining the mixing utensil and preventing it from slipping into the mason jar. 15-7 PH stainless steel is a food-safe material that has high strength and high faitgue resistance	https://www.mcmaster.com/91590A113/
Hinge Pin (OTS09) and Hinge Door Bushings (OTS10)	Dorman Door Hinge Parts 38390, Bushings: 0.372" OD, 0.255" ID, Pin: ø0.342"	Bushing: Steel-Backed Copper Alloy Pin : Steel-Backed Cooper Alloy	AutoZone	\$5.99	1.00	This sets comprises of one hinge pin and two hinge bushings used to join the hinge platform and hinge attachment together. It also applies to keeping the platform from rattling due to virbation, which will keeps its constant 90 degree angle during the process. The material of steel-backed cooper alloy is the steel provides high structural strength and load capacity, while the cooper acts as a soft, low-friction wear layer. This combination maximizes durability, while protecting moving parts from damage.	https://www.autozone.com/p/dorman-door-hinge-pin-bushing-kit-38390/17370
Total Price:				\$99.65			

4B. Manufacturing Time Calculations

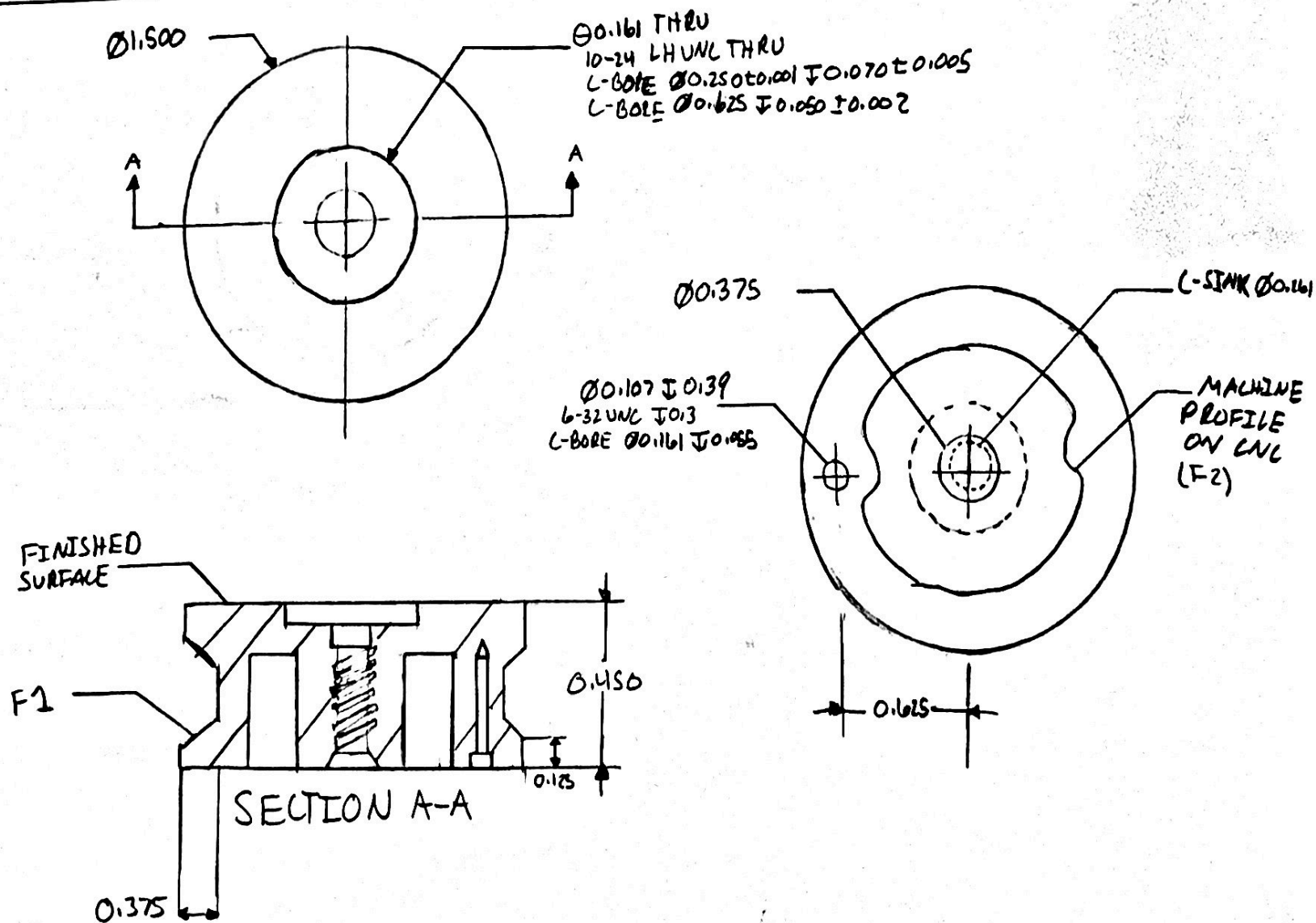
Jacob's Manufacturing Time								
Extended Base								
Process	Category	Unit	Time [MIN/UNIT]	Material Multiplier	Size Multiplier	Feature Quantity	Total	Comments
SELECT MATERIAL	Preparation	pcs	1.00	N	N	1.00	1.00	
MACHINING SETUP, INSTALL AND REMOVE	Preparation	in	10.00	N	N	1.00	10.00	Installing stock in vise, finding zeros
BAND SAW CUTTING	2D Cutting	in	0.50	1.00	0.30	1.00	0.90	Cut to 6.00" length through 0.25" aluminum
MACHINING SETUP, INSTALL AND REMOVE	Preparation	in	10.00	N	N	1.00	10.00	Set up on mill for slot and hole operations
MILLING	Machining	in^3	1.00	1.00	4.00	0.13	0.52	Mill two T-bolt slots 0.43"W × 1.50"L × 0.10"D each
MILLING	Machining	in^3	1.00	1.00	4.00	0.03	0.12	Mill shaft clearance slot 0.750"W × 1.125"L × 0.25"D
DRILLED HOLE < 1 IN DIA.	Machining	hole	0.20	1.00	1.00	2.00	0.40	Drill 2× mount holes to 90 degree plate
DRILLED HOLE < 1 IN DIA.	Machining	hole	0.20	1.00	1.00	1.00	0.20	Drill nail hinge hole Ø.140
DEBURRING	Finishing	in	0.05	1.00	N	22.00	1.10	Deburr all edges of base perimeter
						Subtotal	24.24	

Extended Base



Jacob's Manufacturing Time								
Modified Flywheel								
Process	Category	Unit	Time [MIN/UNIT]	Material Multiplier	Size Multiplier	Feature Quantity	Total	Comments
SELECT MATERIAL	Preparation	pcs	1.00	N	N	1.00	1.00	Select existing flywheel from air engine
MACHINING SETUP, INSTALL AND REMOVE	Preparation	in	10.00	N	N	1.00	10.00	Installing stock in vise, finding zeros
TURNING	Machining	in^3	1.00	3.00	N	0.08	0.24	Turn V-groove profile into flywheel OD
MACHINING SETUP, INSTALL AND REMOVE	Preparation	in	3.00	N	N	1.00	3.00	Re-orient for milling V-groove angle walls
MILLING	Machining	in^3	1.00	3.00	4.00	0.04	0.48	Mill angled sidewalls of V-groove at 34°
DEBURRING	Finishing	in	0.05	3.00	N	5.00	0.75	Deburr V-groove edges
						Subtotal	15.47	

Modified Flywheel

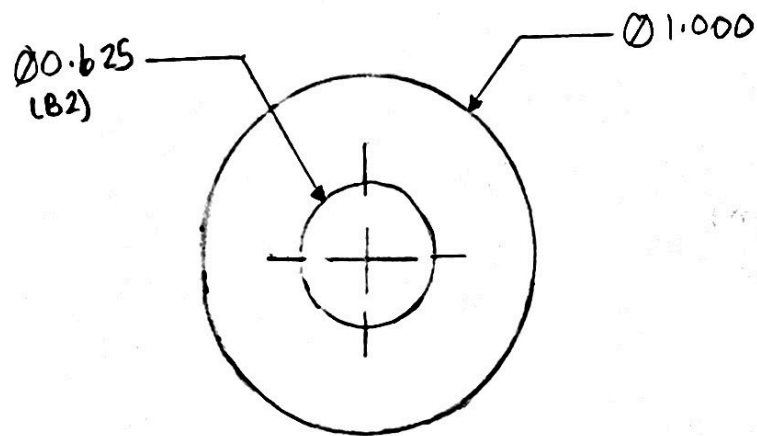


Jacob's Manufacturing Time								
Mixer Blade Assembly								
Process	Category	Unit	Time [MIN/UNIT]	Material Multiplier	Size Multiplier	Feature Quantity	Total	Comments
SELECT MATERIAL	Preparation	pcs	1.00	N	N	1.00	1.00	
MACHINING SETUP, INSTALL AND REMOVE	Preparation	in	10.00	N	N	1.00	10.00	Cut flat bar to 2.500" length on band saw
BAND SAW CUTTING	2D Cutting	in	0.50	3.75	0.30	2.50	1.41	Cut 1.250"×0.250" SS flat bar to 2.500" length
MACHINING SETUP, INSTALL AND REMOVE	Preparation	in	10.00	N	N	1.00	10.00	Set up on mill for hub profile
MILLING	Machining	in^3	1.00	3.75	4.00	0.08	1.20	Mill hub circular profile Ø1.000" from 1.250" wide stock, remove corners
MACHINING SETUP, CHANGE	Preparation	unit	3.00	N	N	1.00	3.00	Re-orient for blade profile milling
MILLING	Machining	in^3	1.00	3.75	4.00	0.12	1.80	Mill curved blade profiles on each side of hub
BORING HOLES	Machining	in	0.60	3.75	N	0.25	0.56	Bore Ø.625" shaft hole through 0.250" hub section
DRILLED HOLE < 1 IN DIA.	Machining	hole	0.20	3.75	1.00	1.00	0.75	Drill Ø.159" tap drill for 10-32 thumb screw hole
TAPPING HOLE (HAND)	Machining	hole	5.00	3.75	1.00	1.00	18.75	Tap 10-32 UNC thumb screw hole through hub

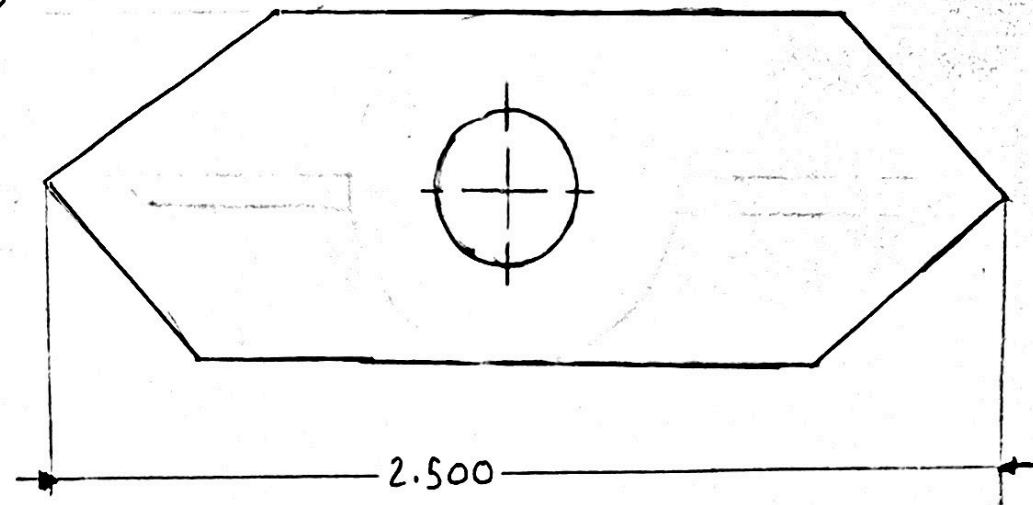
MACHINING SETUP, CHANGE	Preparation	unit	3.00	N	N	1.00	3.00	Re-orient for deburring
DEBURRING	Finishing	in	0.05	3.75	N	8.00	1.50	Deburr all blade and hub edges
						Subtotal	52.97	

Mixer Blade Assembly

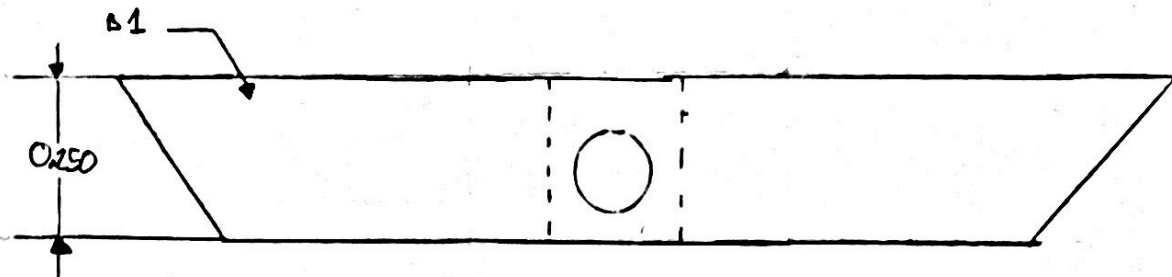
WITHOUT BLADES



WITH BLADES

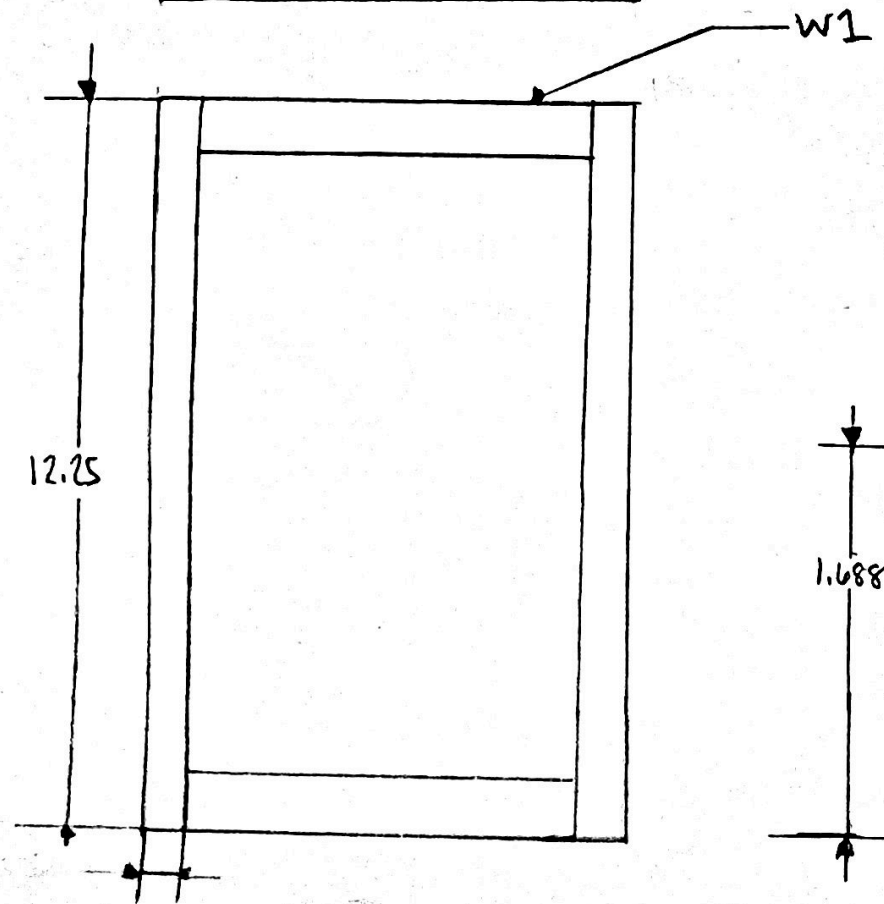
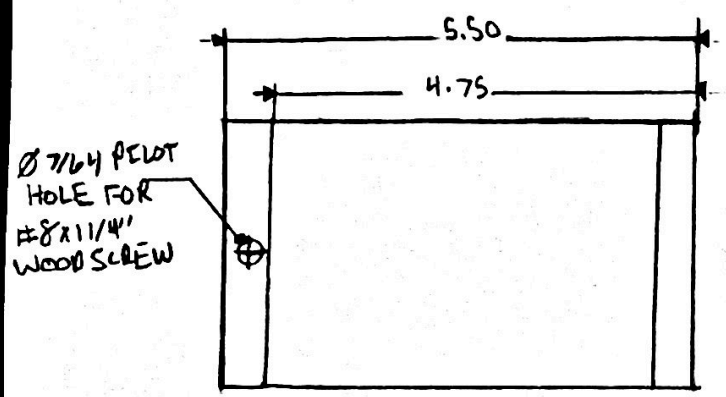


$\varnothing 0.159$ THRU
10-32 UNF-28 THRU
(B3)

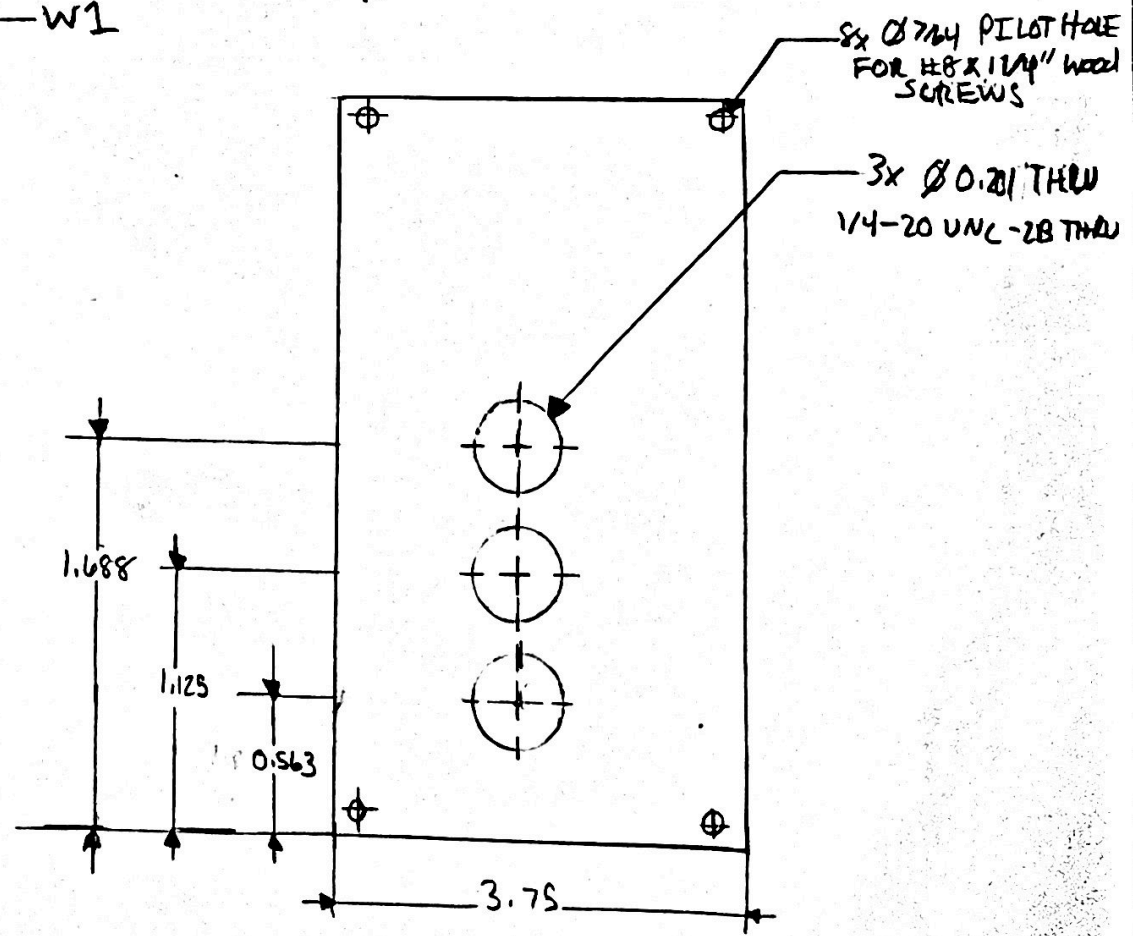


Jacob's Manufacturing Time								
Wood Support Stand								
Process	Category	Unit	Time [MIN/UNI]	Material Multiplier	Size Multiplie	Feature Quantity	Total	Comments
SELECT MATERIAL	Preparation	pcs	1.00	N	N	1.00	1.00	
MACHINING SETUP, INSTALL AND REMOVE	Preparation	in	10.00	N	N	1.00	10.00	Set up on band saw for cutting
BAND SAW CUTTING	2D Cutting	in	0.50	0.50	0.30	24.50	1.84	Cut 2× side rails to 12.250" length each through 0.750" pine
BAND SAW CUTTING	2D Cutting	in	0.50	0.50	0.30	8.00	0.60	Cut 2× top/bottom blocks to 4.000" length each
SETUP, INSTALL AND REMOVE	Preparation	in	10.00	N	N	1.00	10.00	Set up on drill press for tapped holes
DRILLED HOLE < 1 IN DIA.	Machining	hole	0.20	0.50	1.00	3.00	0.30	Drill 3× Ø.201" tap drill holes in right side rail
TAPPING HOLE (HAND)	Machining	hole	5.00	0.50	1.00	3.00	7.50	Tap 3× 1/4-20 UNC holes for cupholder hand knob
DEBURRING	Finishing	in	0.05	0.50	N	40.00	1.00	Sand all cut edges
						Subtotal	32.24	

Wooden Support Stand



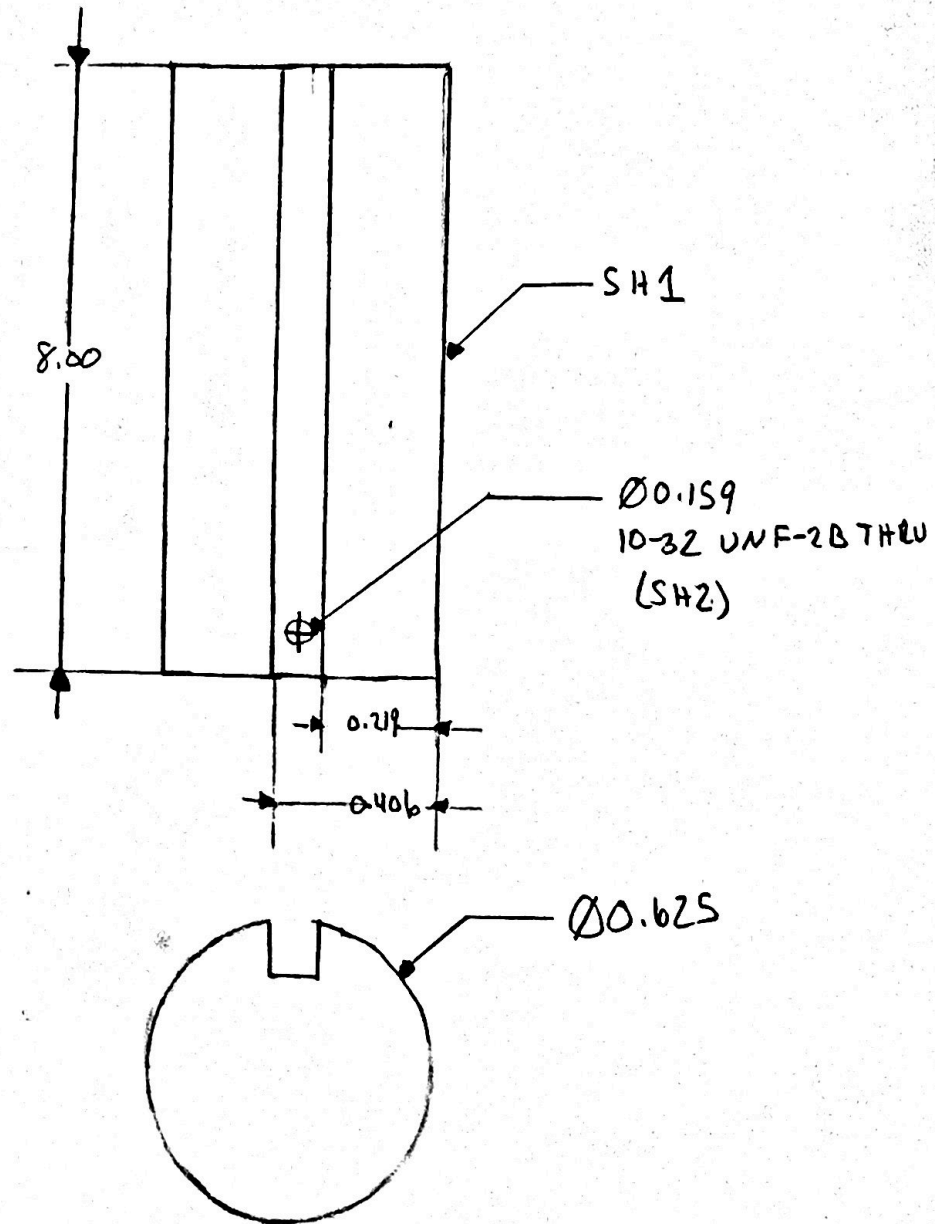
RIGHT VIEW



TYP 0.750

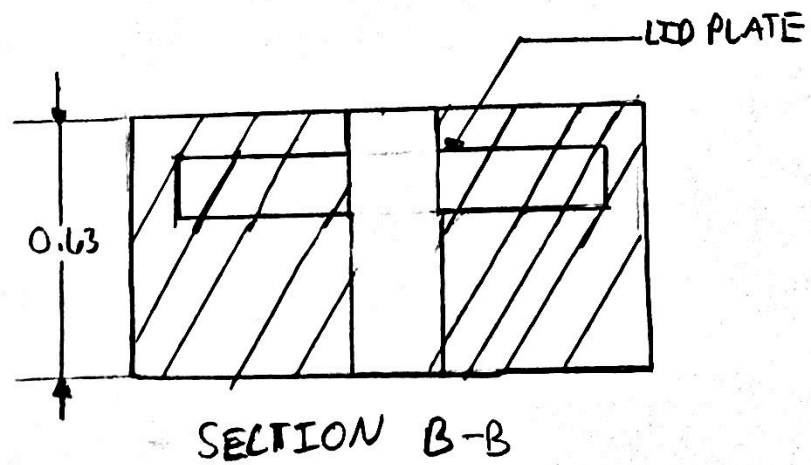
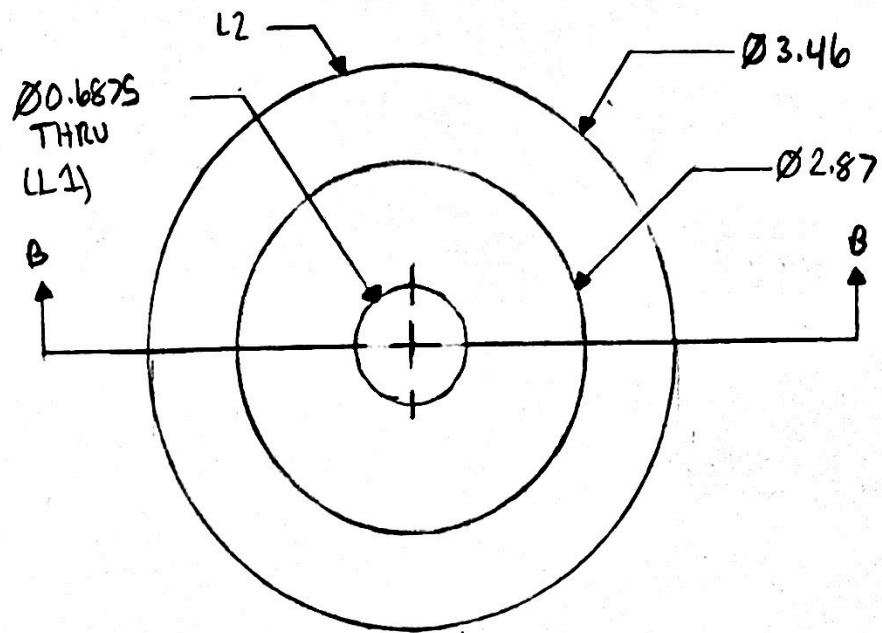
Jacob's Manufacturing Time								
Mixer Shaft								
Process	Category	Unit	Time [MIN/UNIT]	Material Multiplier	Size Multiplier	Feature Quantity	Total	Comments
SELECT MATERIAL	Preparation	pcs	1.00	N	N	1.00	1.00	Select purchased keyed shaft stock
MACHINING SETUP, INSTALL AND REMOVE	Preparation	in	10.00	N	N	1.00	10.00	Set up on band saw
BAND SAW CUTTING	2D Cutting	in	0.50	3.75	0.30	0.63	0.35	Cut shaft to 8.000" length through Ø.625" SS
MACHINING SETUP, INSTALL AND REMOVE	Preparation	in	10.00	N	N	1.00	10.00	Set up on mill for thumb screw hole
DRILLED HOLE < 1 IN DIA.	Machining	hole	0.20	3.75	1.00	1.00	0.75	Drill Ø.159" tap drill for 10-32 blade thumb screw hole
TAPPING HOLE (HAND)	Machining	hole	5.00	3.75	1.00	1.00	18.75	Tap 10-32 UNC blade retention hole through shaft
DEBURRING	Finishing	in	0.05	3.75	N	2.00	0.38	Deburr cut end and hole edges
						Subtotal	41.23	

Mixer Shaft



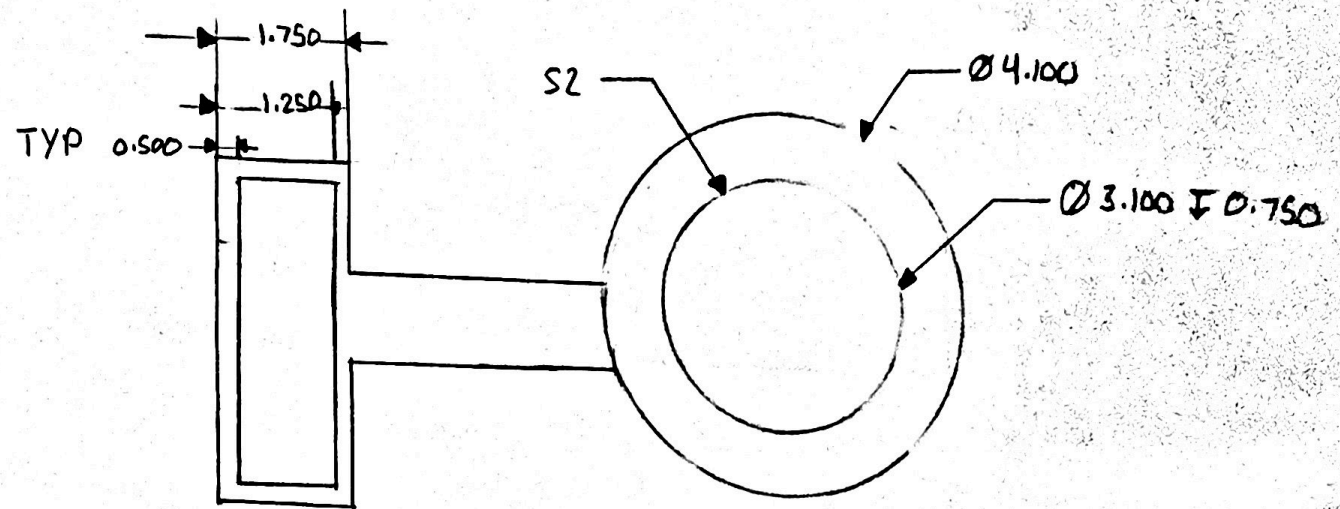
Jacob's Manufacturing Time								
Mason Jar Lid								
Process	Category	Unit	Time [MIN/UNIT]	Material Multiplier	Size Multiplier	Feature Quantity	Total	Comments
SELECT MATERIAL	Preparation	pcs	1.00	N	N	1.00	1.00	Select purchased mason jar lid
MACHINING SETUP, INSTALL AND REMOVE	Preparation	in	10.00	N	N	1.00	10.00	Secure lid in vise for drilling
DRILLED HOLE < 1 IN DIA.	Machining	hole	0.20	3.00	1.00	1.00	0.60	Drill Ø.688" center shaft clearance hole thru lid plate
DEBURRING	Finishing	in	0.05	3.00	N	2.20	0.33	Deburr hole edge, circumference of Ø.688" hole
						Subtotal	11.93	

Mason jar lid

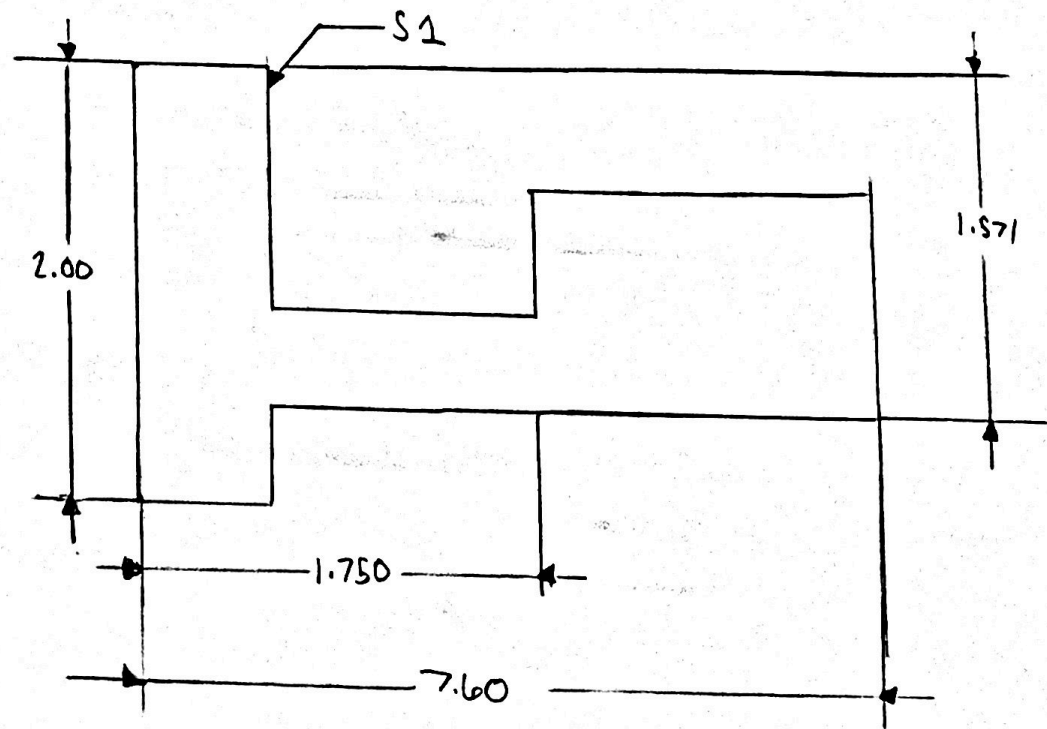
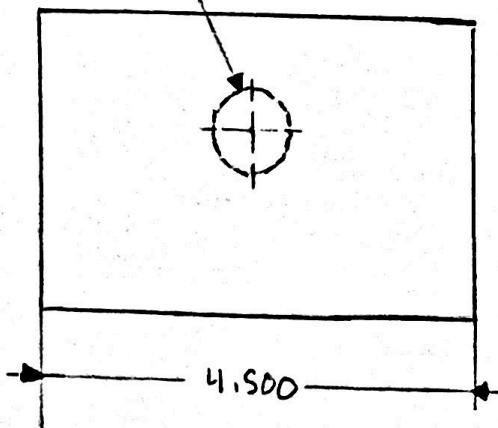


Jacob's Manufacturing Time								
Wood Cupholder Bracket								
Process	Category	Unit	Time [MIN/UNIT]	Material Multiplier	Size Multiplier	Feature Quantity	Total	Comments
SELECT MATERIAL	Preparation	pcs	1.00	N	N	1.00	1.00	Select from existing 1×4 pine board
MACHINING SETUP, INSTALL AND REMOVE	Preparation	in	10.00	N	N	1.00	10.00	Set up on band saw for rough cuts
BAND SAW CUTTING	2D Cutting	in	0.50	0.50	0.30	16.00	1.20	Rough cut U-channel profile from pine stock
MACHINING SETUP, INSTALL AND REMOVE	Preparation	in	10.00	N	N	1.00	10.00	Set up on mill for U-channel and bowl
MILLING	Machining	in^3	1.00	0.50	2.00	1.50	1.50	Mill U-channel slot 0.750"W × 2.000"D through bracket
MILLING	Machining	in^3	1.00	0.50	1.00	1.00	0.50	Mill bowl recess Ø3.100" × 0.750"D for jar support
DRILLED HOLE < 1 IN DIA.	Machining	hole	0.20	0.50	1.00	1.00	0.10	Drill Ø.201" tap drill for 1/4-20 hand knob hole
TAPPING HOLE (HAND)	Machining	hole	5.00	0.50	1.00	1.00	2.50	Tap 1/4-20 UNC hand knob hole through bracket face

DEBURRING	Finishing	in	0.05	0.50	N	20.00	0.50	Sand and deburr all edges
						Subtotal	27.30	

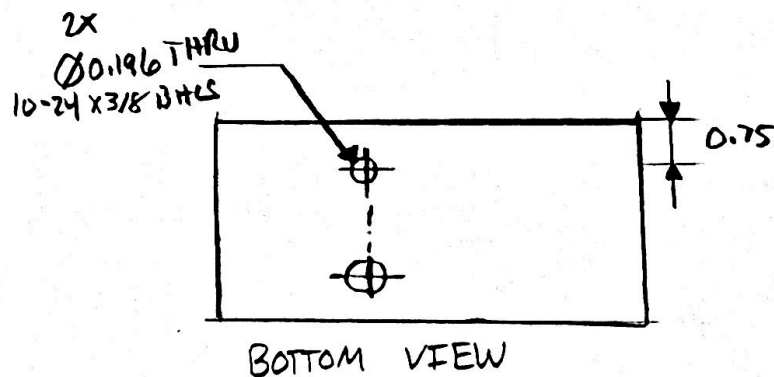
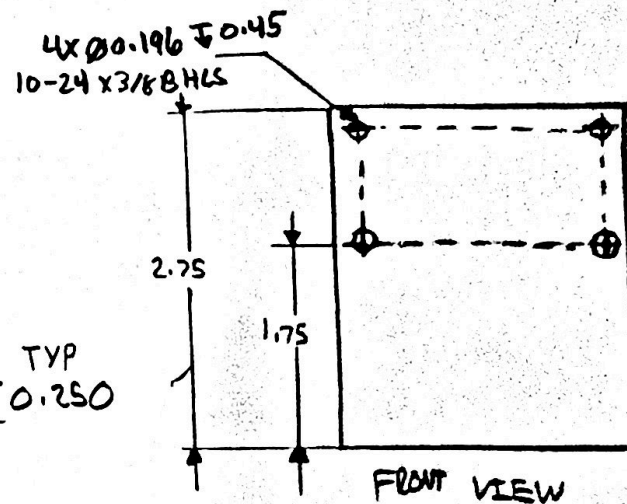
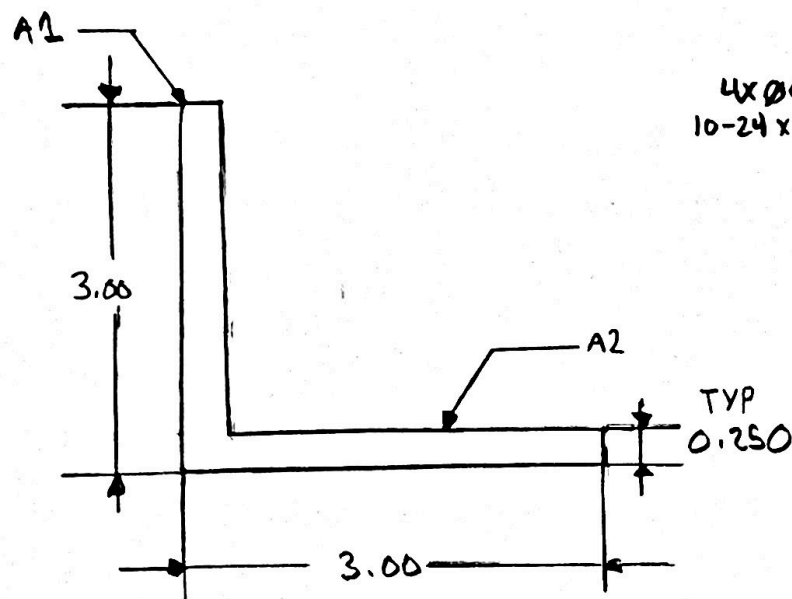


$\varnothing 0.201 \pm 0.750$
 $1/4-20 \text{ UNF}$
 ± 0.750



Jacob's Manufacturing Time								
90° Aluminum Angle								
Process	Category	Unit	Time [MIN/UNIT]	Material Multiplier	Size Multiplier	Feature Quantity	Total	Comments
SELECT MATERIAL	Preparation	pcs	1.00	N	N	1.00	1.00	
MACHINING SETUP, INSTALL AND REMOVE	Preparation	in	10.00	N	N	1.00	10.00	Set up on band saw for cutting
BAND SAW CUTTING	2D Cutting	in	0.50	1.00	0.30	5.00	0.75	Cut two 2.500" lengths from 1ft stock through 0.250" wall
MACHINING SETUP, INSTALL AND REMOVE	Preparation	in	10.00	N	N	1.00	10.00	Set up on drill press for screw holes
DRILLED HOLE < 1 IN DIA.	Machining	hole	0.20	1.00	1.00	4.00	0.80	Drill 4× Ø.196" clearance holes for 10-24 BHCS
DEBURRING	Finishing	in	0.05	1.00	N	10.00	0.50	Deburr all cut edges
						Subtotal	23.05	

90° ANGLE

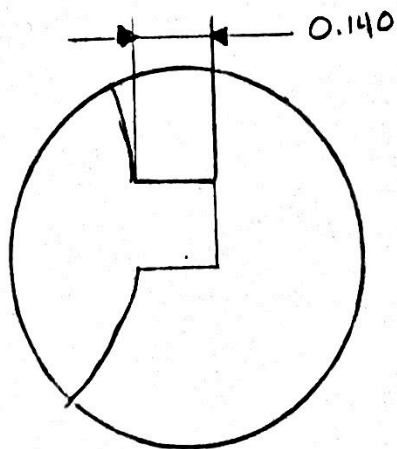
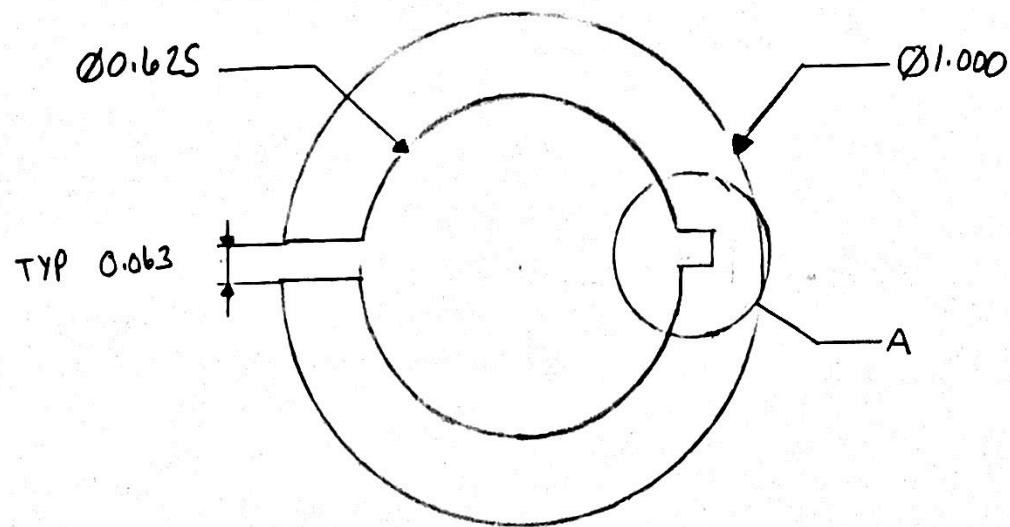
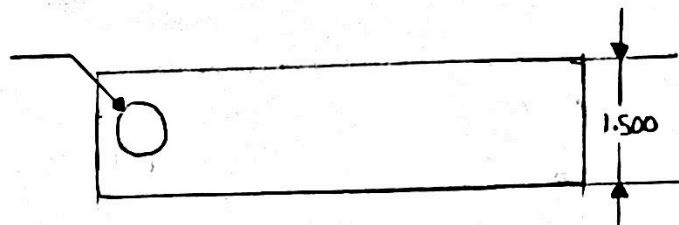


Jacob's Manufacturing Time								
Clamping Shaft Collar								
Process	Category	Unit	Time [MIN/UNIT]	Material Multiplie	Size Multipli	Feature Quantit	Total	Comments
SELECT MATERIAL	Preparation	pcs	1.00	N	N	1.00	1.00	
MACHINING SETUP, INSTALL AND REMOVE	Preparation	in	10.00	N	N	1.00	10.00	Cut stock to 1.500" length on band saw
BAND SAW CUTTING	2D Cutting	in	0.50	1.00	1.00	1.50	0.75	Cut Ø1.500" aluminum round bar to 1.500" length
MACHINING SETUP, INSTALL AND REMOVE	Preparation	in	10.00	N	N	1.00	10.00	Set up in lathe for turning
TURNING	Machining	in^3	1.00	1.00	N	0.58	0.58	Turn OD from Ø1.500" down to Ø1.000", remove 0.58 in ³
BORING HOLES	Machining	in	0.60	1.00	N	1.50	0.90	Bore Ø.625" shaft bore through full 1.500" length
MACHINING SETUP, CHANGE	Preparation	unit	3.00	N	N	1.00	3.00	Re-orient for milling operations
MILLING	Machining	in^3	1.00	1.00	4.00	0.05	0.20	Mill longitudinal split cut through both sides of collar

DRILLED HOLE < 1 IN DIA.	Machining	hole	0.20	1.00	1.00	1.00	0.20	Drill Ø.159" tap drill for 10- 32 thumb screw hole
TAPPING HOLE (HAND)	Machining	hole	5.00	1.00	1.00	1.00	5.00	Tap 10-32 UNC thumb screw hole through split
DEBURRING	Finishing	in	0.05	1.00	N	5.00	0.25	Deburr all machined edges
						Subtotal	31.88	

Clamping Shaft Collar

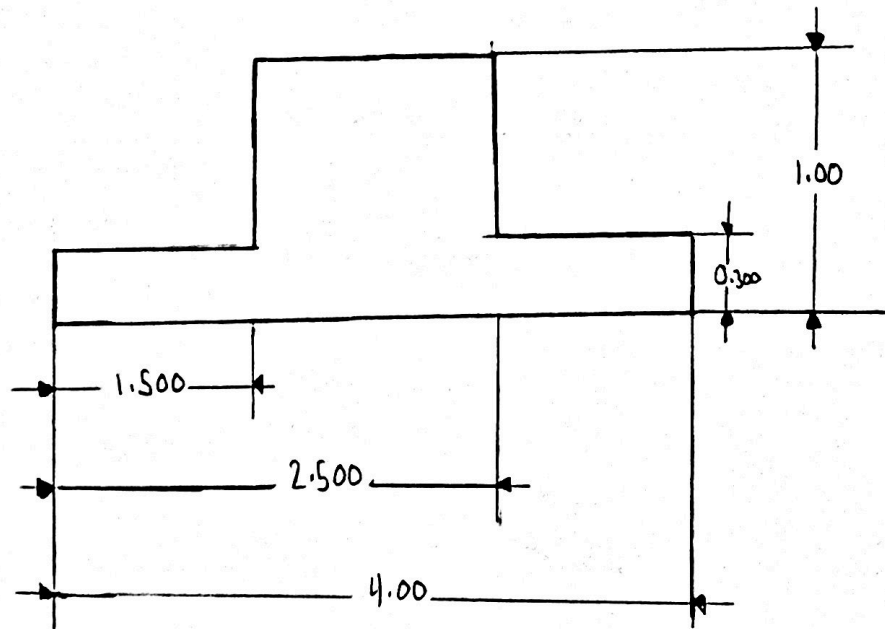
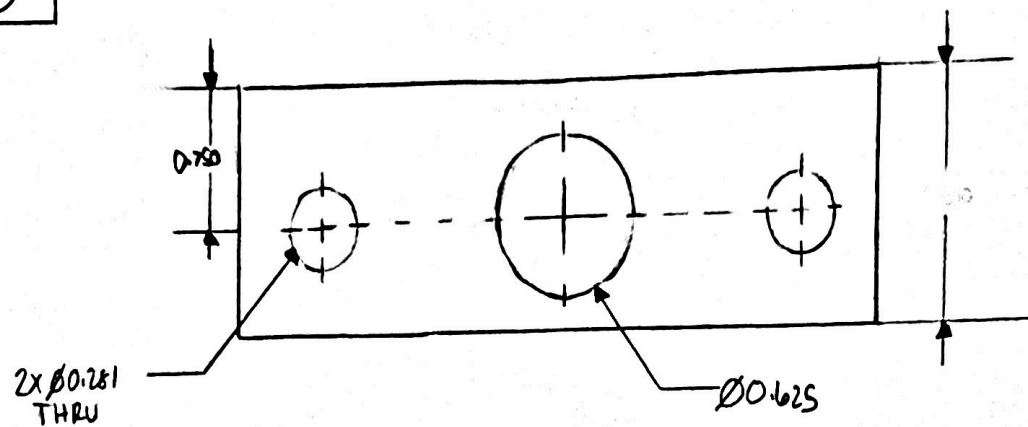
#10-32
TAP THRU



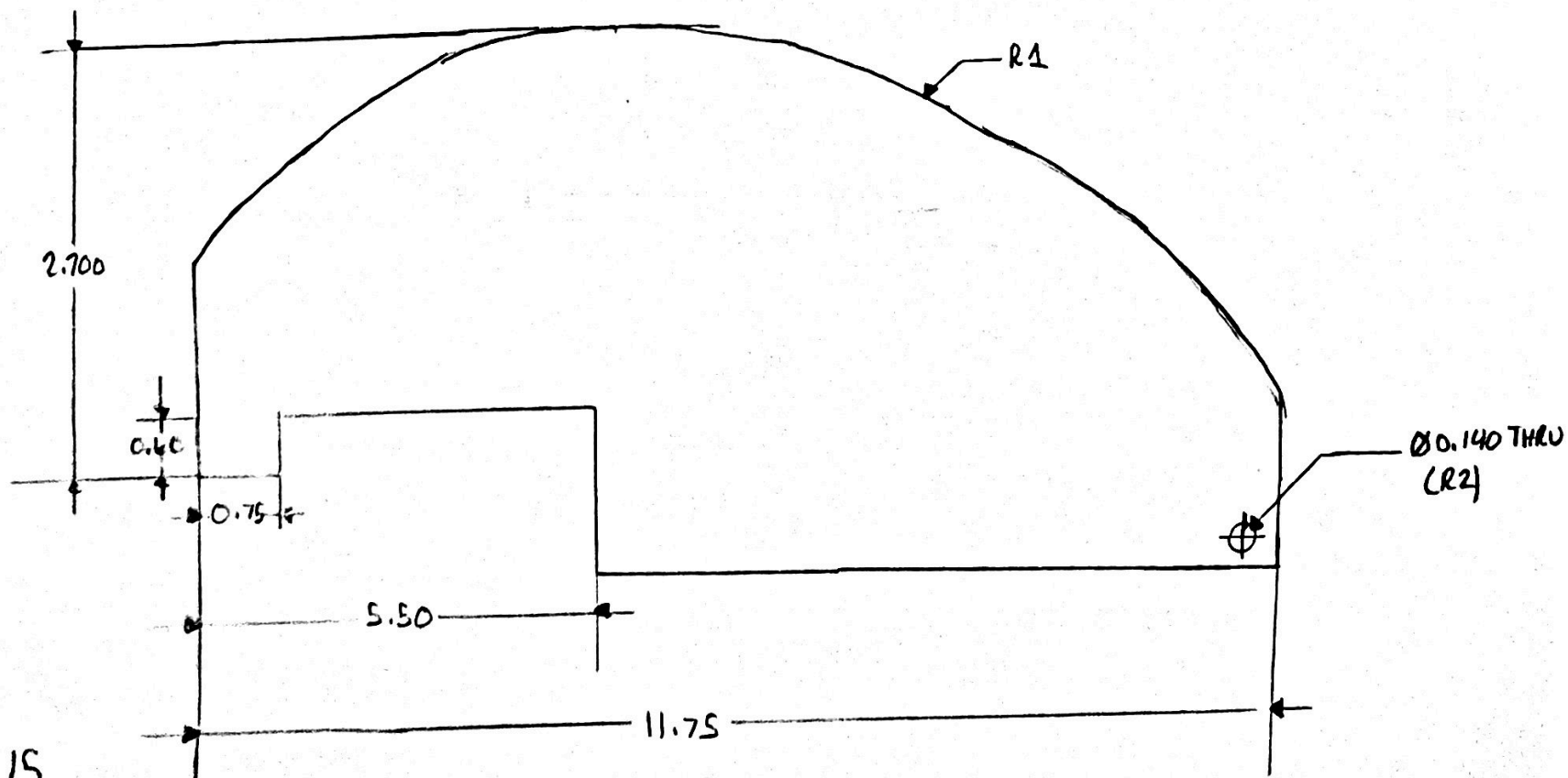
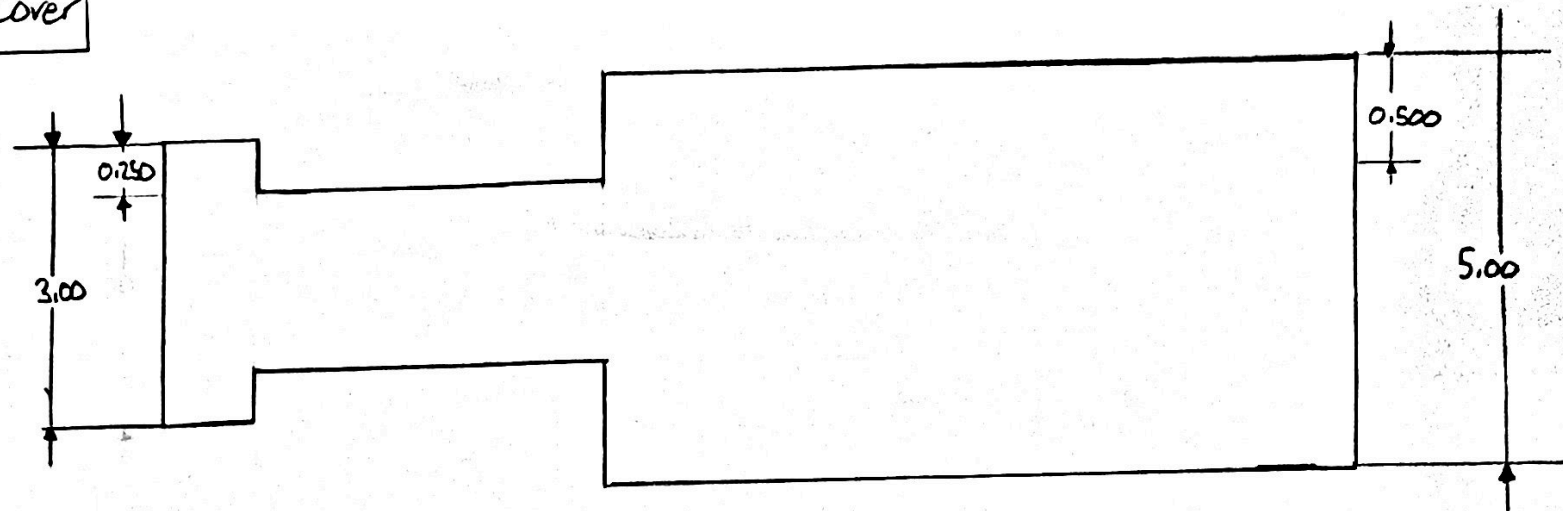
Jacob's Manufacturing Time								
Bearing Housing								
Process	Category	Unit	Time [MIN/UNIT]	Material Multiplier	Size Multiplier	Feature Quantity	Total	Comments
SELECT MATERIAL	Preparation	pcs	1.00	N	N	1.00	1.00	
MACHINING SETUP, INSTALL AND REMOVE	Preparation	in	10.00	N	N	1.00	10.00	Cut stock to 4.00" length on band saw
BAND SAW CUTTING	2D Cutting	in	0.50	1.00	1.00	1.50	0.75	Cut 1.5"×1.5" bar to 4.00" length
MACHINING SETUP, INSTALL AND REMOVE	Preparation	in	10.00	N	N	1.00	10.00	Set up on mill for height reduction
MILLING	Machining	in^3	1.00	1.00	2.00	2.00	4.00	Mill housing height from 1.500" down to 1.000", remove 0.500"×1.500"×4.000" = 3.00 in³ but use 2× endmill mult for 0.5-1.0" tool
MACHINING SETUP, CHANGE	Preparation	in	3.00	N	N	1.00	3.00	Re-orient for boring bearing bores

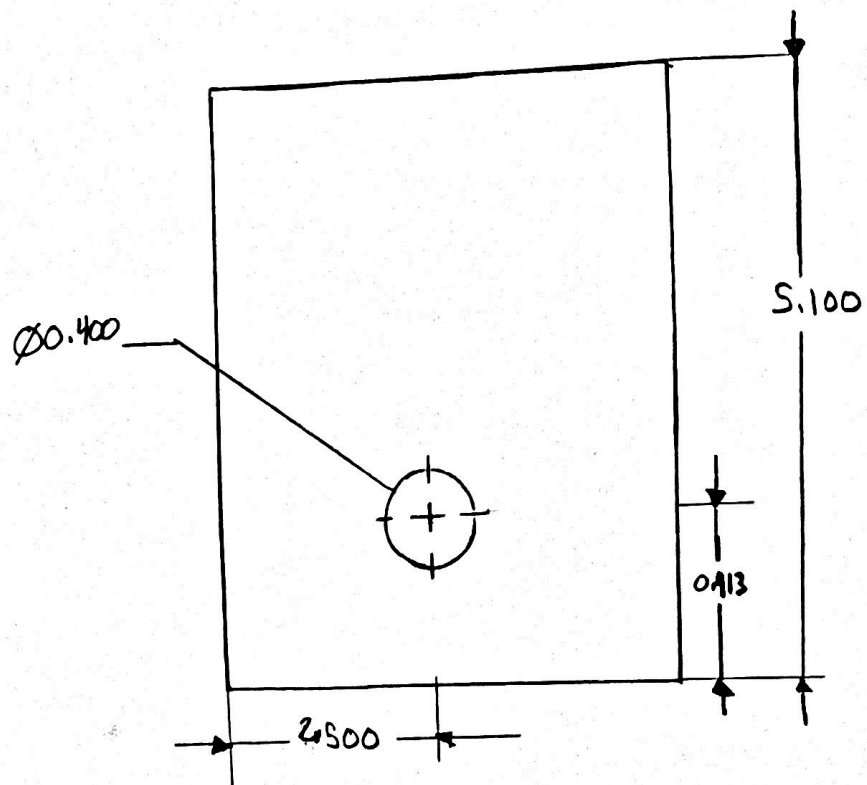
BORING HOLES	Machining	in	0.60	1.00	N	0.69	0.41	Bore 2× bearing seats Ø1.375" × 0.344" deep each = 0.688" total depth
DRILLED HOLE < 1 IN DIA.	Machining	hole	0.20	1.00	1.00	1.00	0.20	Drill shaft clearance hole Ø.620 thru 1.000" housing
MACHINING SETUP, CHANGE	Preparation	in	3.00	N	N	1.00	3.00	Re-orient for T-bolt clearance holes on bottom face
DRILLED HOLE < 1 IN DIA.	Machining	hole	0.20	1.00	1.50	2.00	0.60	Drill 2× Ø.281 T-bolt clearance holes thru 1.000" housing, depth ≥ 4D
DEBURRING	Finishing	in	0.05	1.00	N	11.00	0.55	Re-orient for T-bolt clearance holes on bottom face
						Subtotal	33.51	

Bearing Housing



Jacob's Manufacturing Time								
3D Printed Cover								
Process	Category	Unit	Time [MIN/UNIT]	Material Multiplier	Size Multiplier	Feature Quantity	Total	Comments
3D PRINT - SLICE / SETUP	Rapid Prototype	part	20.00	N	N	1.00	20.00	Export model, upload to slicer,
3D PRINT - PLASTIC	Rapid Prototype	in^3	45.00	N	N	2.00	90.00	Print PETG cover ~2.00 in ³ estimated volume
						Subtotal	110.00	
						Total	403.80	



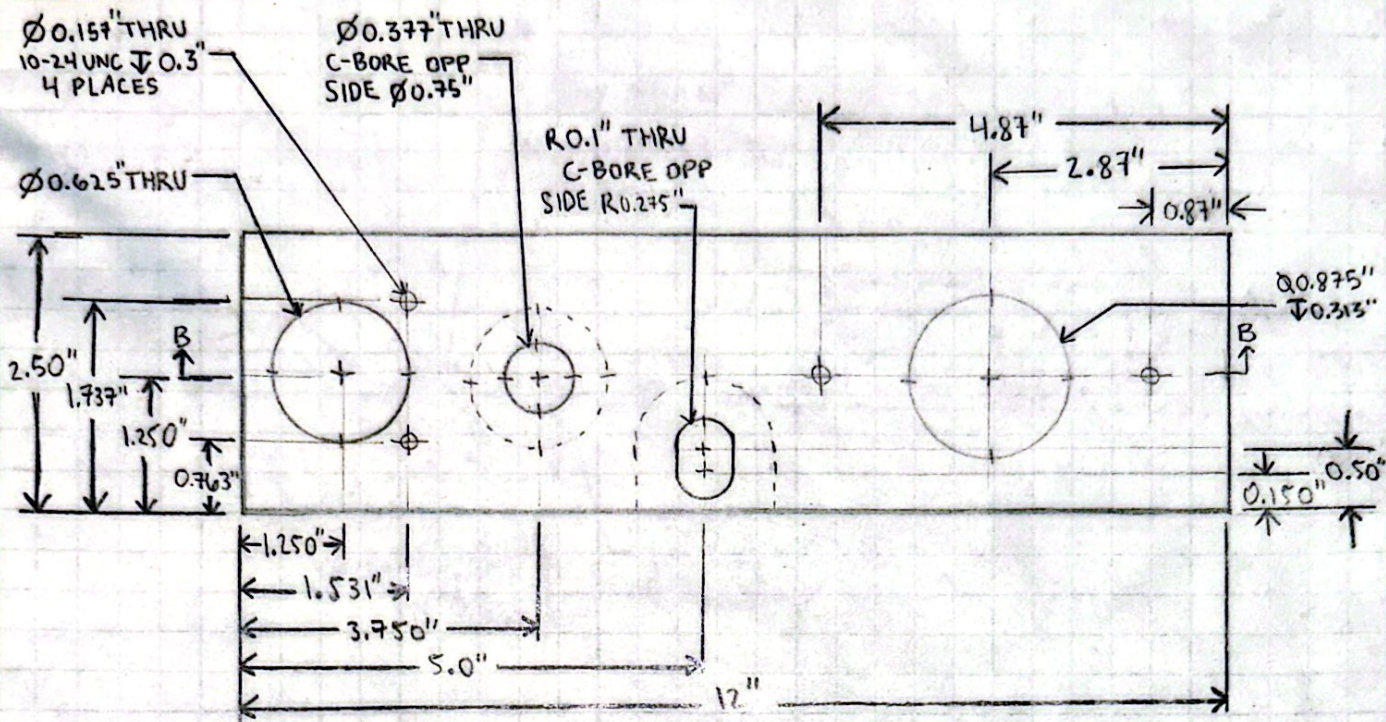


Matthew's Manufacturing Time								
Modified Base								
Process	Category	Unit	Time [MIN/UNIT]	Material Multiplier	Size Multiplier	Feature Quantity	Total	Comments
SELECT MATERIAL	Preparation	pcs	1.00	N	N	1.00	1.00	
MACHINING SETUP, INSTALL AND REMOVE	Preparation	in	10.00	N	N	1.00	10.00	Installing stock in vise, finding zeros, etc; needs to be done for each machine
BAND SAW CUTTING	2D Cutting	in	0.50	1.00	2.00	1.00	1.00	Cut to 12" long through 2.5" of material
MACHINING SETUP, INSTALL AND REMOVE	Preparation	in	10.00	N	N	1.00	10.00	Installing stock in vise, finding zeros, etc; needs to be done for each machine
MILLING	Machining	in^3	1.00	1.00	1.00	4.00	4.00	Mill to 12"x0.6"x2.5"
DRILLED HOLE < 1 IN DIA.	Machining	hole	0.20	1.00	3.00	2.00	1.20	Drill tensioner arm thru holes
MILLING	Machining	in^3	1.00	1.00	1.00	1.00	1.00	Mill between holes
DRILLED HOLE < 1 IN DIA.	Machining	hole	0.20	1.00	1.50	1.00	0.30	Drill tensioner arm c-bore 0.3" deep
MILLING	Machining	in^3	1.00	1.00	1.00	1.00	1.00	Mill between hole and edge
DRILLED HOLE < 1 IN DIA.	Machining	hole	0.20	1.00	1.50	2.00	0.60	Drill platform support thru holes
TAPPING HOLE (HAND)	Machining	hole	5.00	1.00	3.00	2.00	30.00	Tap platform support holes 10-24 UNC thru
MACHINING SETUP, CHANGE	Preparation	unit	3.00	N	N	1.00	3.00	Re-orienting part for second op; machining second identical part with work stop; etc.
DRILLED HOLE < 1 IN DIA.	Machining	hole	0.20	1.00	3.00	1.00	0.60	Drill shaft support 0.313" deep (for bearing + shaft)
						Subtotal	63.70	

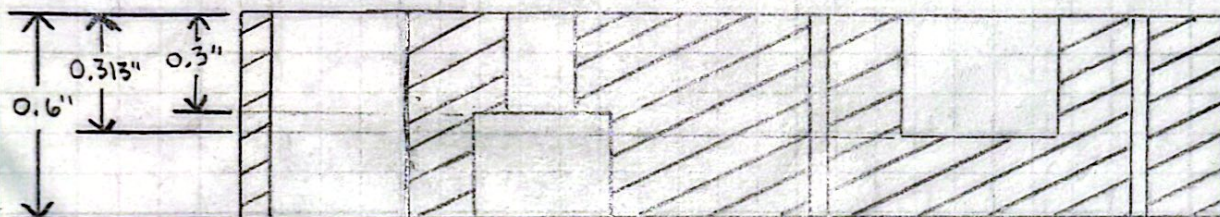
BASE

(MODIFIED) AIR ENGINE BASE

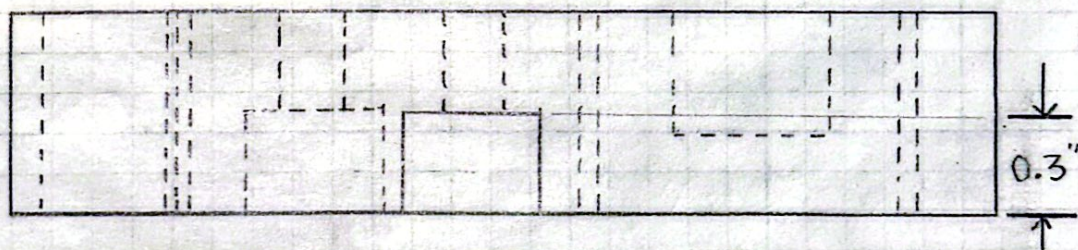
TOP



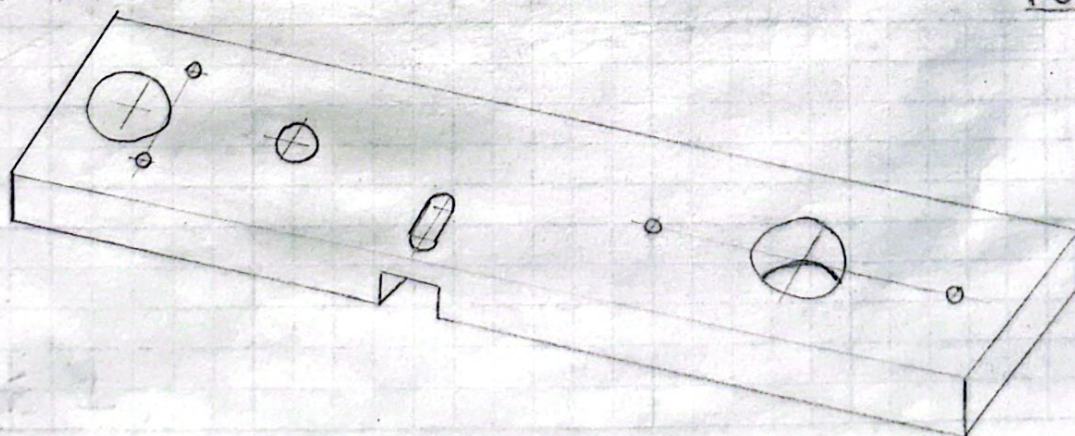
SECTION B-B



SIDE



ISOMETRIC



Matthew's Manufacturing Time								
Modified Flywheel								
Process	Category	Unit	Time [MIN/UNIT]	Material Multiplier	Size Multiplier	Feature Quantity	Total	Comments
SELECT MATERIAL	Preparation	pcs	1.00	N	N	1.00	1.00	
MACHINING SETUP, INSTALL AND REMOVE	Preparation	in	10.00	N	N	1.00	10.00	Installing stock in vise, finding zeros, etc; needs to be done for each machine
TURNING	Machining	in^3	1.00	3.00	N	1.00	3.00	Turn down the flywheel to 1.4" diameter leaving 1.5" diameter lips for belt stability 0.05" tall (each)
MACHINING SETUP, INSTALL AND REMOVE	Preparation	in	10.00	N	N	1.00	10.00	Installing stock in vise, finding zeros, etc; needs to be done for each machine
BAND SAW CUTTING	2D Cutting	in	0.50	3.00	2.00	1.00	3.00	Cut to 12" long through 2.5" of material
						Subtotal	27.00	

FLYWHEEL (MODIFIED AIR ENGINE FLYWHEEL)

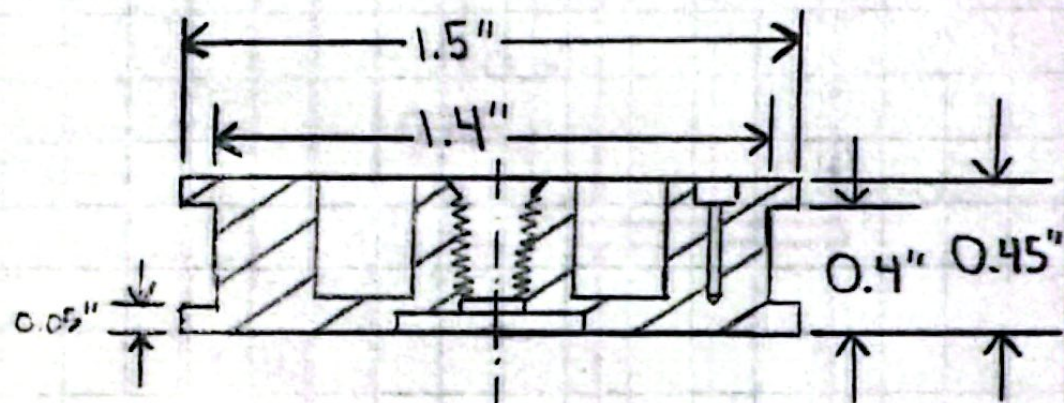
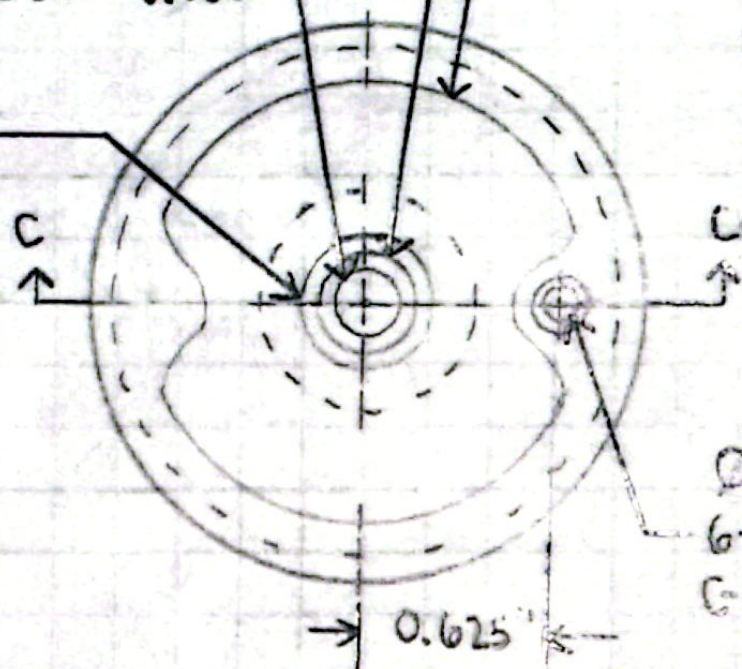
TOP

SECTION C-C

Ø0.161" THRU
10-24 LH UNC THRU
C-BORE OPP SIDE Ø0.252" $\pm$ 0.070"
C-BORE OPP SIDE Ø0.650" $\pm$ 0.050"

C-SINK Ø0.261"
MACHINE PROFILE
ON CNC

Ø0.375"

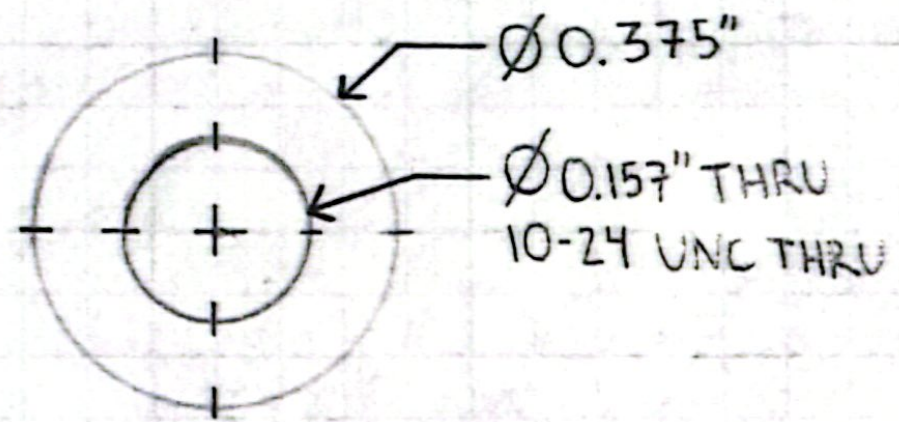


Ø0.107" $\pm$ 0.39"
6-32 UNC $\pm$ 0.3"
C-BORE Ø0.161" $\pm$ 0.055"

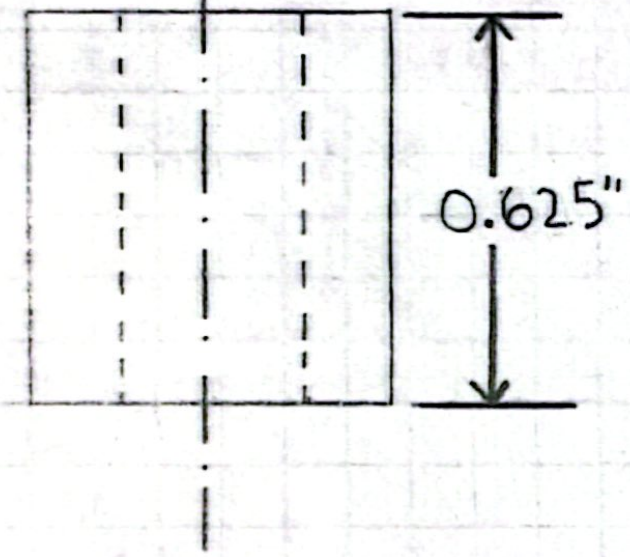
Matthew's Manufacturing Time								
Tensioner Arm								
Process	Category	Unit	Time [MIN/UNIT]	Material Multiplier	Size Multiplier	Feature Quantity	Total	Comments
SELECT MATERIAL	Preparation	pcs	1.00	N	N	1.00	1.00	
MACHINING SETUP, INSTALL AND REMOVE	Preparation	in	10.00	N	N	1.00	10.00	Installing stock in vise, finding zeros, etc; needs to be done for each machine
BAND SAW CUTTING	2D Cutting	in	0.50	1.00	0.30	1.00	0.15	Cut to 0.625" long through 0.375" of material
MACHINING SETUP, INSTALL AND REMOVE	Preparation	in	10.00	N	N	1.00	10.00	Installing stock in vise, finding zeros, etc; needs to be done for each machine
TURNING	Machining	in^3	1.00	1.00	N	1.00	1.00	Ensure correct diameter 0.375" and length 0.625"
DRILLED HOLE < 1 IN DIA.	Machining	hole	0.20	1.00	1.50	1.00	0.30	Drill hole in center
TAPPING HOLE (HAND)	Machining	hole	5.00	1.00	1.50	1.00	7.50	10-24 UNC thru
						Subtotal	29.95	

TENSIONER ARM

TOP



SIDE

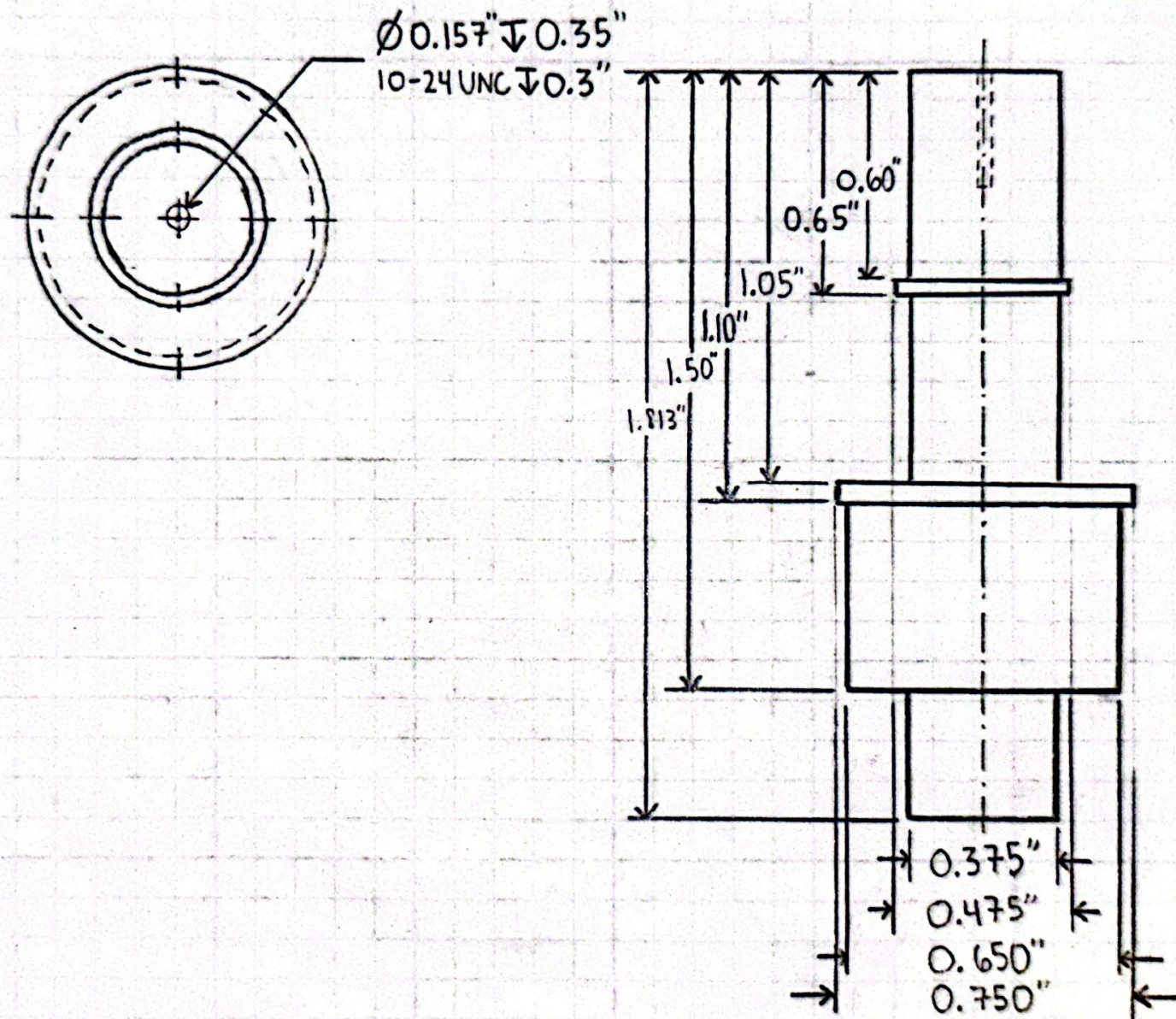


Matthew's Manufacturing Time								
Shaft								
Process	Category	Unit	Time [MIN/UNIT]	Material Multiplier	Size Multiplier	Feature Quantity	Total	Comments
SELECT MATERIAL	Preparation	pcs	1.00	N	N	1.00	1.00	
MACHINING SETUP, INSTALL AND REMOVE	Preparation	in	10.00	N	N	1.00	10.00	Installing stock in vise, finding zeros, etc; needs to be done for each machine
BAND SAW CUTTING	2D Cutting	in	0.50	1.00	0.50	1.00	0.25	Cut to 1.813" long through 0.75" of material
MACHINING SETUP, INSTALL AND REMOVE	Preparation	in	10.00	N	N	1.00	10.00	Installing stock in vise, finding zeros, etc; needs to be done for each machine
TURNING	Machining	in^3	1.00	1.00	N	1.00	1.00	Surface finish the bandsaw cut so its flat and correct length
TURNING	Machining	in^3	1.00	1.00	N	6.00	6.00	Turn each diameter in the shaft
DRILLED HOLE < 1 IN DIA.	Machining	hole	0.20	1.00	1.50	1.00	0.30	Drill hole for drive pin 0.35" deep
TAPPING HOLE (HAND)	Machining	hole	5.00	1.00	1.50	1.00	7.50	10-24 UNC 0.3" deep
						Subtotal	36.05	

SHAFT

Top

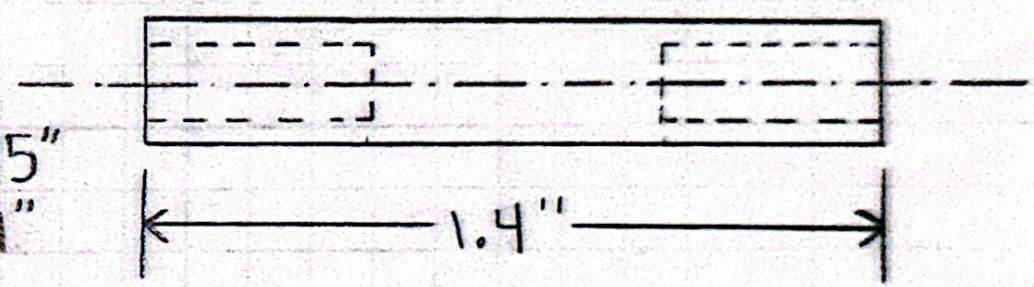
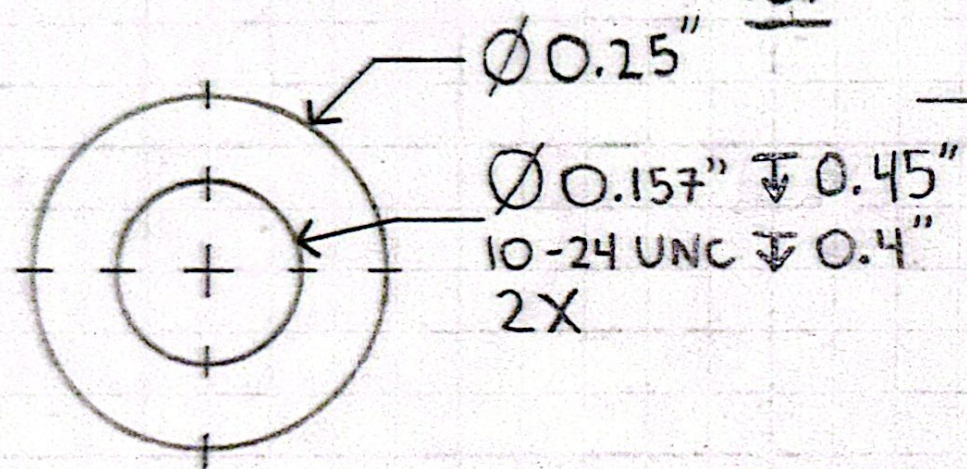
SIDE



Matthew's Manufacturing Time								
Platform Supports								
Process	Category	Unit	Time [MIN/UNIT]	Material Multiplier	Size Multiplier	Feature Quantity	Total	Comments
SELECT MATERIAL	Preparation	pcs	1.00	N	N	2.00	2.00	
MACHINING SETUP, INSTALL AND REMOVE	Preparation	in	10.00	N	N	2.00	20.00	Installing stock in vise, finding zeros, etc; needs to be done for each machine
BAND SAW CUTTING	2D Cutting	in	0.50	1.00	0.30	2.00	0.30	Cut to 1.4" long through 0.25" of material
MACHINING SETUP, INSTALL AND REMOVE	Preparation	in	10.00	N	N	1.00	10.00	Installing stock in vise, finding zeros, etc; needs to be done for each machine
TURNING	Machining	in^3	1.00	1.00	N	1.00	1.00	Ensure correct diameter 0.25" and length 1.4"
DRILLED HOLE < 1 IN	Machining	hole	0.20	1.00	1.50	2.00	0.60	Drill holes for support bolts
TAPPING HOLE (HAND)	Machining	hole	5.00	1.00	1.50	2.00	15.00	10-24 UNC 0.4" deep in top and bottom of support rod
						Subtotal	48.90	

PLATFORM SUPPORT

SIDE



Matthew's Manufacturing Time								
Lid Platform								
Process	Category	Unit	Time [MIN/UNIT]	Material Multiplier	Size Multiplier	Feature Quantity	Total	Comments
3D PRINT - SLICE / SETUP	Rapid Prototype	part	20.00	N	N	1.00	20.00	Export model from CAD, upload to slicer, orient on bed, adjust settings, slice, upload to printer
3D PRINT - PLASTIC	Rapid Prototype	in^3	45.00	N	N	1.00	45.00	
						Subtotal	65.00	

LID PLATFORM

TOP

Ø0.875 THRU
C-BORE Ø3.460" ↓ 0.40"

R0.25"

Ø3.60"

2.0"

Ø0.157" THRU
10-24 UNC THRU
2 PLACES

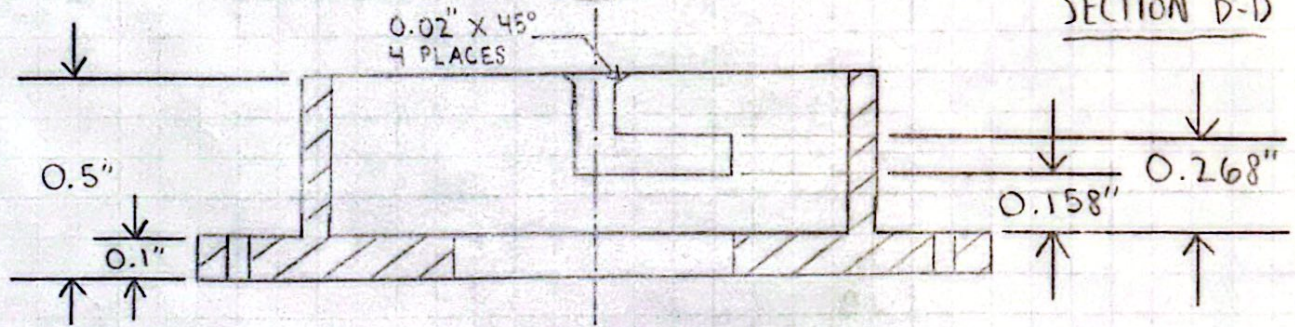
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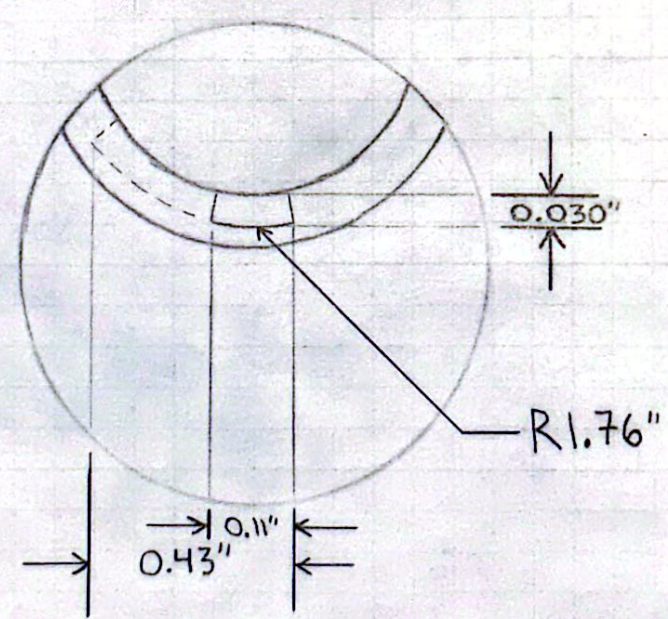
B

0.02" X 45°
4 PLACES

SECTION D-D



DETAIL B

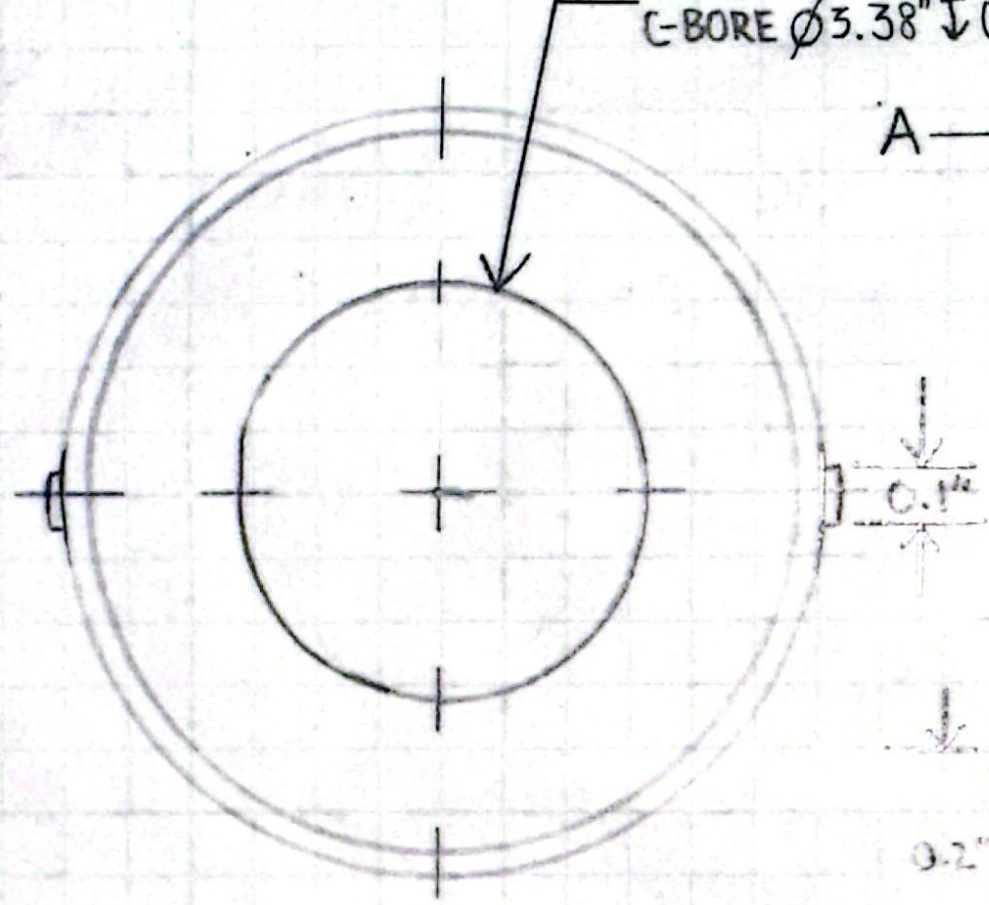


Matthew's Manufacturing Time								
Lid Adapter								
Process	Category	Unit	Time [MIN/UNIT]	Material Multiplier	Size Multiplier	Feature Quantity	Total	Comments
SELECT MATERIAL	Preparation	pcs	1.00	N	N	1.00	1.00	
MACHINING SETUP, INSTALL AND REMOVE	Preparation	in	10.00	N	N	1.00	10.00	Installing stock in vise, finding zeros, etc; needs to be done for each machine
BAND SAW CUTTING	2D Cutting	in	0.50	1.00	4.00	1.00	2.00	Cut to 0.5" long through 3.5" of material
MACHINING SETUP, INSTALL AND REMOVE	Preparation	in	10.00	N	N	1.00	10.00	Installing stock in vise, finding zeros, etc; needs to be done for each machine
DRILLED HOLE < 2 IN DIA.	Machining	hole	0.50	1.00	1.50	1.00	0.75	Thru hole center cut for drive pin to blade connection.
MACHINING SETUP, CHANGE	Preparation	unit	3.00	N	N	1.00	3.00	Re-orienting part for second op; machining second identical part with work stop; etc.
TURNING	Machining	in^3	1.00	1.00	N	2.00	2.00	Remove the top and bottom portions of the outer notches for L-lock mechanism
MACHINING SETUP, CHANG	Preparation	unit	3.00	N	N	1.00	3.00	Re-orienting part for second op; machining second identical part with work stop; etc.
BORING HOLES	Machining	in	0.60	1.00	N	1.00	0.60	Bore diam 3.38" at 0.465" deep
MACHINING SETUP, INSTALL AND REMOVE	Preparation	in	10.00	N	N	1.00	10.00	Installing stock in vise, finding zeros, etc; needs to be done for each machine
MILLING	Machining	in^3	1.00	1.00	8.00	4.00	32.00	Mill the outer surface of the lid adapter to create notches that lock with the lid platform
						Subtotal	74.35	

LID ADAPTER

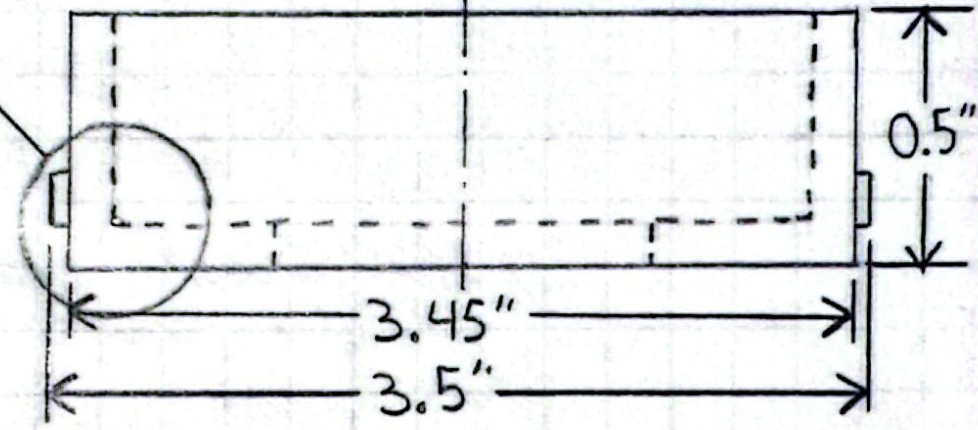
TOP

Ø1.95" THRU
C-BORE Ø3.38" ±0.465"

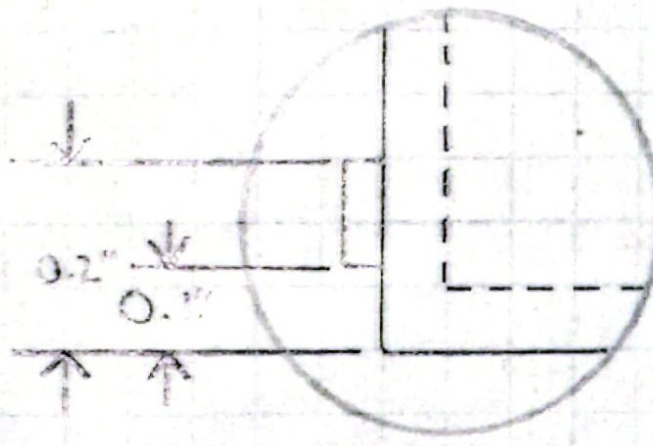


SIDE

A



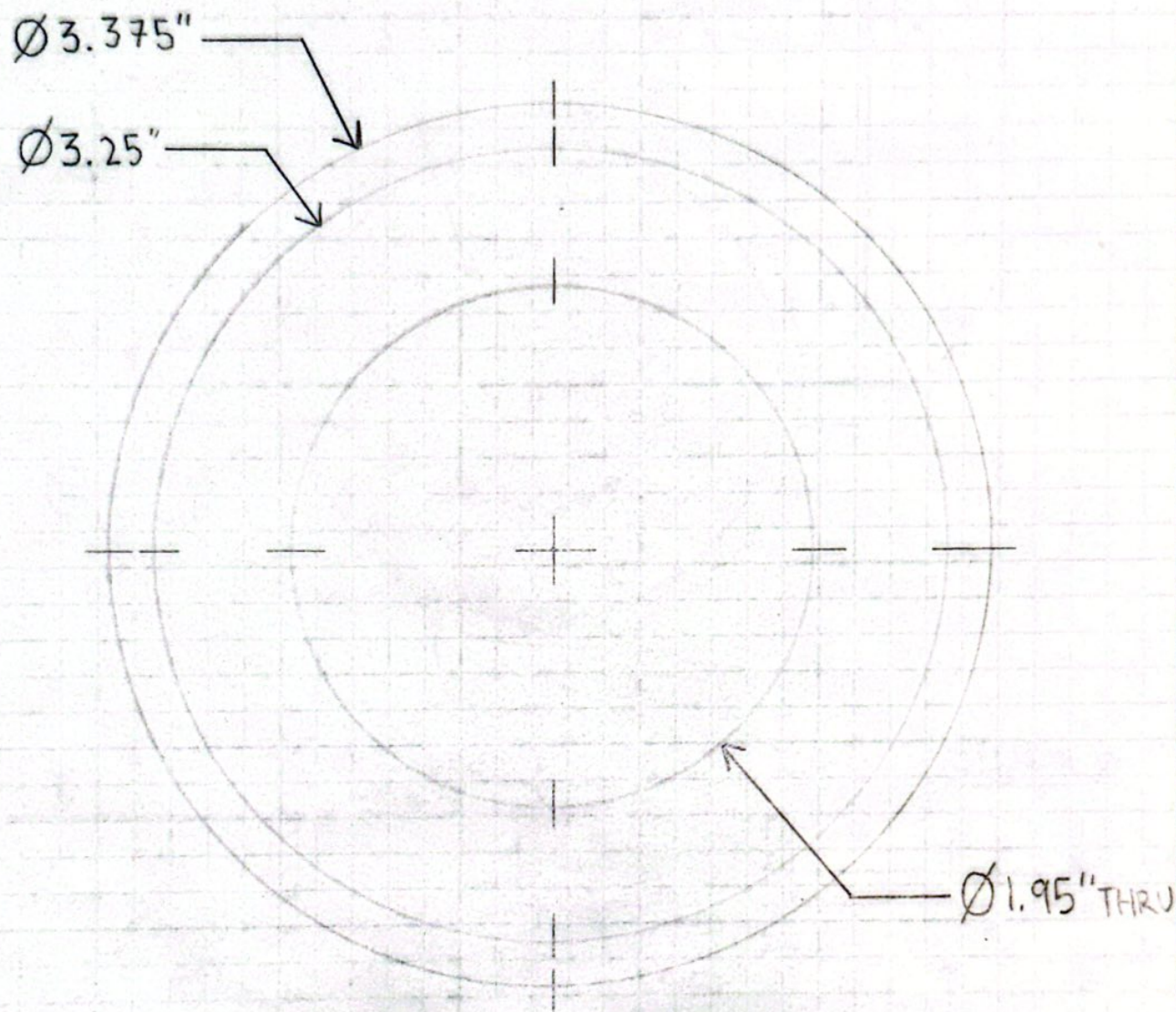
DETAIL A



Matthew's Manufacturing Time								
Lid								
Process	Category	Unit	Time [MIN/UNIT]	Material Multiplier	Size Multiplier	Feature Quantity	Total	Comments
SHEET METAL PUNCHING	Sheet Metal	hole	1.50	N	N	1.00	1.50	Modified OTS, only needs a thru hole cutout 1.95" diameter
						Subtotal	1.50	
						Total	346.45	

LID

TOP

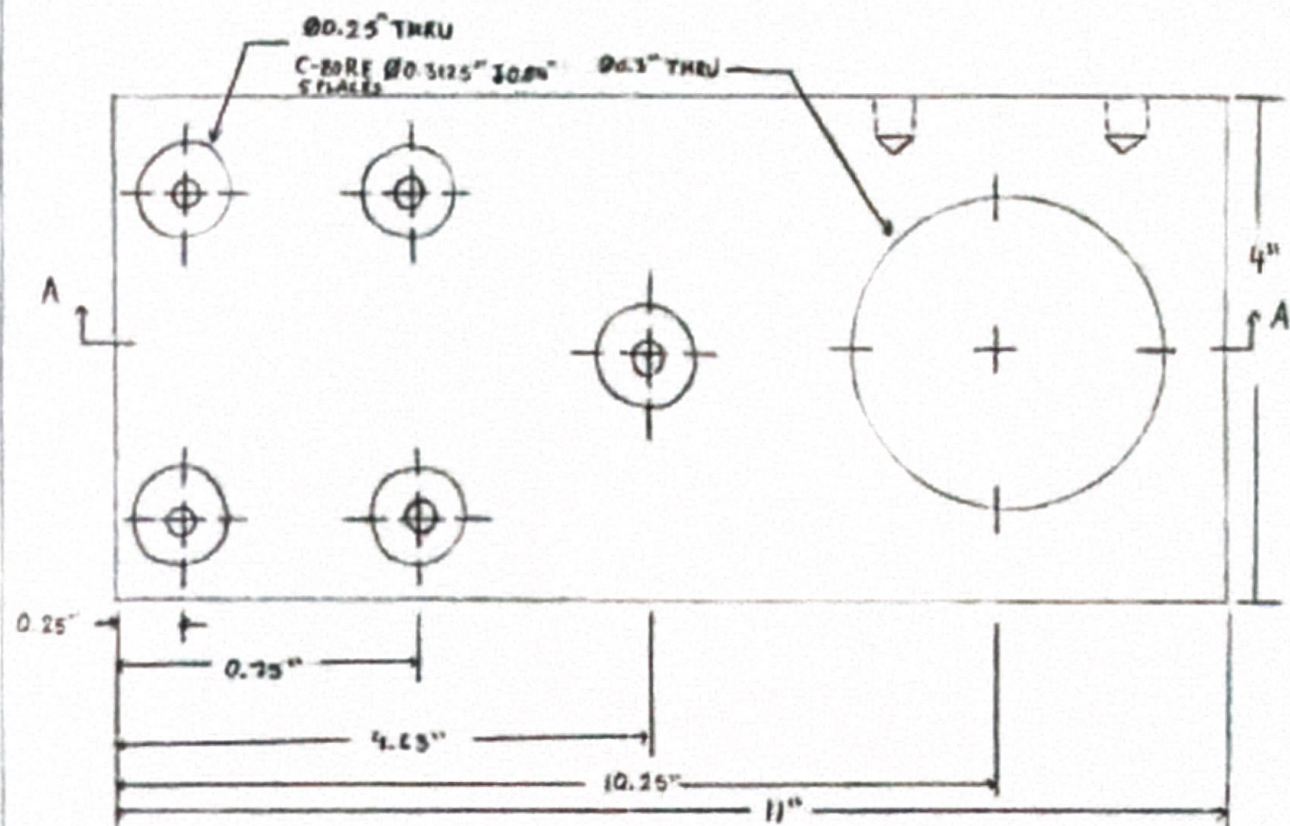


* STANDARD OTS ONE-PIECE WIDE MOUTH
MASON JAR LID WITH CENTER THRU HOLE.

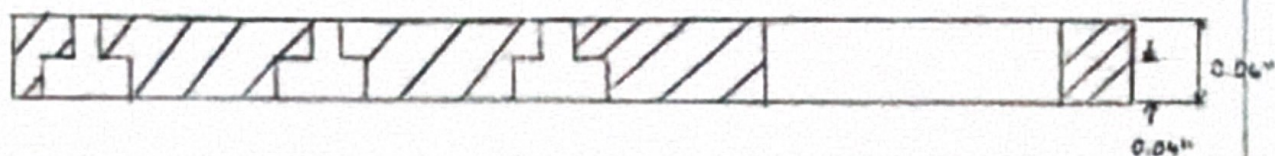
Om's Manufacturing Time								
Base Plate								
Process	Category	Unit	Time [MIN/UNIT]	Material Multiplier	Size Multiplier	Feature Quantity	Total	Comments
SELECT MATERIAL	Preparation	pcs	1	N	N	1	1	Find material on material rack. Material is 6061-T6 Aluminum
MACHINING SETUP, INSTALL AND REMOVE	Preparation	in	10	N	N	1	10	Installing stock in vise, finding zeros, etc; needs to be done for each machine
BAND SAW CUTTING	2D Cutting	in	0.5	1	0.3	1	0.15	Cut 12" stock to 11" for the base plate
MACHINING SETUP, INSTALL AND REMOVE	Preparation	in	10	N	N	1	10	Installing stock in vise, finding zeros, etc; needs to be done for each machine
MILLING	Machining	in^3	1	1	8	5	40	Make passes through the top face of the base plate to get a height of 0.1"
DRILLED HOLE < 2 IN DIA.	Machining	hole	0.5	1	1.5	1	0.75	Dill a 3" diameter thru hole for the base of the mason jar
DRILLED HOLE < 1 IN DIA.	Machining	hole	0.2	1	1.5	5	1.5	Drill four 0.25" diameter thru holes for the mounting legs
BORING HOLES	Machining	in	0.6	1	N	5	3	Drill 0.3125" diameter c-bore with a depth of 0.04"
MACHINING SETUP, CHANGE	Preparation	unit	3	N	N	1	3	Re-orienting part on its side for the hinge platform
DRILLED HOLE < 1 IN DIA.	Machining	hole	0.2	1	1.5	2	0.6	Drill two 0.157" holes with a depth of 0.50"
TAPPING HOLE (HAND)	Machining	hole	5	1	1.5	2	15	Tap side holes with 10-24 UNC
						Subtotal	85	

Base Plate

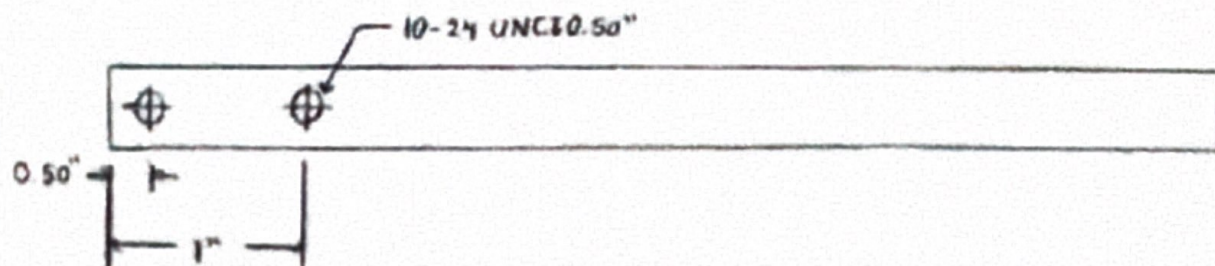
Top:



Section A-A:

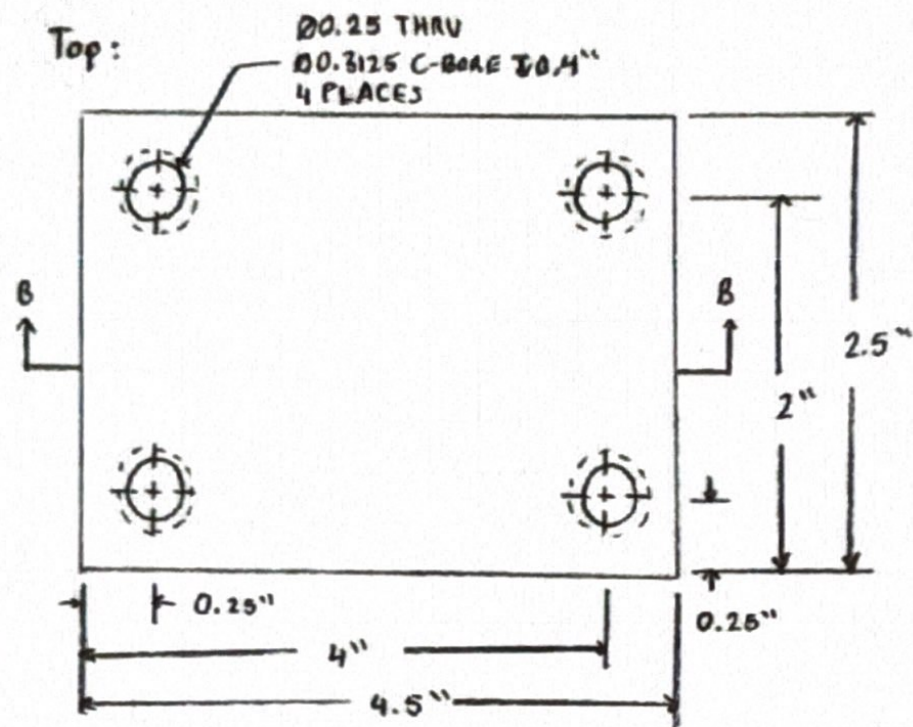


Side

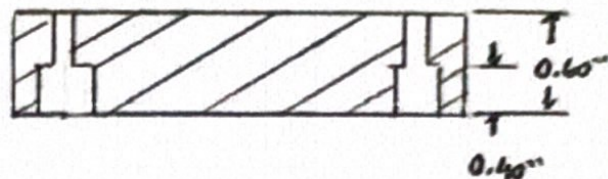


Om's Manufacturing Time								
Modified Air Engine Base								
Process	Category	Unit	Time [MIN/UNIT]	Material Multiplier	Size Multiplier	Feature Quantity	Total	Comments
MACHINING SETUP, INSTALL AND REMOVE	Preparation	in	10	N	N	1	10	Installing stock in vise, finding zeros, etc; needs to be done for each machine
DRILLED HOLE < 1 IN DIA.	Machining	hole	0.2	1	1.5	4	1.2	Drill four 0.25" diameter thru holes in the air engine base (given with subtractive modification)
BORING HOLES	Machining	in	0.6	1	N	4	2.4	Drill four 0.3125 diameter c-bore 0.4" diamater deep
						Subtotal	13.6	

Modified Air Engine Base (Given)



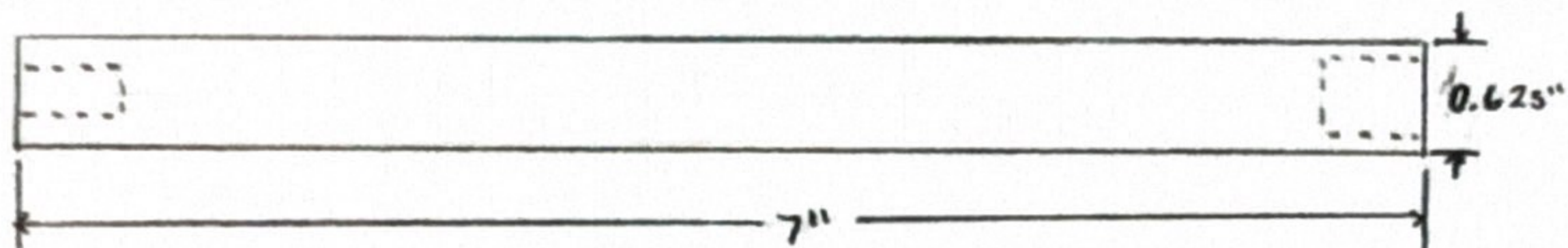
Section B-B:



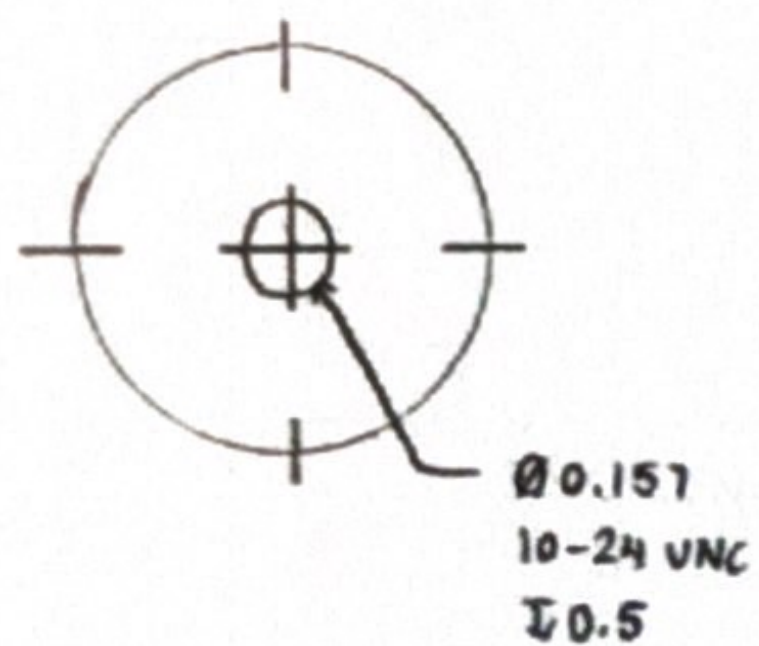
Om's Manufacturing Time								
Mounting Legs								
Process	Category	Unit	Time [MIN/UNIT]	Material Multiplier	Size Multiplier	Feature Quantity	Total	Comments
SELECT MATERIAL	Preparation	pcs	1	N	N	1	1	Find material on material rack. Material used is A36 Low Carbon Steel
MACHINING SETUP, INSTALL AND REMOVE	Preparation	in	10	N	N	1	10	Installing stock in vise, finding zeros, etc; needs to be done for each machine
BAND SAW CUTTING	2D Cutting	in	0.5	3	0.5	4	3	Given a 36" stock, cut four 7" pieces to get the support legs with material to spare
MACHINING SETUP, INSTALL AND REMOVE	Preparation	in	10	N	N	1	10	Installing stock in vise, finding zeros, etc; needs to be done for each machine
DRILLED HOLE < 1 IN DIA.	Machining	hole	0.2	3	1.5	1	0.9	Drill 0.157" diameter hole 0.5" deep that will connect the legs to the air engine
TAPPING HOLE (HAND)	Machining	hole	5	3	1.5	1	22.5	Tap air engine mounting legs hole with 10-24 UNC
MACHINING SETUP, CHANGE	Preparation	unit	3	N	N	1	3	Re-orienting part for second op; machining second identical part with work stop; etc.
DRILLED HOLE < 1 IN DIA.	Machining	hole	0.2	3	1.5	1	0.9	Drill 0.25" diameter hole 0.5" deep that will connect the legs to the base plate
TAPPING HOLE (HAND)	Machining	hole	5	3	1.5	1	22.5	Tap mounting legs hole with 10-24 UNC
						Subtotal	73.8	

Mounting Legs (2:1)

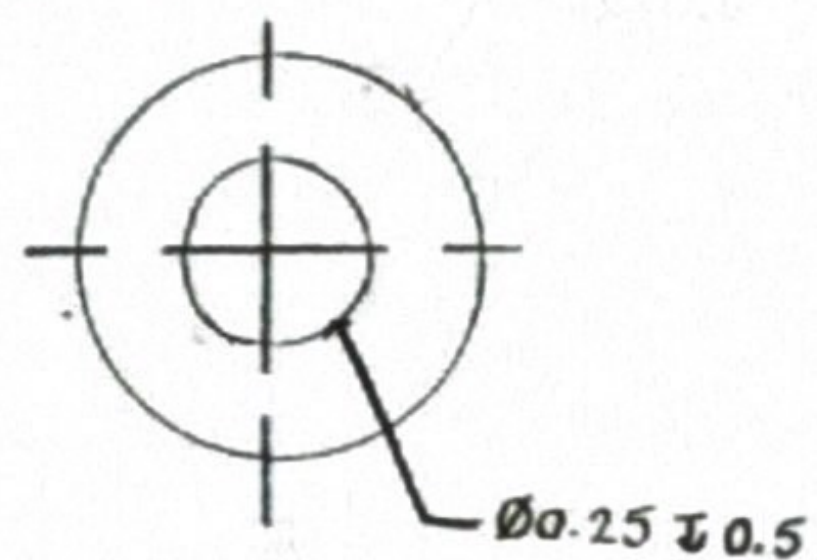
Side:



Top:

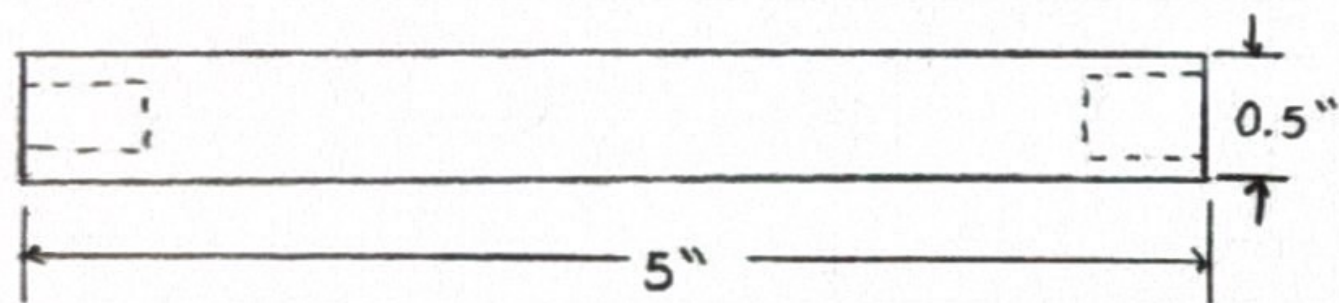


Bottom:

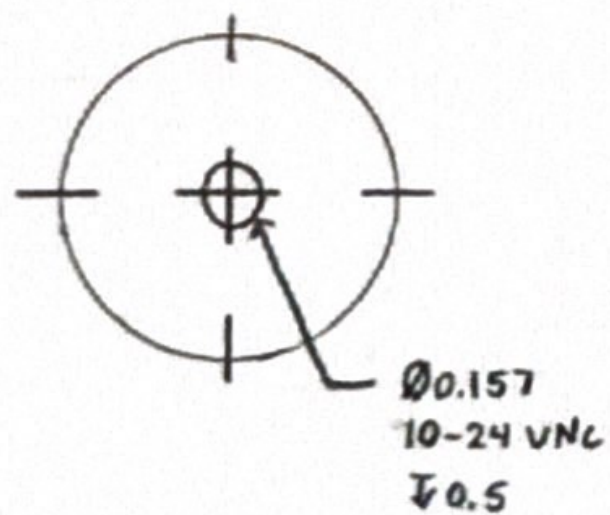


Om's Manufacturing Time								
Support Rod								
Process	Category	Unit	Time [MIN/UNIT]	Material Multiplier	Size Multiplier	Feature Quantity	Total	Comments
SELECT MATERIAL	Preparation	pcs	1	N	N	1	1	Find material on material rack. Material used is A36 Low Carbon Steel
MACHINING SETUP, INSTALL AND REMOVE	Preparation	in	10	N	N	1	10	Installing stock in vise, finding zeros, etc; needs to be done for each machine
BAND SAW CUTTING	2D Cutting	in	0.5	3	0.5	1	0.75	Cut 5" out of the 12" long stock
MACHINING SETUP, INSTALL AND REMOVE	Preparation	in	10	N	N	1	10	Installing stock in vise, finding zeros, etc; needs to be done for each machine
DRILLED HOLE < 1 IN DIA.	Machining	hole	0.2	3	1.5	1	0.9	Drill 0.157" diameter hole with a depth of 0.5"
TAPPING HOLE (HAND)	Machining	hole	5	3	1.5	1	22.5	Tap support rod with 10-24 UNC for the threaded rod
MACHINING SETUP, CHANGE	Preparation	unit	3	N	N	1	3	Re-orienting part for second op; machining second identical part with work stop; etc.
DRILLED HOLE < 1 IN DIA.	Machining	hole	0.2	3	1.5	1	0.9	Drill 0.25" diameter hole with a depth of 0.5" for connection with the base
						Subtotal	49.05	

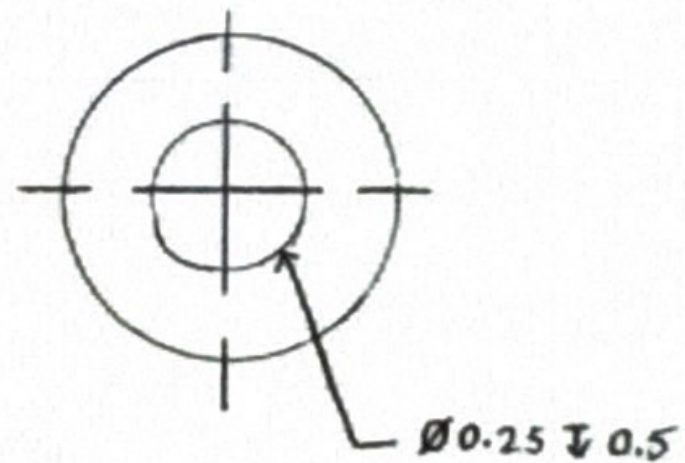
Support Rod (2:1)



Top:

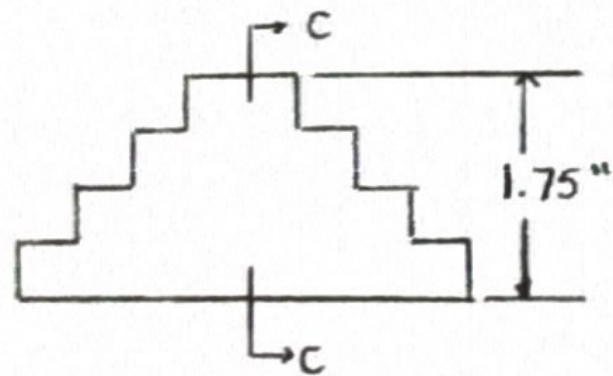


Bottom:

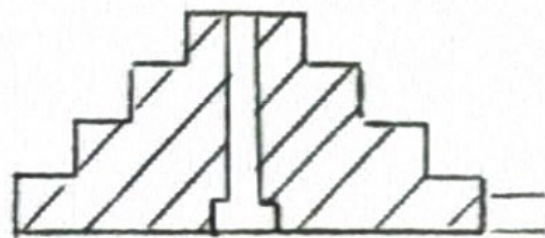


Om's Manufacturing Time								
Stepped Pulley 2								
Process	Category	Unit	Time [MIN/UNIT]	Material Multiplier	Size Multiplier	Feature Quantity	Total	Comments
MACHINING SETUP, INSTALL AND REMOVE	Preparation	in	10	N	N	1	10	Installing stock in vise, finding zeros, etc; needs to be done for each machine
BORING HOLES	Machining	in	0.6	1	N	3	1.8	Modified OTS, needs a 0.55" diameter bore at a height of 0.75" to insert the snap ring that will constrain the mixing attachment and a washer to reduce grinding in rotation. For boring, a 0.25" step up method is applied (3 passes) for the diameter with pecking for the height.
						Subtotal	11.8	

Modified Step Pulley 2 (OTS)

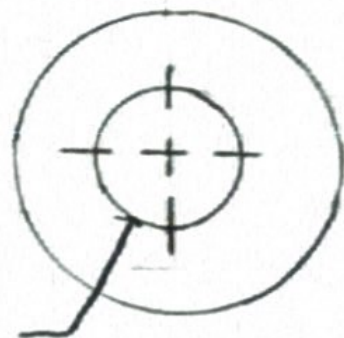


Section C-C:



$\varnothing 0.55$
 $\downarrow 0.75$

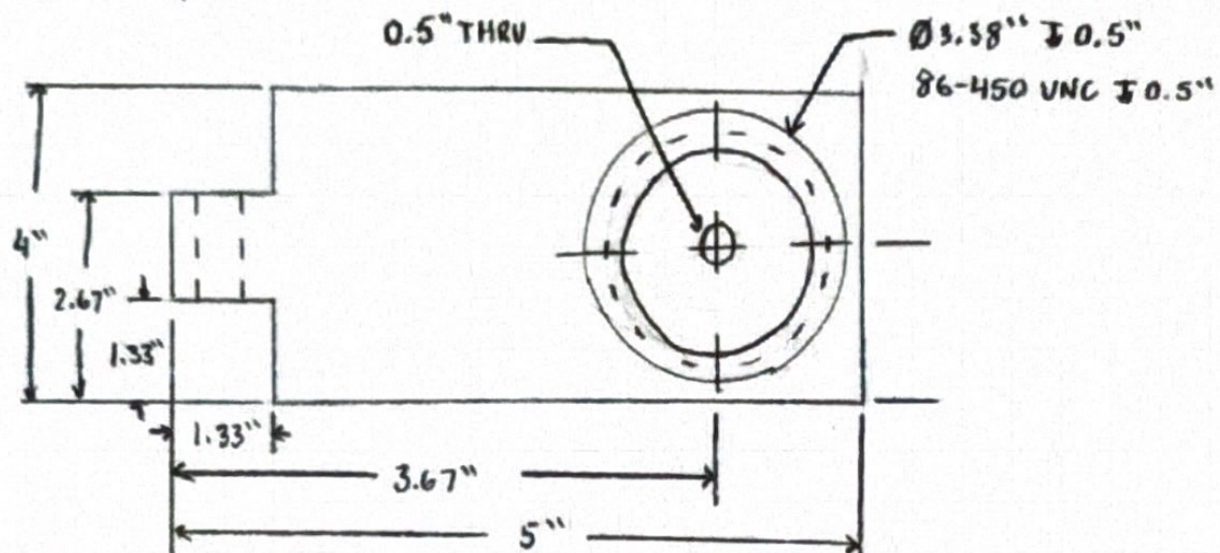
Bottom:



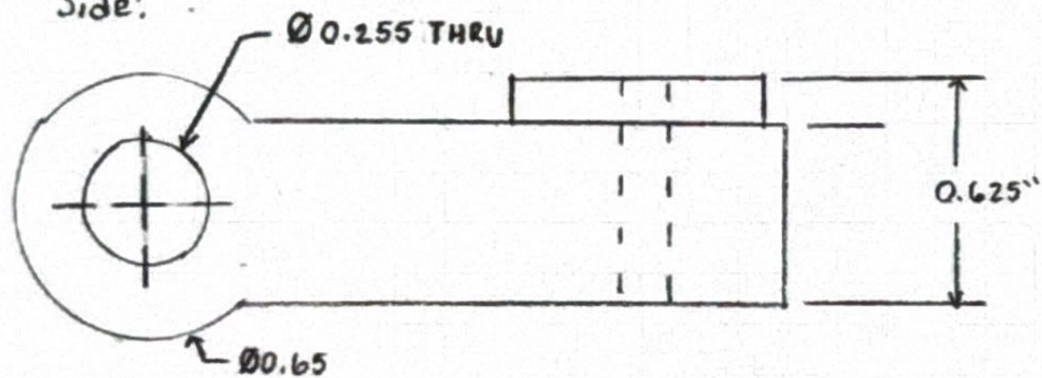
Om's Manufacturing Time								
Hinge Platform								
Process	Category	Unit	Time [MIN/UNIT]	Material Multiplier	Size Multiplier	Feature Quantity	Total	Comments
SELECT MATERIAL	Preparation	pcs	1	N	N	1	1	Find material on material rack. Material used is A36 Low Carbon Steel
								Programming CNC machine to manufacutre a part. Each toolpath requires separate programming time. An operation includes: selecting geometry, selecting a tool, configuring step downs and step overs, and modifying any other parameters for the toolpath.
CNC PROGRAMMING	CNC Machining	Operation	10	N	N	1	10	Features typically need both roughing and finishing passes. Holes of the same size can be grouped in one operation.
CNC MACHINING SETUP	CNC Machining	part	45	N	N	1	45	Setting up part and tooling. Zeroing / probing part and all tools. Checking offsets and clearances.
CNC VERIFICATION	CNC Machining	in^3	0.5	N	N	1	0.5	Confirming that program and setup are correct and that there will be no machine collisions during machining. Only necessary for first part if making multiple of the same part.
CNC MACHINING	CNC Machining	in^3	0.5	3	N	1	1.5	Volume of material being removed to get from raw stock to part geometry. Machining must include a minimum 1mm of machining stock to be removed from all surfaces with a machined surface.
						Subtotal	58	

Hinge Platform

Top:



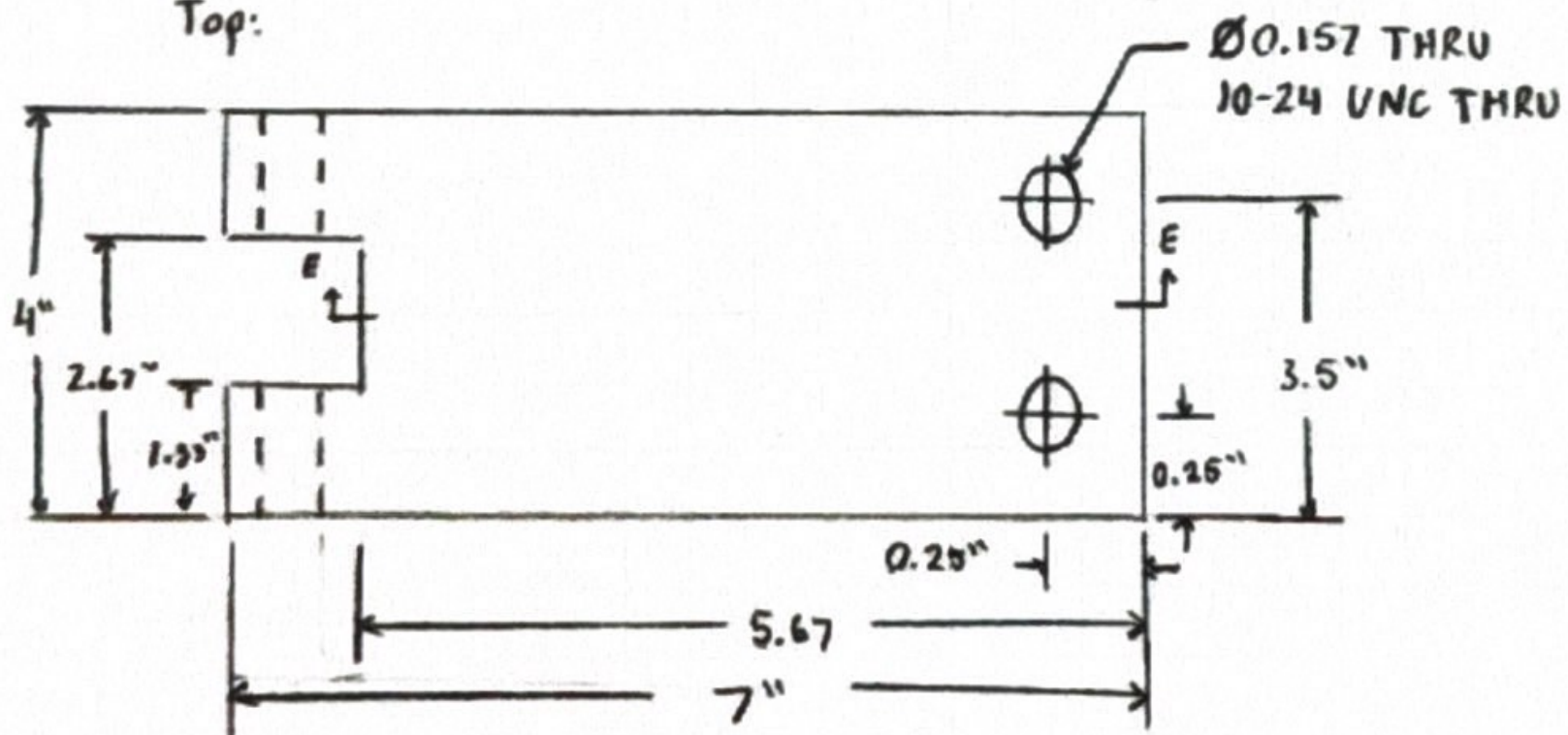
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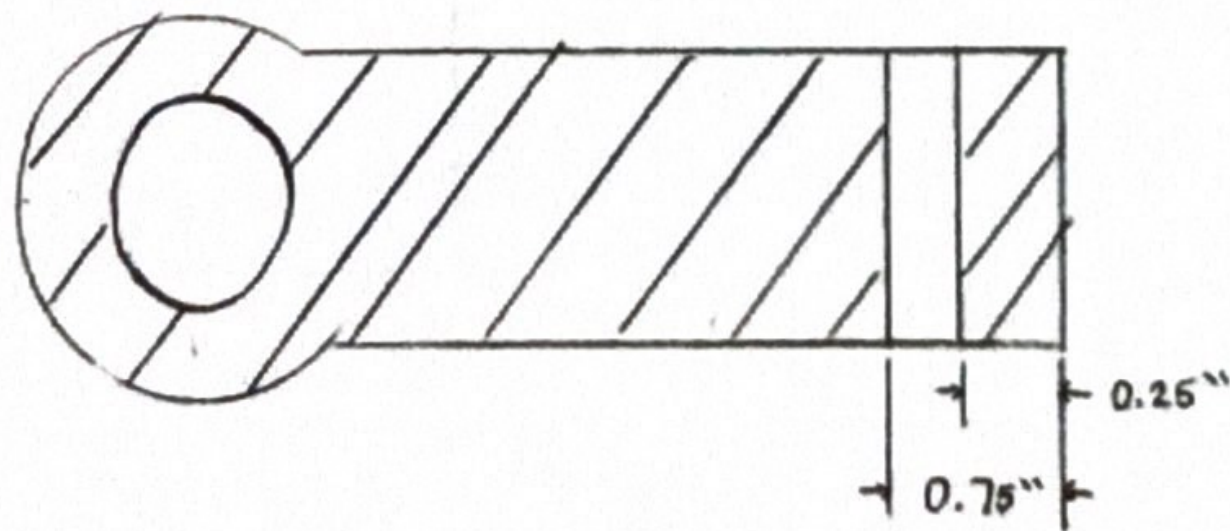
Om's Manufacturing Time								
Hinge Attachment								
Process	Category	Unit	Time [MIN/UNIT]	Material Multiplier	Size Multiplier	Feature Quantity	Total	Comments
3D PRINT - SLICE / SETUP	Rapid Prototype	part	20	N	N	1	20	Export model from CAD, upload to slicer, orient on bed, adjust settings, slice, upload to printer
3D PRINT - PLASTIC	Rapid Prototype	in^3	45	N	N	1	45	Slice model in Prusa Slicer or Cura to get more accurate time.
						Subtotal	65	

Hinge Attachment

Top:



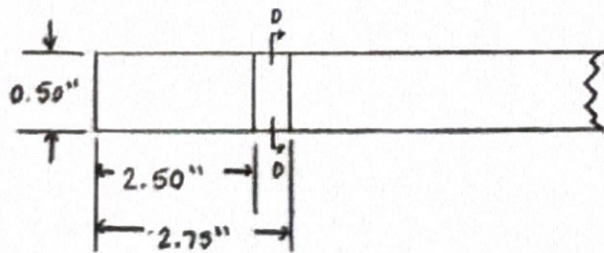
Section E-E:



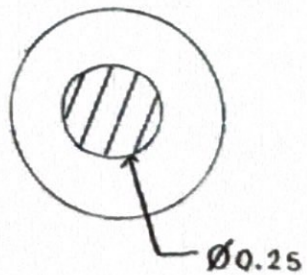
Om's Manufacturing Time								
Mixing Attachment								
Process	Category	Unit	Time [MIN/UNIT]	Material Multiplier	Size Multiplier	Feature Quantity	Total	Comments
MACHINING SETUP, INSTALL AND REMOVE	Preparation	in	10	N	N	1	10	Installing stock in vise, finding zeros, etc; needs to be done for each machine
TURNING	Machining	in^3	1	3.75	N	3	11.25	Modified OTS, needs a 0.25" inner diamter with a height of 0.25 in. for the snap ring concept. This process will consist of three passes: two 0.100" passes and one 0.05" pass.
						Subtotal	21.25	
						Total	377.5	

Modified Mixing Rod (OTS)

Broken:



Section D-D:



4C. Size Calculations

Size		
Design	Size (in ³)	Justification/Notes
Jacob's Design	854.5	Length: 11.75" (total length of base) Width: 5.0" (width of extended base) Height: 0.32" (rubber feet) + 12.25" (side wooden support beams) + 1.975" (total air engine height) = 14.545" $11.75 \times 5.0 \times 14.545 = 854.5$
Matthew's Design	113.8	Length: 12" (total length of base) Width: 3.6" (diameter of lid platform) Height: 0.6" (base) + 1.4" (platform support) + 0.1" (lid platform bottom) + 0.035" (lid adapter bottom) + 0.5" (lid) = 2.635" $12 \times 3.6 \times 2.635 = 113.832$
Nicholas's Design	343	Length: 10" (total length of base) Width: 4" (total width of base plate) Height: 0.6" (base) + 6" (support rods) + 1.975" (air engine) = 8.575" $10 \times 4 \times 8.575 = 343$
Om's Design	421.5	Length: 11" (total length of base plate) Width = 4" (total width of base plate) Height: 0.6" (base plate) + 7" (mounting legs) + 1.975" (air engine) = 9.58" $11 \times 4 \times 9.58 = 421.5$

4D. Part Count Calculations

Part Count		
Design	Quantity of Individual Parts	Justification/Notes
Jacob's Design	57	1 extended base, 1 modified flywheel, 1 bearing housing, 1 mason jar lid, 1 mixer blade assembly, 1 wooden cupholder, 1 V-belt, 1 3-stepped pulley, 1 pulley key, 1 mixer shaft, 2 sealed ball bearings, 1 custom clamping shaft collar, 2 T-track bolt clamping set, 1 hand knob screw, 1 wooden support stand, 4 rubber feet, 1 3d printed cover, 2 knurled hand screws, 1 V-ring shaft seal, 1 nail, 1 aluminum 90° angle, 3 pan head phillips screws, 6 button head hex drive screws, 6 hex nuts, 9 phillips flat head wood screws, 4 general purpose washers, 1 wood coating (2oz), 1 corner bracket
Matthew's Design	24	1 modified base, 1 modified flywheel, 1 shaft, 2 platform supports, 1 lid platform, 1 lid adapter, 1 lid, 1 belt, 1 tensioner arm, 1 1.25" bolt, 2 1" bolt, 2 0.5" bolt, 4 bearings, 1 spacer, 1 nut, 1 drive pin, 1 blade cutter, 1 silicone sealant
Nicholas's Design		1 modified base, 1 modified flywheel, 1 mixer base, 1 lower base, 1 shaft, 1
Om's Design	38	1 base plate, 4 air engine mounting legs, 2 stepped pulleys, 1 support rod, 1 hinge platform, 1 hinge attachment, 1 mixer attachment, 2 v-belts, 5 flanged sleeve bushing, 9 steel socket head screws, 4 washers, 2 round head screws, 1 threaded rod, 1 snap ring, 1 hinge pin, 2 door hinge bushings

4E. User Operability Calculations

User Operability		
Design	Degree of User Operability	Justification/Notes
Jacob's Design	3 + binary penalty score	2 steps to load mason jar + full shut down for speed adjustment 1) Screw threaded mason jar lid onto mason jar 2) Slide cupholder around base of mason jar 3) Lock cupholder in place
Matthew's Design	2 + binary penalty score	2 steps to load mason jar + full shut down for speed adjustment 1) Thread mason jar lid assembly onto mason jar 2) L-Lock mason jar with lid onto lid platform
Nicholas's Design	3 + binary penalty score	3 steps to load mason jar and insert tool + full shut down for speed adjustment 1) Lift mixing base up 2) 3)
Om's Design	4 + binary penalty score	4 steps to load mason jar and insert tool + full shut down for speed adjustment 1) Release tension in v-belt 2) Lift hinged platform 3) Insert tool through hinge platform into the pulley 4) Place mason jar into the base plate

4F. Speed Versatility Calculations

Speed Versatility		
Design	Degree of Speed Versatility	Justification/Notes
Jacob's Design	3	Flywheel: 1.500" Pulley diameters: Level 1: 2.00" Level 2: 3.00" Level 3: 4.00" Speed Versatility Ratios: 1) 1.5:4 (Slow) 2) 1.5:3 (Medium) 3) 1.5:2 (Fast)
Matthew's Design	2	Diameters: Flywheel Diam - 1.4" Slow Speed Pulley Diam - 0.650" Fast Speed Pulley Diam - 0.375" Speed Versatility Ratios: 1) 1:2.15 (Slow) 2) 1:3.73 (Fast)
Nicholas's Design	2	Diameters: Flywheel Diam - 1.5" Fast Speed Pulley Diam - Slow Speed Pulley Diam - Speed Versatility Ratios: 1) 1.5: (Fast) 2) 1.5: (Slow)
Om's Design	3	Pulley diameters: Level 1: 2" Level 2: 2.5" Level 3: 3.5 " Level 4: 4" Speed Versatility Ratios: 1) 3.5:2 (Fast) 2) 2.5:2.5 (Medium) 3) 2:3.5 (Slow)

5. Sub-Appendix A1: Concept Modifications

5A. Jacob's Concept Modifications

EML2322L Design Specification Table								
Line #	Component (Name and/or Part Number)	Description / Size	Critical Surfaces (surface IDs and brief description)	Material	Vendor (if applicable)	Cost	Qty.	Justification / Notes
1	Extended Base (8975K432)	24" x 5" x 0.25" Raw Stock (Machined to 6.0" length for the compact 15" belt drivetrain layout).	B1: Bearing block mounting surface	Aluminum 6061 T6	McMaster Carr	\$ 9.53	1.00	Area = 6*5 = 30 sqr in. 24" x 5" x 0.25" = \$38.10 \$38.10/120 = 0.3175 0.3175 * 30 = \$9.53 Forms the lower tier deck. Features an integrated belt-tensioning tab and pre-drilled edge holes to anchor the mixer enclosure lid hinge. Two 0.10" deep × 0.43" wide 1.750" Long parallel slots milled into top surface, for dual T-bolt clamping mechanism securing bearing housing
2	Modified Flywheel	1.500" OD × 0.450" Thick	F1: Machined V-groove for belt drive; F2: Inner threaded bore	Mild Steel	Existing Air Engine	\$ 0.00	1.00	Flywheel modified with V groove, no additional material purchased
3	Custom Sliding Bearing Housing (9008K46)	Machined from 1.5" × 1.5" Aluminum Square Bar 4" long piece	H1: Precision bored inner diameters for ball bearings; H2: Base mounting face	6061-T6 Aluminum	McMaster Carr	\$ 7.20	1.00	Prorated from 8 ft length (\$172.96 / 96" × 4"). Features wide milled base for horizontal sliding belt tensioning. Bearing bore centered at 0.5" height within 1.0" tall housing. Housing height machined down from 1.5" stock to 1.0" so that pulley middle step groove aligns with flywheel centerline at 1.5" above extended base. Two 11/32" wide bearings stack to 0.688" total, fitting within 1.0" housing with adequate wall material. Two 0.281" clearance holes drilled through base face to accommodate T-bolt shafts from clamping sets positioned 0.375" from front and back edges of housing base face.
4	Threaded Mason Jar Lid	Wide Mouth (86mm/3.4in)	L1: Central shaft clearance hole; L2: Threaded outer ring for jar engagement	Food-Grade Tinplate	Amazon	\$ 0.50	1.00	\$17.99 for pack of 72 = \$0.50 per count. Food safe, protects against splashing. Lid modified by drilling 11/16" center hole to allow 5/8" shaft clearance while retaining enough material to prevent passage of 1" blade hub
5	Mixer Blade Assembly (8992K507)	Single piece 304 SS blade/hub assembly, machined from 1.250" × .250" flat bar stock (8992K507), 2.500" LG. Hub section Ø1.000" × .250" with Ø.625" bore and 10-32 tapped radial hole. Blade sections .875" × 1.000" extending from each side of hub, curved profile milled in.	B1: Blade faces; B2: 5/8" hub bore, shaft interface; B3: Ø0.159 hole	304 Stainless Steel	McMaster Carr	\$ 1.86	1.00	\$8.92/12 × 2.50 = \$1.86. Hub and blades machined from same flat bar stock. Hub circular profile milled from 1.250" wide stock giving adequate machining allowance above Ø1.000" hub diameter.
6	Wood Cupholder Bracket	U-shaped bracket, ~8" total pine stock, wraps around 0.75" × 3.5" wood rail; circular bowl recess cut into base to cradle mason jar; 1/4-20 tapped hole through bracket face for hand knob clamping	S1: Rail contact face, clamped by hand knob screw against rail; S2: Circular bowl interior, supports and centers mason jar base	Pine Wood	Home Depot	\$ 0.00	1.00	Cut from existing 1×4 pine board (line 15), prorated cost included in wood stand entry. U-shaped profile wraps around right side wood rail with 1/4-20 tapped hole through bracket face. Hand knob screw threads through and presses against rail face to clamp at desired height, threaded mechanism resists vibration loosening. Pine selected for strength to support mason jar load. Circular bowl recess cradles jar base and prevents lateral movement during operation.
7	V- Belt	3L150 FHP V-Belt, 15 in Outside Length, 3/8 in Top Width, 7/32" Thickness, 1 Ribs	VB1: Angular sidewall clutching surfaces	Gum Rubber	Zoro	\$ 6.19	1.00	3L150 FHP V-belt selected for 15" center-to-center drivetrain layout. Gum rubber construction provides high friction coefficient on V-groove surfaces for positive power transmission. 3/8" top width matches flywheel and stepped pulley groove geometry
8	3 Stepped Pulley	2", 3", 4" OD Steps, 5/8" Bore	P5: V groove surfaces; P6: 5/8" center bore	Zinc	Ace Hardware	\$ 19.99	1.00	Chicago Die Cast zinc die-cast 3-step pulley provides three discrete speed ratios using 2", 3", and 4" diameter steps. Speed ratio relative to flywheel changes with each step, enabling variable mixing speeds without disassembly. 5/8" bore matches mixer shaft diameter.
9	Pulley Key (98870A130)	3/16" x 3/16"	K1: Key faces transmitting torque between shaft and pulley	Low Carbon Steel	McMaster Carr	\$ 0.26	1.00	\$2.62/10 = \$0.26 3/16"×3/16" key selected to match keyway geometry on 5/8" mixer shaft and stepped pulley bore
10	Mixer Shaft	5/8" Dia Keyed Shaft, 8" Used from 18" Stock	SH1: Ground bearing surfaces; S2: Knurled Thumb screw hole	303 Stainless Steel	Zoro	\$ 17.86	1.00	\$80.39/36 * 8 = \$17.86 303 stainless steel selected for corrosion resistance and machinability; keyed profile transmits torque from pulley to blade assembly.

11	Sealed Ball Bearings	5/8" ID × 1-3/8" OD × 11/32" width	BR1: Inner race; BR2: Outer race	Chromium Steel	Amazon	\$ 3.44	2.00	\$17.19 for pack of 10, \$17.19/10 * 2 = \$3.44 Provides smooth rotation for the drive system Chromium steel races selected for hardness and wear resistance under radial and axial loads.
12	Custom Split Clamping Shaft Collar (1610T11)	1.0" OD × 1.5" Length, 5/8" bore, split clamp style with 10-32 tapped transverse hole	C1: Bottom face of collar: contacts top of bearing housing as axial stop; C2: Split clamp bore: grips shaft when thumb screw tightened	6061-T6 Aluminum	McMaster Carr	\$ 3.55	1.00	1 1/2" = \$3.55 Machined from 6061-T6 aluminum round stock with longitudinal split cut through both sides and 10-32 tapped transverse hole through split. Thumb screw (see knurled hand screw entry) threads through split to close collar and grip shaft. Positioned above bearing housing, bottom face rests on housing top face to set shaft height at each pulley step. Loosen thumb screw to slide shaft up/down to desired pulley step, retighten to lock. Split clamp design provides uniform clamping force around shaft circumference, more secure against vibration than set screw or star knob.
13	T-Track Bolt Clamping Set	1/4-20 × 2" T-bolt, star knob, washer	N/A	Carbon Steel, Plastic	Amazon	\$ 2.25	2.00	\$8.99 / 8 * 2 = \$2.25 Slot cut into top surface of extended base, T-bolt slides in from side with head captured in slot and shaft pointing upward through bearing housing clearance hole. Star knob with washer threads down from above onto bearing housing top face, clamping housing firmly to base. Loosen knob to slide housing for belt tensioning, retighten to lock.
14	Hand Knob Screw	1/4-20 × 1" thread, plastic knob with steel insert	N/A	Carbon Steel, Plastic	Amazon	\$ 0.80	1.00	\$7.99 / 10 * 1 = \$0.80 Threads through wooden cupholder bracket into tapped 1/4-20 holes in wood rail. Replaces pull pin for height indexing, threaded connection resists vibration loosening better than clearance-fit pin.
15	Wood Support Stand	1 in. × 4 in. × 8 ft.	W1: Flat top/bottom mounting faces	Pine Wood	Home Depot	\$ 1.41	1.00	Entire board = \$3.34 using 12.25" walls, 4" top and bottom, (40.5/96) * \$3.34 = \$1.41 Pine 1×4 (actual 0.75"×3.5") Side rails include 3 pre-drilled and tapped 1/4-20 holes spaced 0.5625" apart for cupholder height indexing.
16	Rubber Feet	0.95" Diameter Screw On Rubber Feet	RF1: Non-slip floor interface	Rubber	Amazon	\$ 1.07	4.00	Pack of 60 costs \$15.98 15.98/60 * 4 = \$1.07. Reduces vibration along the counter or desk space.
17	3D Printed Cover	Custom curved enclosure, printed to fit over pulley/belt assembly; integrated hinge hole for nail pivot pin; optimized profile for clearance over all three pulley steps	R1: Inner curved surface, clearance over pulley/belt assembly; R2: Hinge hole for nail pivot pin	PETG Plastic	Amazon	\$ 0.38	1.00	\$0.31/oz × 1.23oz (35g) = \$0.38. PETG selected for impact resistance and heat deflection temperature of 70-75°C. Custom printed profile provides precise clearance over pulley and belt assembly. Integrated Ø.140 nail hinge hole allows cover to pivot open for belt access without removal from machine.
18	Knurled Hand Screw	#10-32, 5/32" Head Height, 3/8" Length	N/A	18-8 Stainless Steel	Zoro	\$ 3.94	2.00	\$9.85/5 * 2 = \$3.94 (1) Blade hub secured to shaft via 10-32 knurled thumb screw threaded into tapped radial hole in hub, bearing on shaft keyway flat for positive retention against centrifugal forces. (2) Split shaft collar clamp secured via same spec thumb screw threading through split to close collar around shaft.
19	V-Ring Shaft Seal (VA16-NBR)	VA type, 16mm shaft diameter, Buna-N rubber	N/A	NBR (Buna-N) Rubber	123 Bearing	\$ 0.95	1.00	Stretch-fit onto rotating shaft above lid inner plate. Active sealing lip contacts stationary lid face during operation to seal shaft clearance hole and prevent splatter.
20	Nail	Zinc Plated Common Nails 1/8" x 3-1/8" (3 x 80 mm), Flat Round Head Construction and Woodworking Nails	N1: Shank cylindrical surface acting as hinge pin	Zinc	Amazon	\$ 0.17	1.00	Pack of 100 = \$16.99 \$16.99/100 = \$.17 Functions as a hinge pin for the pivoting PETG cover. Inserted through aligned holes in the base and cover, allowing rotation for access to internal components.
21	Aluminum 90° Angles (8982K61)	3" × 3" × 1/4" thick wall,	A1: Leg face contacting existing air engine base; A2: Leg face contacting extended aluminum base	Aluminum 6061 T6	McMaster Carr	\$ 9.23	1.00	\$22.16/12 × 5 = \$9.23. Cut from 1ft stock to two 2.5" lengths. 3" leg height creates ~2.625" drop from existing air engine base down to extended base, positioning flywheel centerline at correct height above extended base so small pulley step groove aligns with flywheel center. Aluminum 6061 selected to match base material and minimize galvanic corrosion.
22	Pan Head Phillips Screws (91772A194)	#8 × 1/2" pan head screws	N/A	18-8 Stainless Steel	McMaster Carr	\$ 0.32	3.00	\$10.86/100 * 3 = \$0.32 Used to secure corner bracket to wood block and air engine base
23	Button Head Hex-Drive Screws (92949A240)	10-24 × 3/8"	N/A	18-8 Stainless Steel	McMaster Carr	\$ 0.55	6.00	\$9.16/100 * 6 = \$0.55 Used to fasten 90° angle brackets to aluminum base and wood block

24	Hex Nuts (90480A011)	10-24 Hex Nut	N/A	Zinc-Plated Steel	McMaster Carr	\$ 0.14	6.00	\$2.33/100 * 6 = \$.14 Mating nuts for button head cap screws where tapping is not feasible
25	Phillips Flat Head Wood Screws (90031A201)	#8 × 1-1/4"	N/A	Zinc-Plated Steel	McMaster Carr	\$ 0.77	9.00	\$8.51/100 * 9 = \$0.77 Assembles pine wood box frame and secures side rails to top and bottom blocks
26	General Purpose Washers (90107A011)	#10 flat washers	N/A	Stainless Steel	McMaster Carr	\$ 0.21	4.00	\$5.28/100 * 4 = \$0.21 Distributes clamping load under button head screw heads at aluminum angle joints
27	Wood Coating	Mineral oil, food-safe, 2oz used	N/A	Mineral Oil	Amazon	\$ 0.70	2.00	\$44.99 / 128 * 2 = \$0.70 Applied to pine wood support stand to prevent moisture absorption and mold growth in food preparation environment.
28	Corner Bracket (15705A45)	1-1/2" × 1-1/2" Zinc-Plated Steel, 2 holes, No. 10 straight	BR1: Leg face contacting air engine base; BR2: Leg face contacting wood block.	Zinc-Plated Steel	McMaster Carr	\$ 1.20	1.00	1-49 = \$1.20 Connects top wood block to underside of existing air engine base. Straight No. 10 holes accommodate both 10-24 button head cap screws (into aluminum base) and #8 wood screws (into wood block) from existing fastener set.
					Total	\$ 94.47		

Jacob's Concept Modifications

Bearing housing clamping mechanism:

The bearing housing tensioning mechanism was revised from two pull pins to a dual T-bolt clamping system. Two slots are cut into the top surface of the extended base, each capturing a T-bolt head inserted from the side, shown on page 3. Each bolt shaft points upward through a clearance hole in the bearing housing base face (page 14), and a star knob with washer threads down from above onto the housing top face, clamping it firmly to the base (page 1 & 17). To adjust belt tension, both star knobs are loosened, the housing is slid left or right to the desired position, and the knobs are retightened. This provides a more secure, vibration-resistant clamping action compared to pull pins, which are clearance-fit and susceptible to loosening under vibration.

Pulley to shaft connection:

The stepped pulley is secured to the mixer shaft via two mechanisms working in conjunction. A 3/16" × 3/16" key seated in matching keyways on both the shaft and pulley bore prevents relative rotation between the pulley and shaft, transmitting torque from the shaft to the pulley. The hollow head set screw included with the Chicago Die Cast pulley threads radially into the pulley hub and bears on the key to prevent axial movement along the shaft. Together these fully constrain the pulley on the shaft without requiring additional purchased components.

Zinc material justification:

Several components in this design are zinc or zinc-plated, including the stepped pulley, pull pins, hex nuts, wood screws, and corner bracket. All zinc components are located entirely outside the food contact zone. The mason jar and lid assembly fully enclose all food during operation, preventing contact between food or liquids and any zinc hardware. The stepped pulley is additionally enclosed within the 3D printed PETG cover, providing a secondary barrier. As such, corrosion from acidic food contact is not a concern for any zinc component in this design.

Blade hub attachment:

Drawn on Page 5, the blade hub attachment was revised from a transverse pull pin to a 10-32 knurled stainless steel thumb screw threaded into a tapped radial hole in the hub, bearing on the shaft keyway flat. The original pull pin design posed a risk of ejection due to centrifugal forces acting on the pin during rotation. The knurled thumb screw provides positive threaded retention against centrifugal forces while maintaining tool-free blade removal for cleaning by hand.

Wood coating:

Food-safe mineral oil sealant was applied to the pine wood support stand and wooden cupholder bracket to prevent moisture absorption and inhibit mold growth in the food preparation environment. Pine is naturally porous and susceptible to moisture damage over time, mineral oil penetrates the wood grain and creates a barrier against liquid absorption. The mineral oil selected is food-safe and commonly used for conditioning wood cutting boards and food preparation surfaces.

V-ring shaft seal:

A VA16-NBR V-ring shaft seal was added to the design to address splatter through the shaft clearance hole in the mason jar lid inner plate, as depicted on page 11. The V-ring stretch-fits onto the rotating shaft above the lid inner plate and rotates with the shaft during operation. Its flexible sealing lip extends outward and contacts the stationary lid inner plate face, creating a dynamic wiper seal that prevents splatter from escaping through the clearance hole. The V-ring sits above the lid plate at all times and does not interfere with the lid sliding up and down along the shaft during jar insertion and removal.

Lid mechanism clarification:

The mason jar lid consists of a standard two-piece wide-mouth design: an outer threaded ring and a thin inner sealing plate, shown on page 8. The inner plate is modified by drilling a central 11/16" clearance hole allowing the 5/8" rotating shaft to pass through freely without contact. The hole diameter is smaller than the 1" blade hub outer diameter, preventing the plate from sliding off the shaft. During use, the jar is raised onto the shaft positioning the curved blades in the lower third of the jar for effective mixing. As the jar rises, its rim contacts the underside of the inner plate and lifts it upward along the shaft. The lid ring is then screwed onto the jar, capturing the inner plate between the jar rim and ring and sealing the vessel. When the jar is removed after use, the inner plate slides back down the shaft under gravity and rests on the blade hub. The V-ring seal above does not interfere with this motion as it remains above the plate at all times.

3D printed cover:

The heat-formed ABS roof cover was replaced with a custom 3D printed PETG cover. The previous semicircular heat-formed design required precise forming of flat ABS sheet stock, which is difficult to achieve consistently. The 3D printed design allows a precisely optimized enclosure profile providing clearance over the belt and pulley assembly at all three pulley step positions. PETG was selected over ABS for its superior impact resistance and higher heat deflection temperature of 70-75°C. The cover includes an integrated Ø.140" nail hinge hole allowing it to pivot open for belt access without

removal from the machine, ensuring speed adjustment does not require disassembly as well as a cutout for the compressed air to go into the manifold (page 15 & 16).

Wooden cupholder bracket:

The 3D printed PETG cupholder bracket was replaced with a pine wood bracket cut from the existing 1×4 support stand board, as shown on page 9. Pine was selected for its superior load-bearing strength compared to PETG for supporting the static weight of a full mason jar. The locking mechanism was changed from a pull pin through a clearance hole to a 1/4-20 hand knob screw threading into one of three tapped holes in the wood rail spaced 0.5625" apart, corresponding to the three pulley step heights. The threaded connection provides significantly more vibration-resistant locking than a clearance-fit pull pin, preventing the bracket from loosening under mixing vibration.

Shaft collar redesign:

The shaft collar was redesigned from a purchased clamp collar with star knob to a custom-machined split clamp collar secured by a 10-32 knurled stainless steel thumb screw, shown on page 13. The original star knob protruded significantly from the rotating collar, creating centrifugal force and vibration risks during operation. The split clamp collar design features a longitudinal cut through one side and a tapped transverse hole for the thumb screw. When tightened, the thumb screw closes the split and grips the shaft uniformly around its circumference. The recessed thumb screw profile minimizes protrusion from the rotating collar, eliminating centrifugal force concerns while maintaining tool-free height adjustment between pulley steps.

Design Specification Table:

The design specification table was revised to improve formatting consistency and readability. The cost of the modified flywheel was reformatted to display as \$0.00 instead of \$0, and all cost values were aligned consistently throughout the table. "N/A" was added where applicable to eliminate blank fields and clearly indicate non-applicable entries. Unnecessary notes at the bottom of the table were also removed to create a cleaner and more professional presentation.

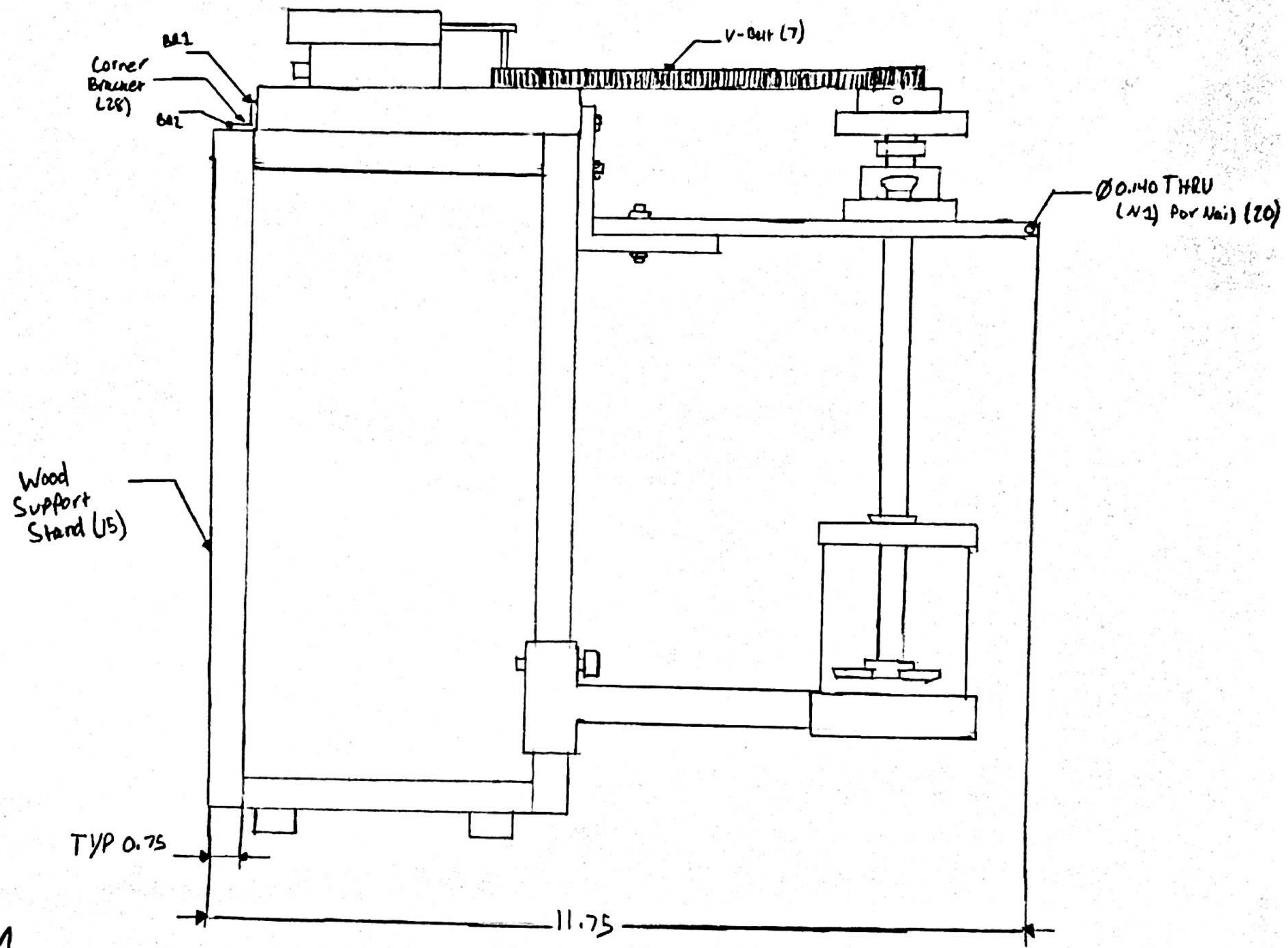
Concept Sketches Redraw:

The concept sketches were completely redrawn to improve clarity, consistency, and overall presentation quality. The original DR1 sketches contained inaccurate proportions, incomplete details, and poor line quality that made several design features difficult to interpret. The revised sketches incorporate the finalized design modifications, including the updated bearing housing clamping mechanism, 3D printed cover, wooden cupholder bracket, shaft collar, and other revised components. Additional orthographic

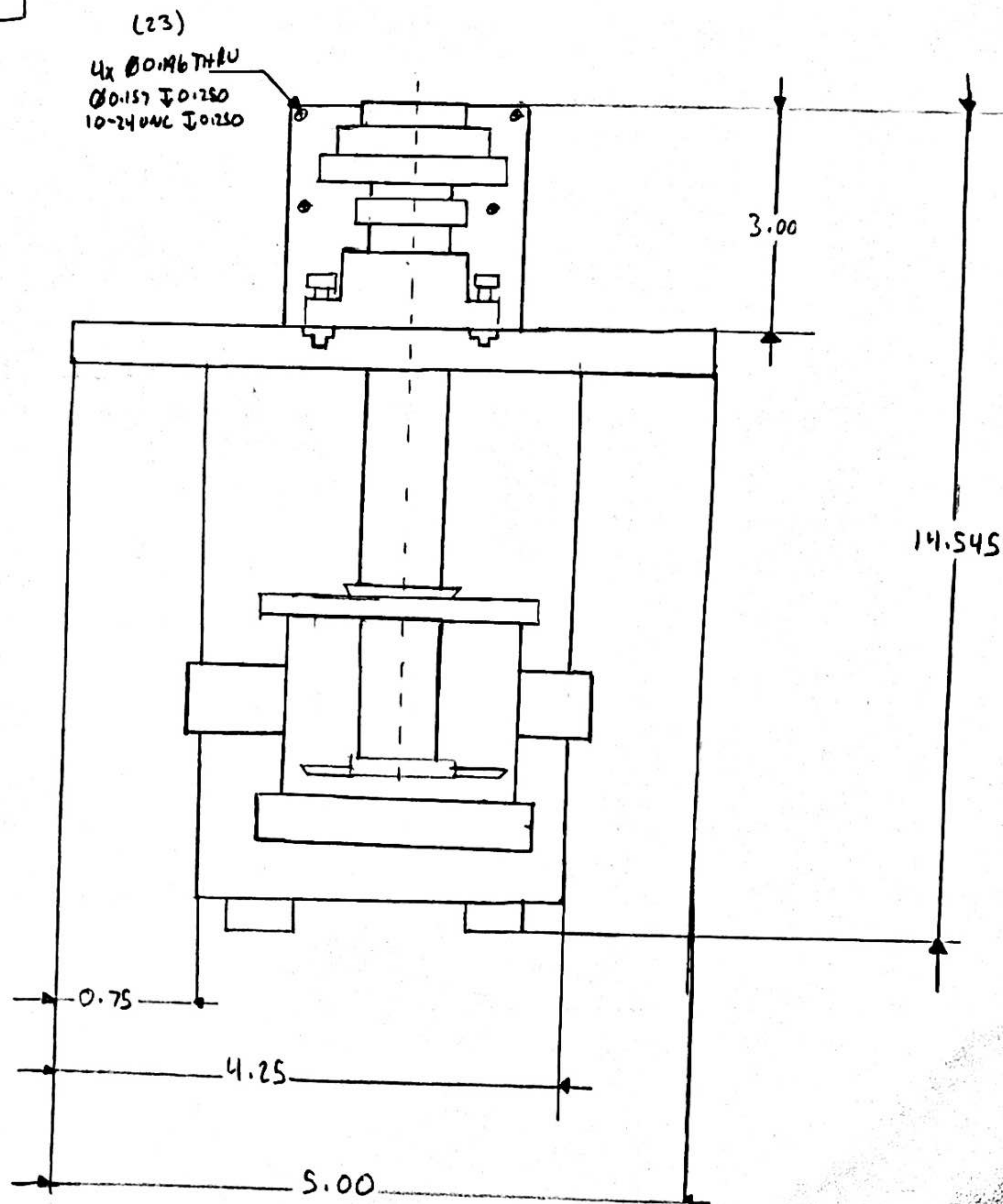
and detailed views were also added where necessary to better communicate the function and assembly of the design while providing a more professional engineering presentation.

Full Assembly Side View

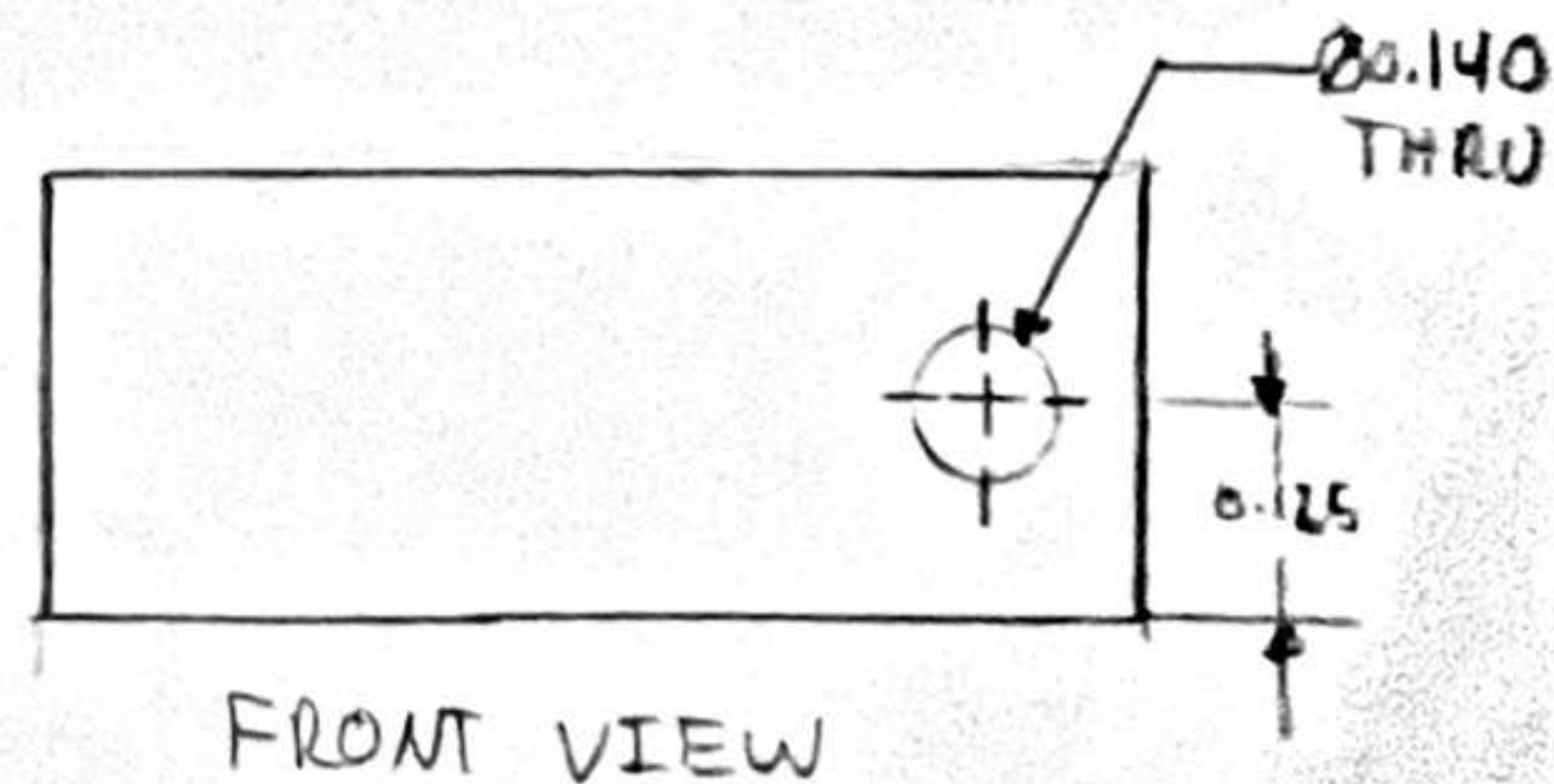
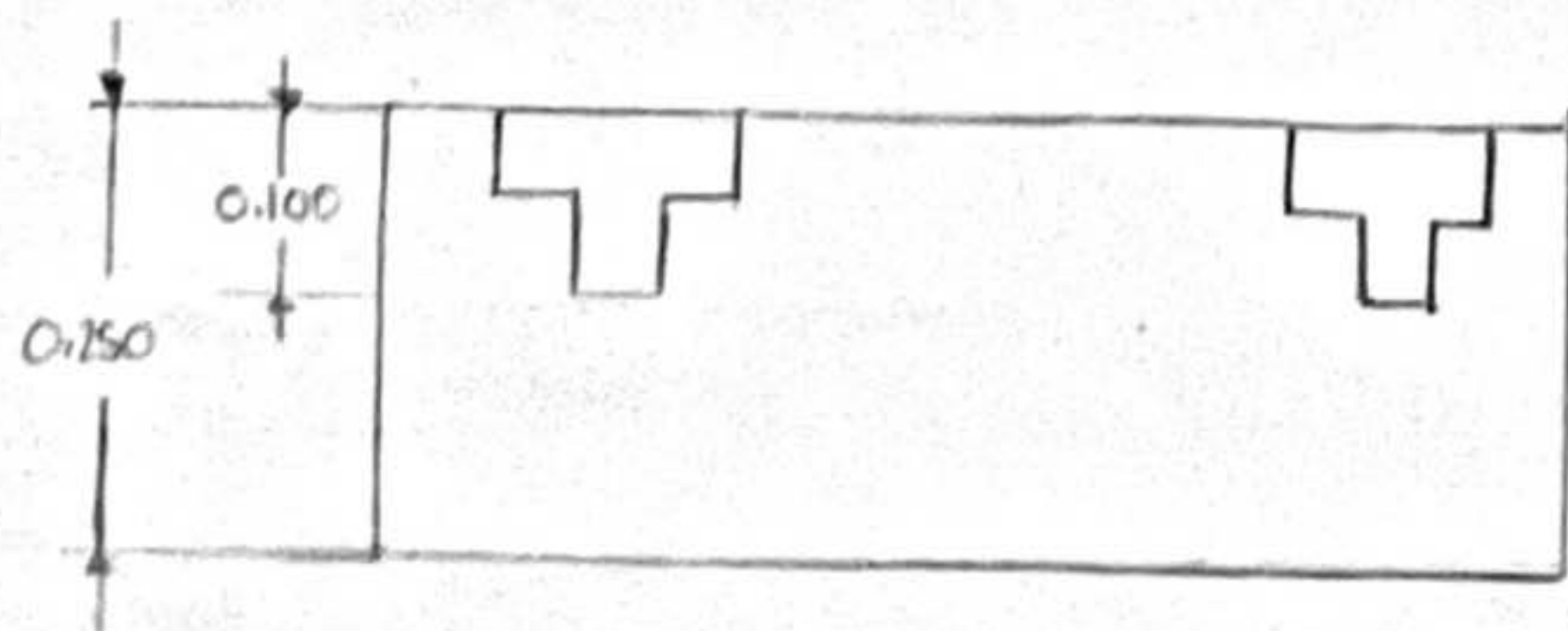
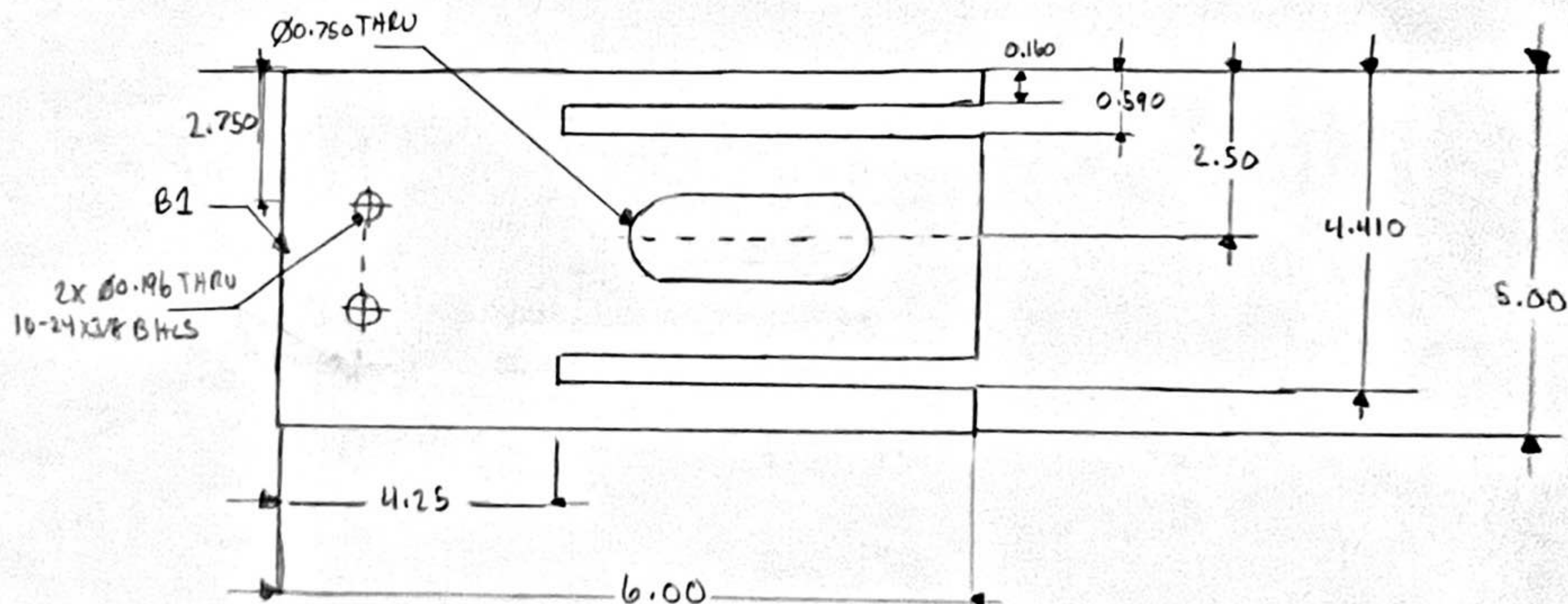
Cover removed
for clarity



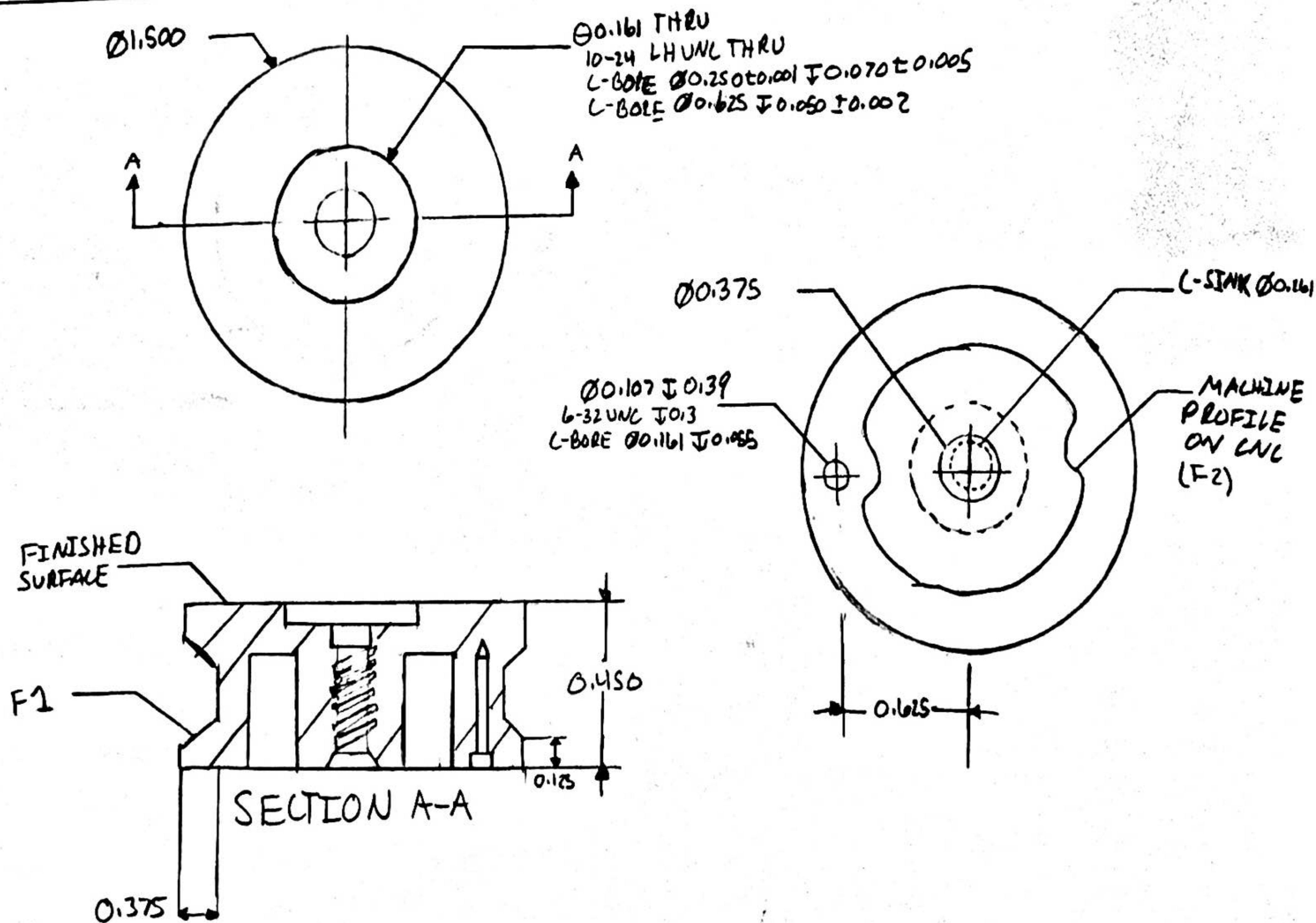
Full Assembly Front View



Extended Base

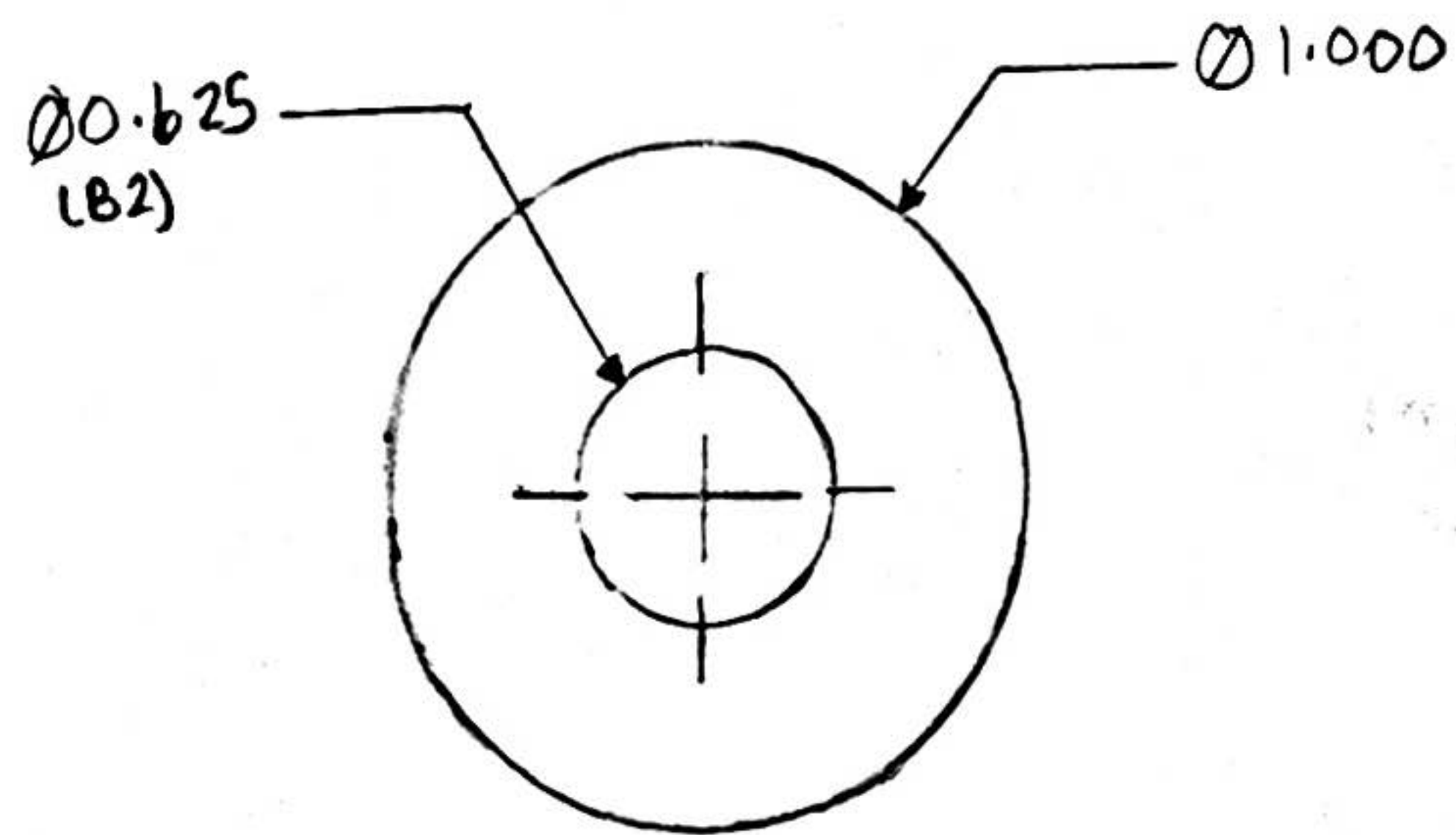


Modified Flywheel

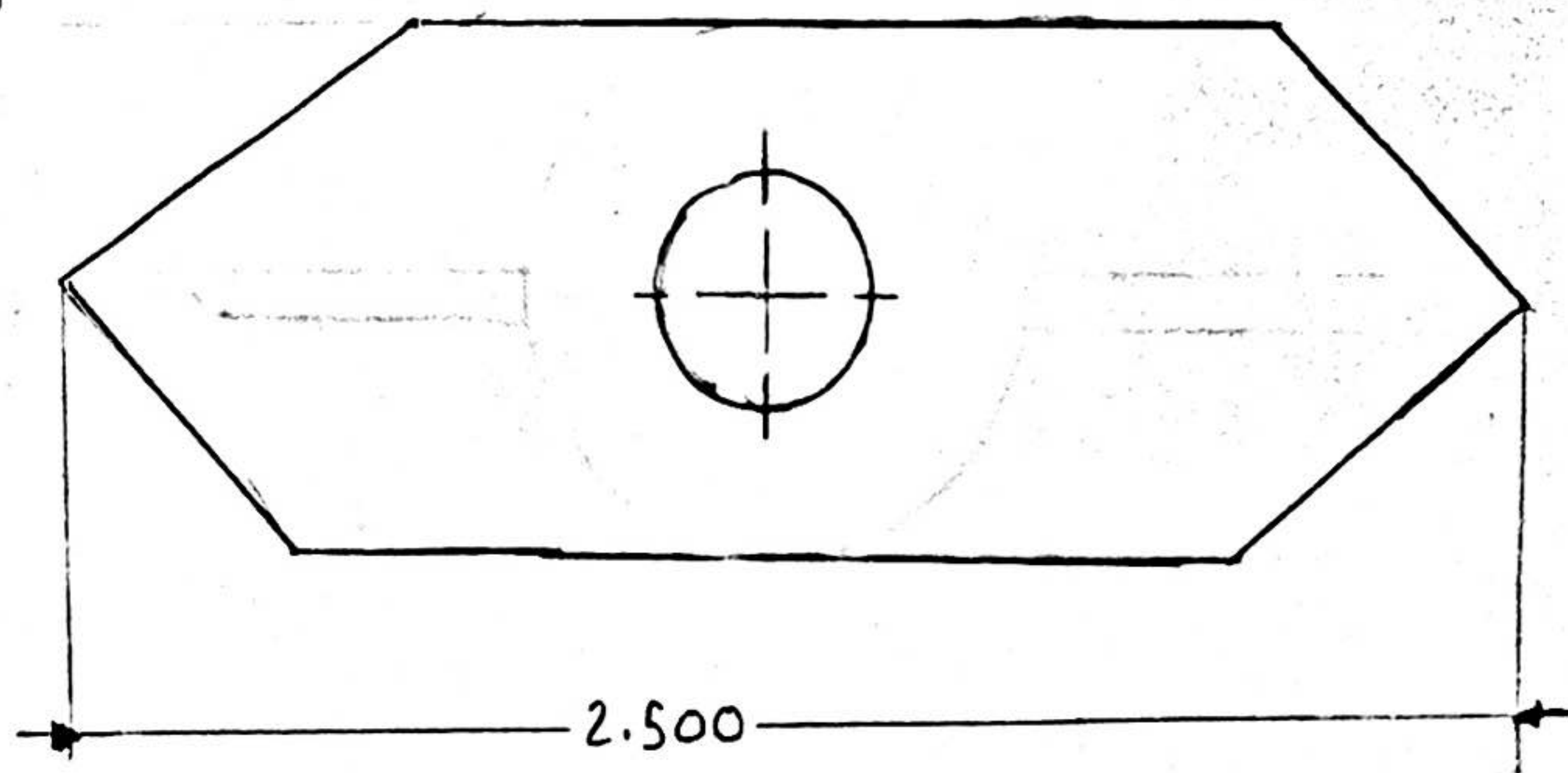


Mixer Blade Assembly

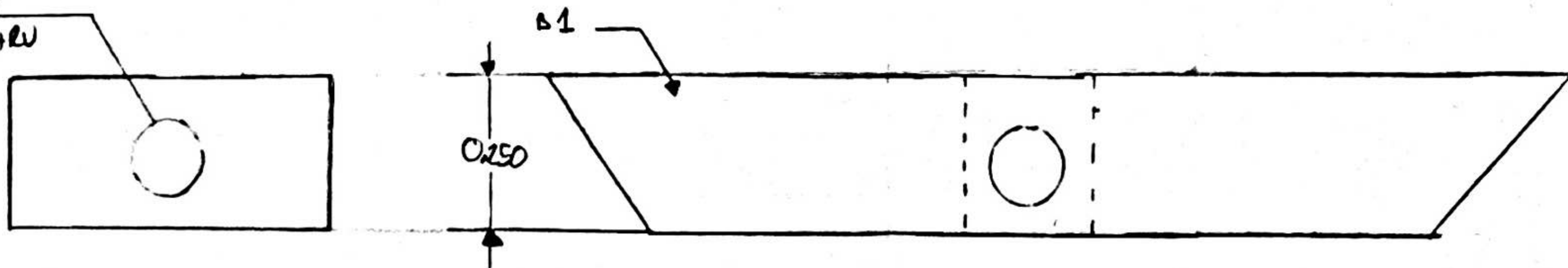
WITHOUT BLADES



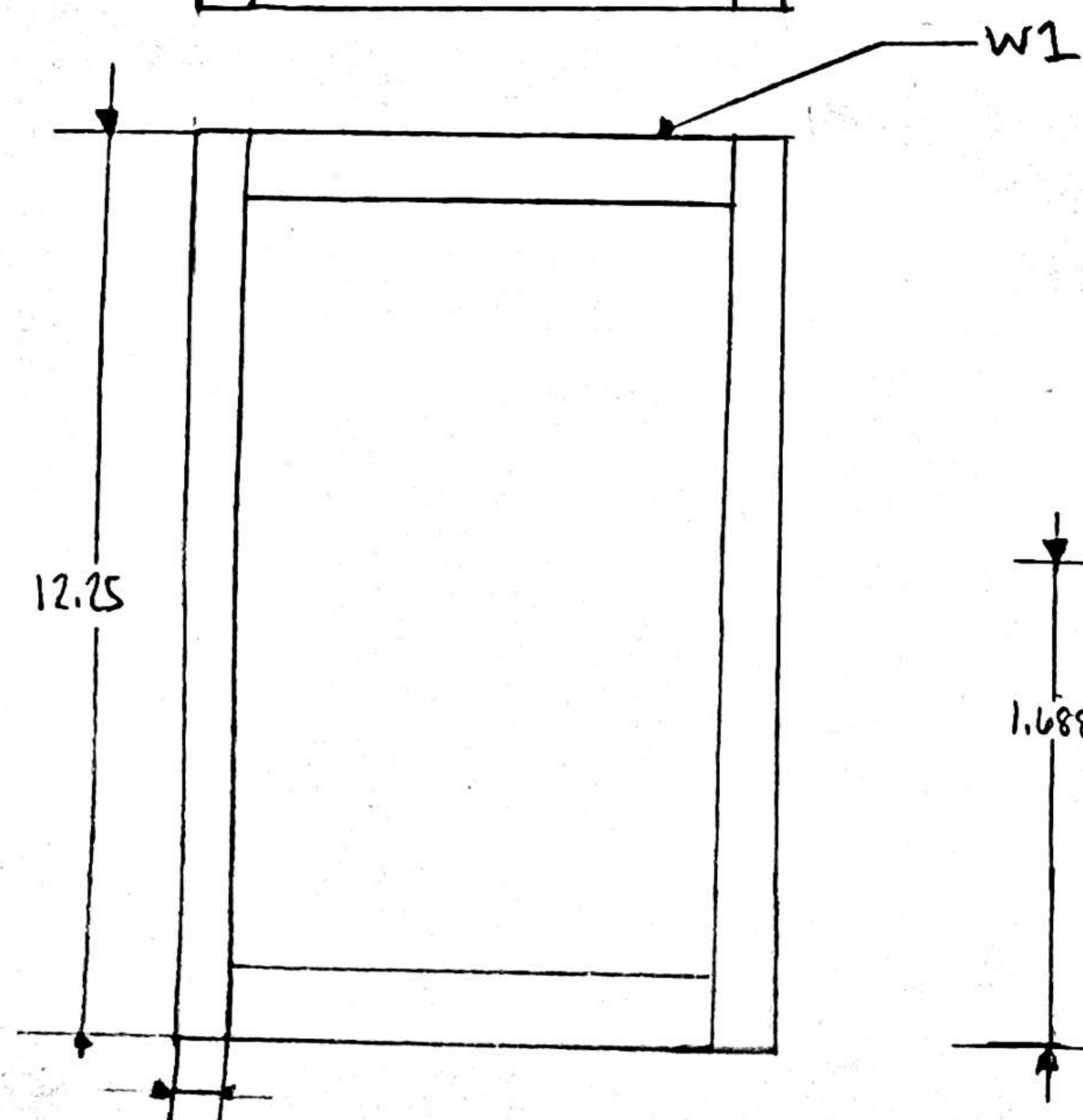
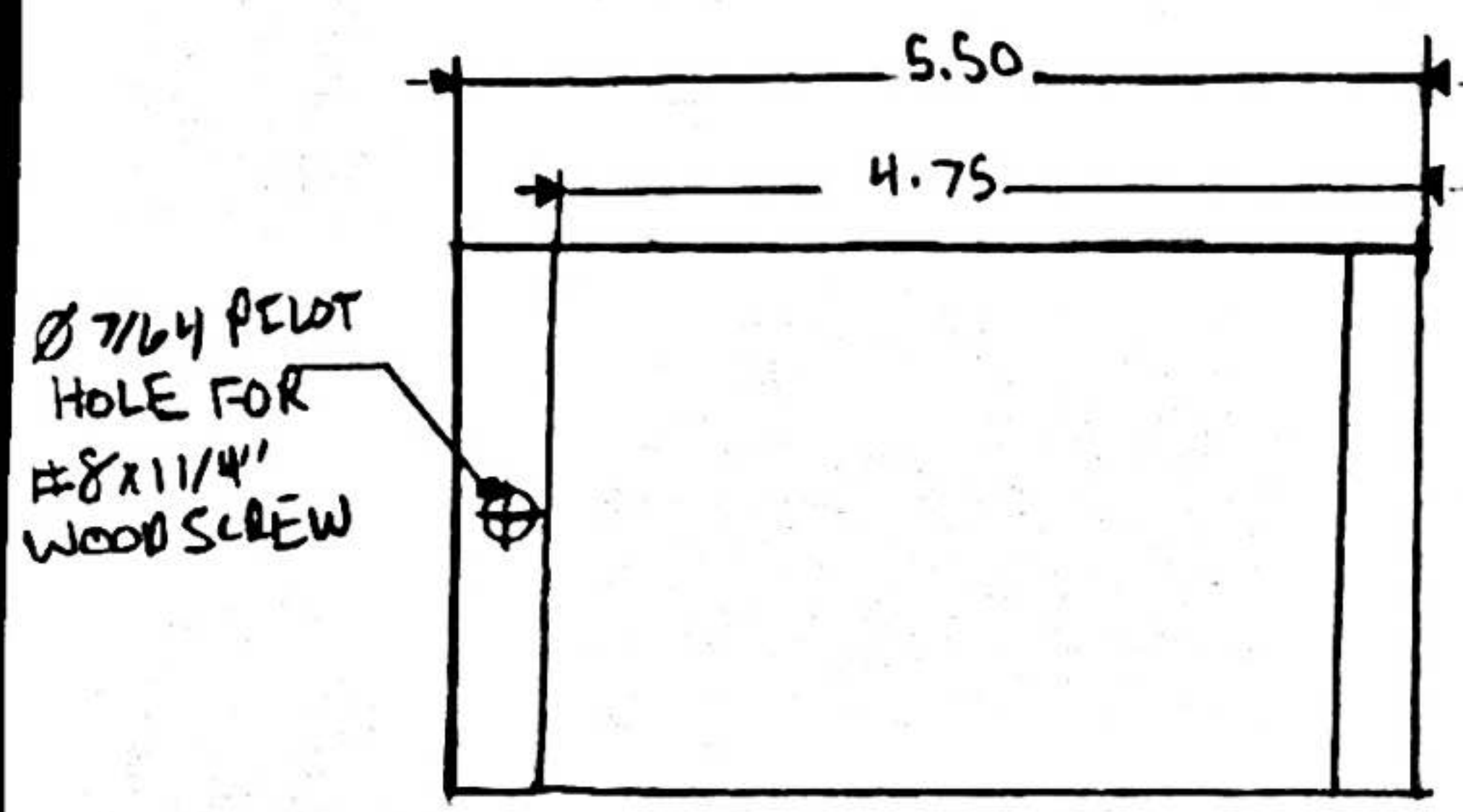
WITH BLADES



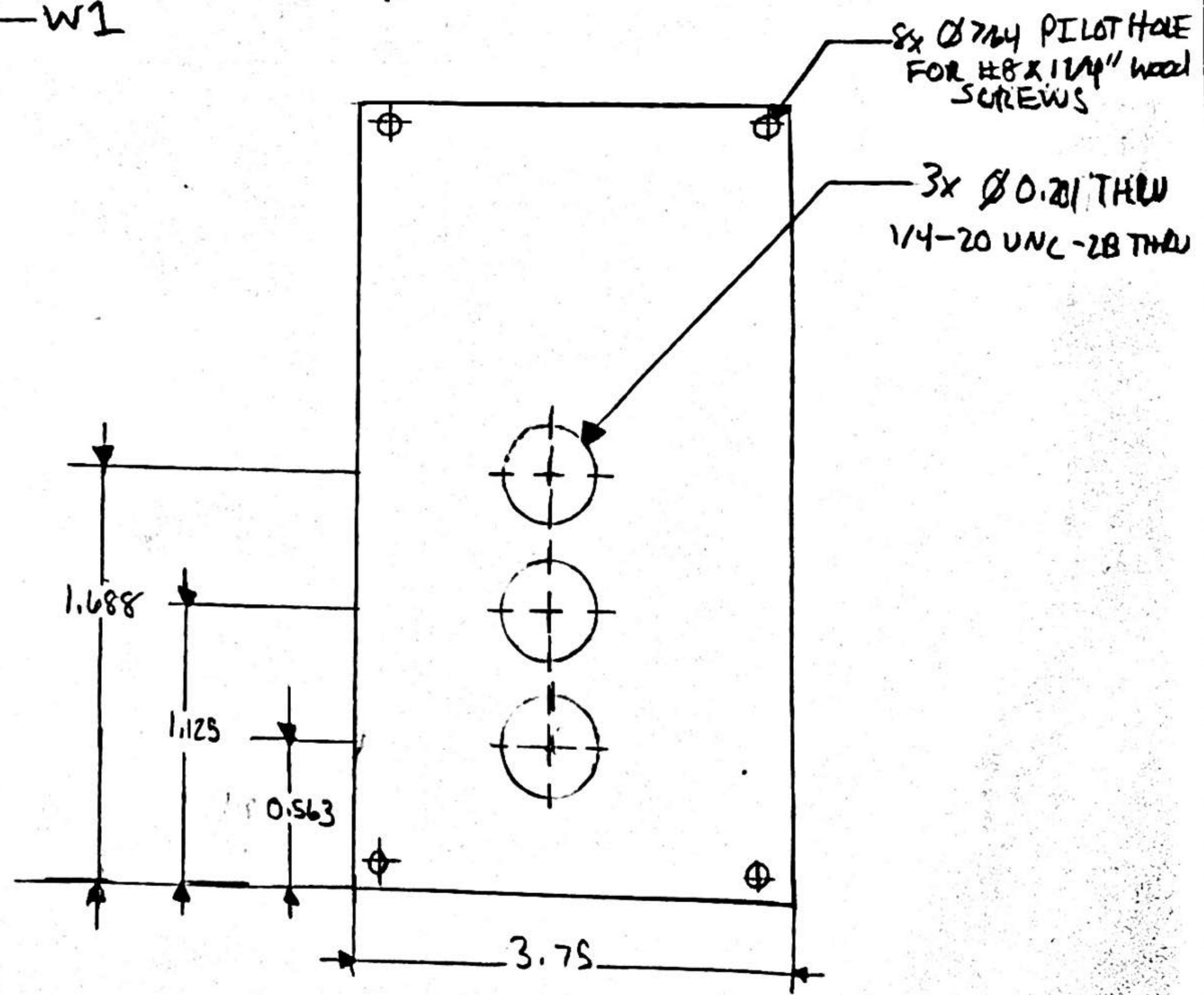
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10-32 UNF-28 THRU
(B3)



Wooden Support Stand

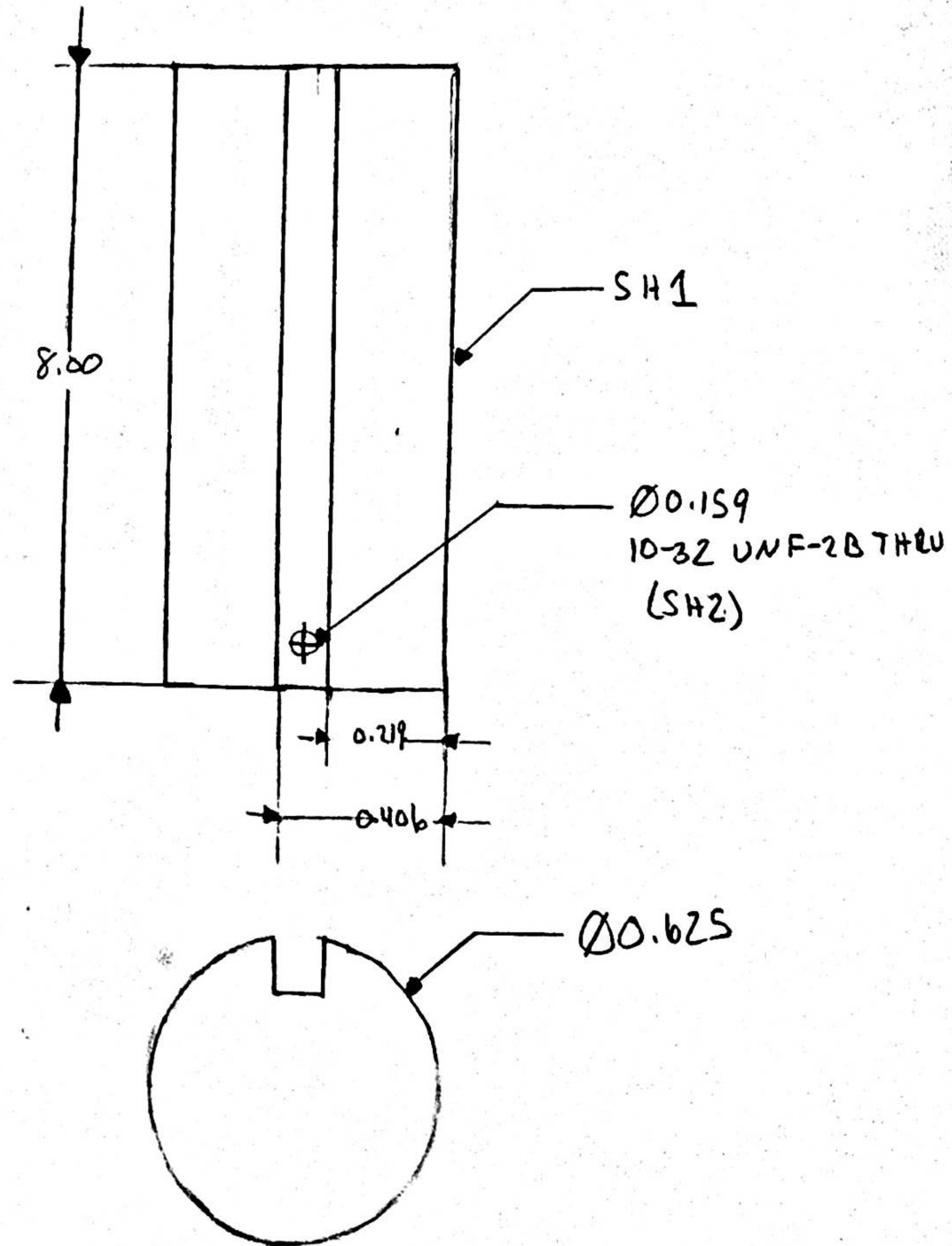


RIGHT VIEW

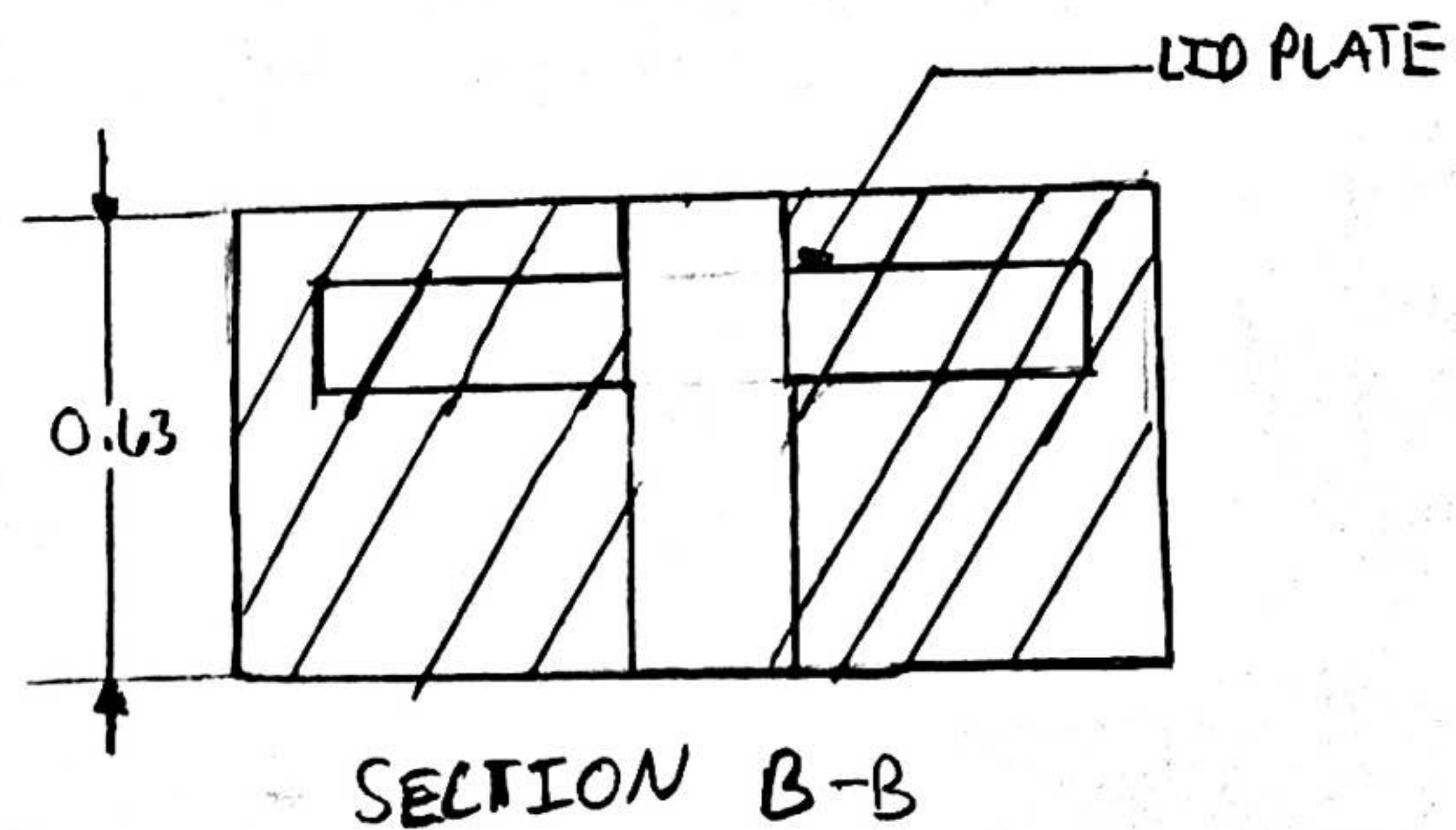
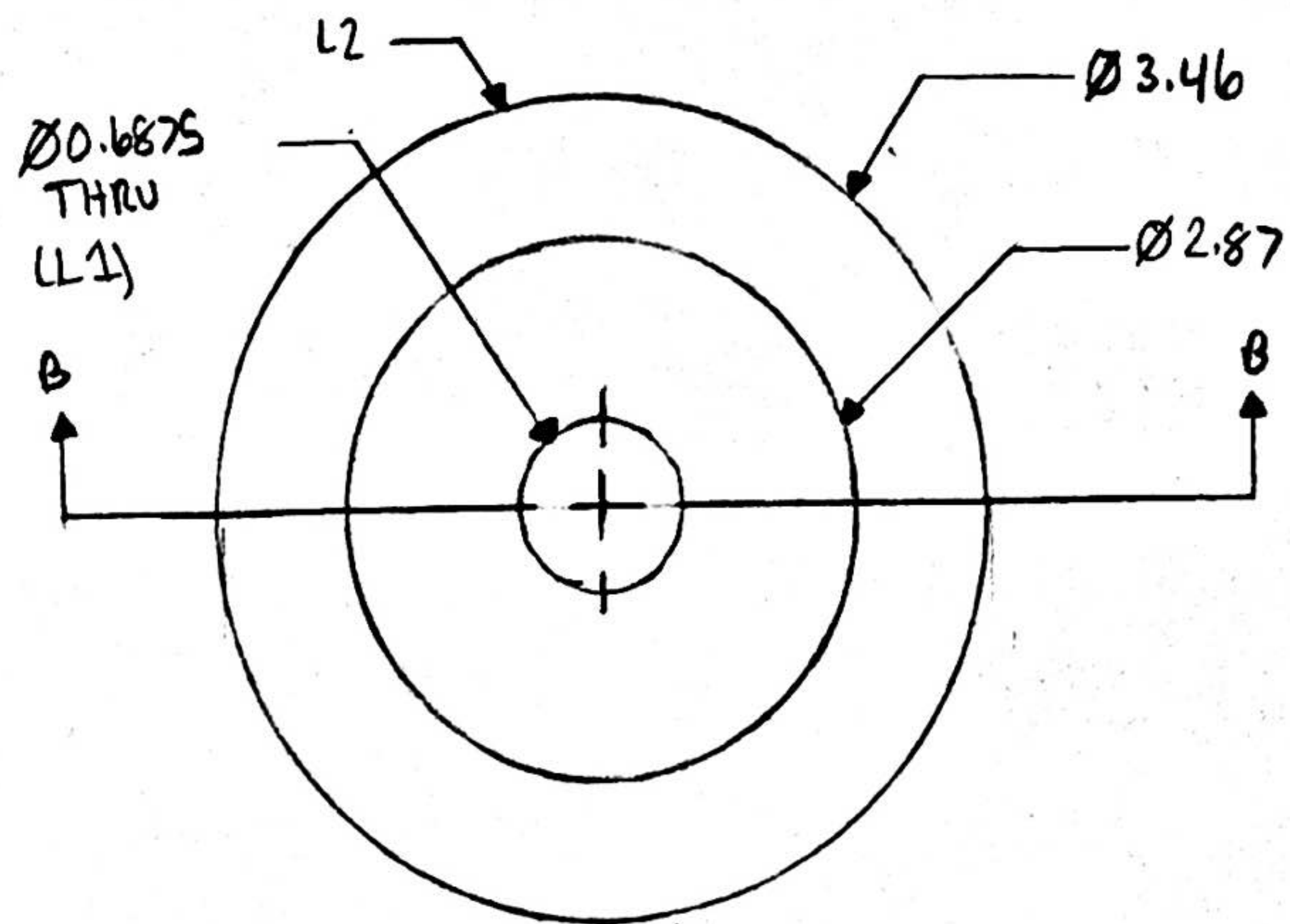


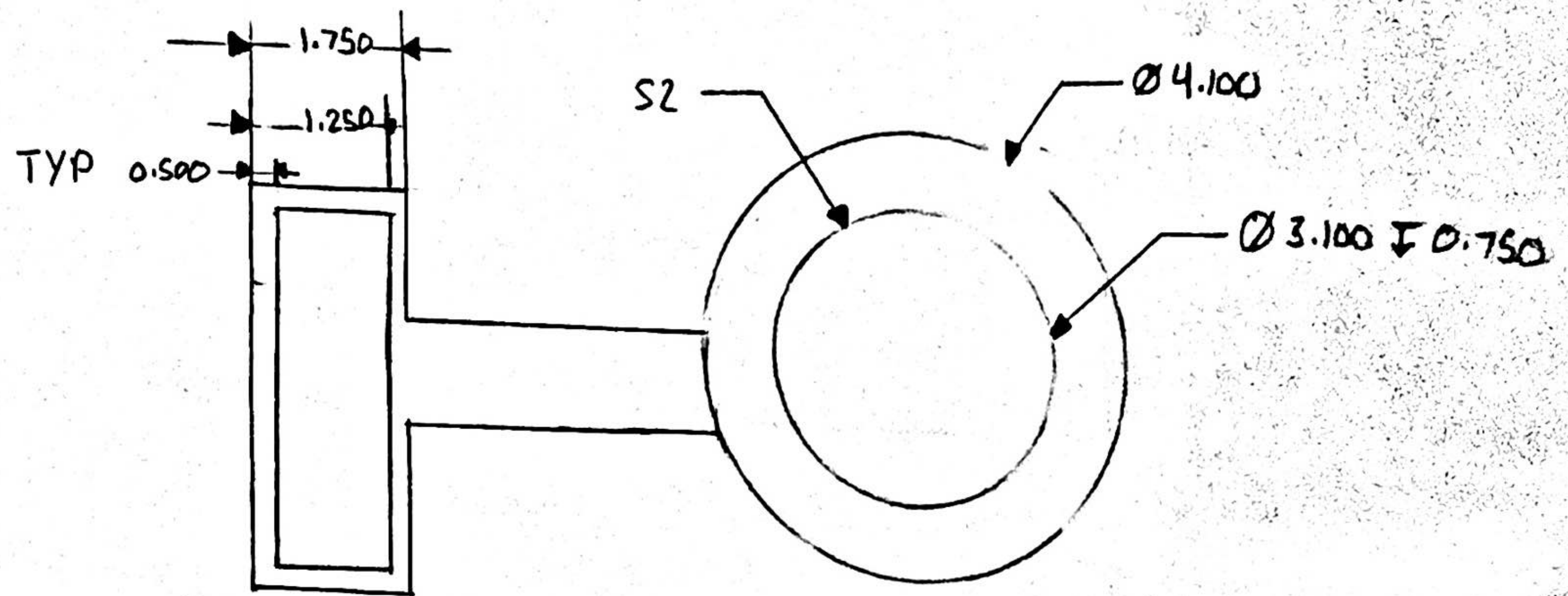
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Mixer Shaft

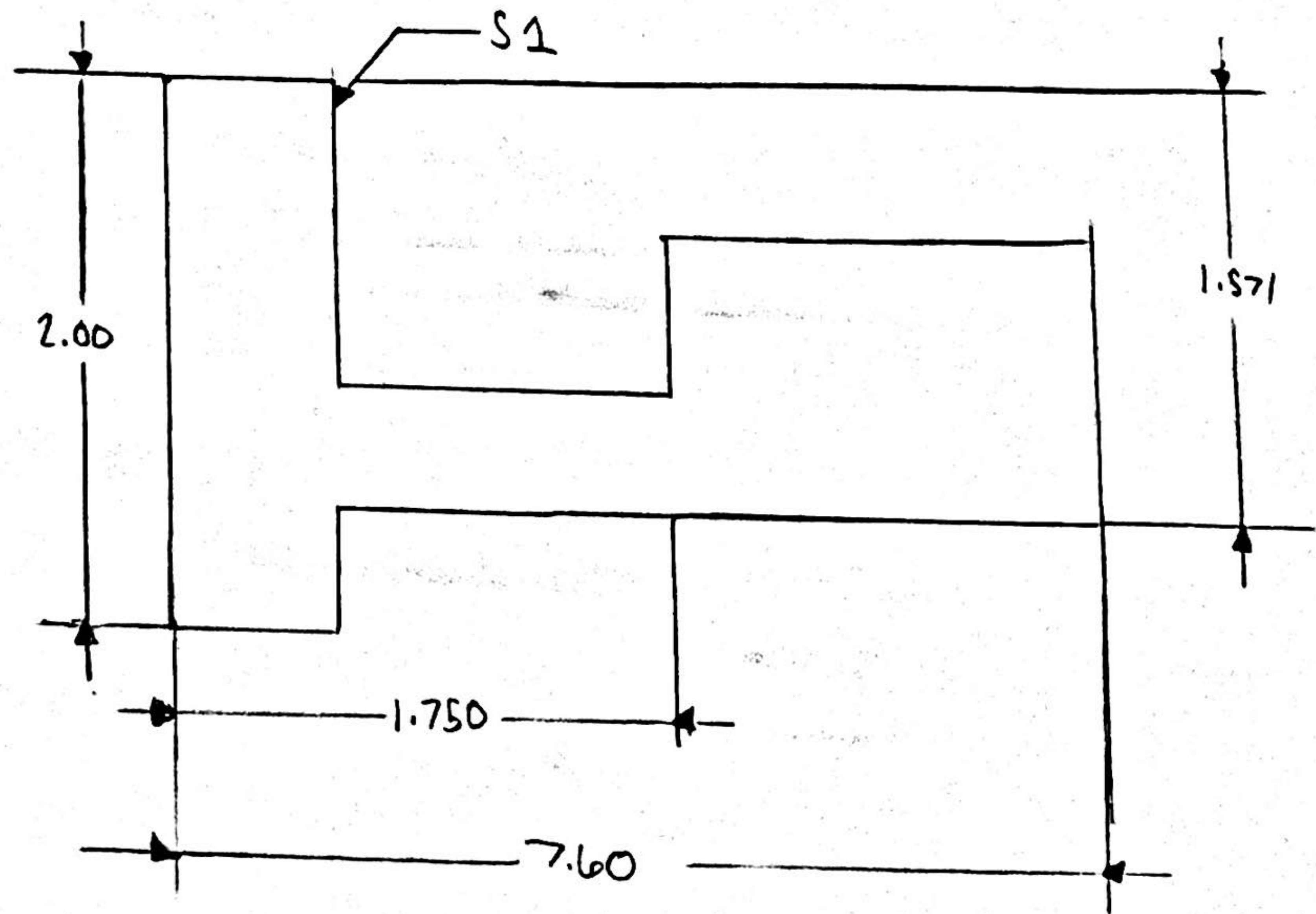
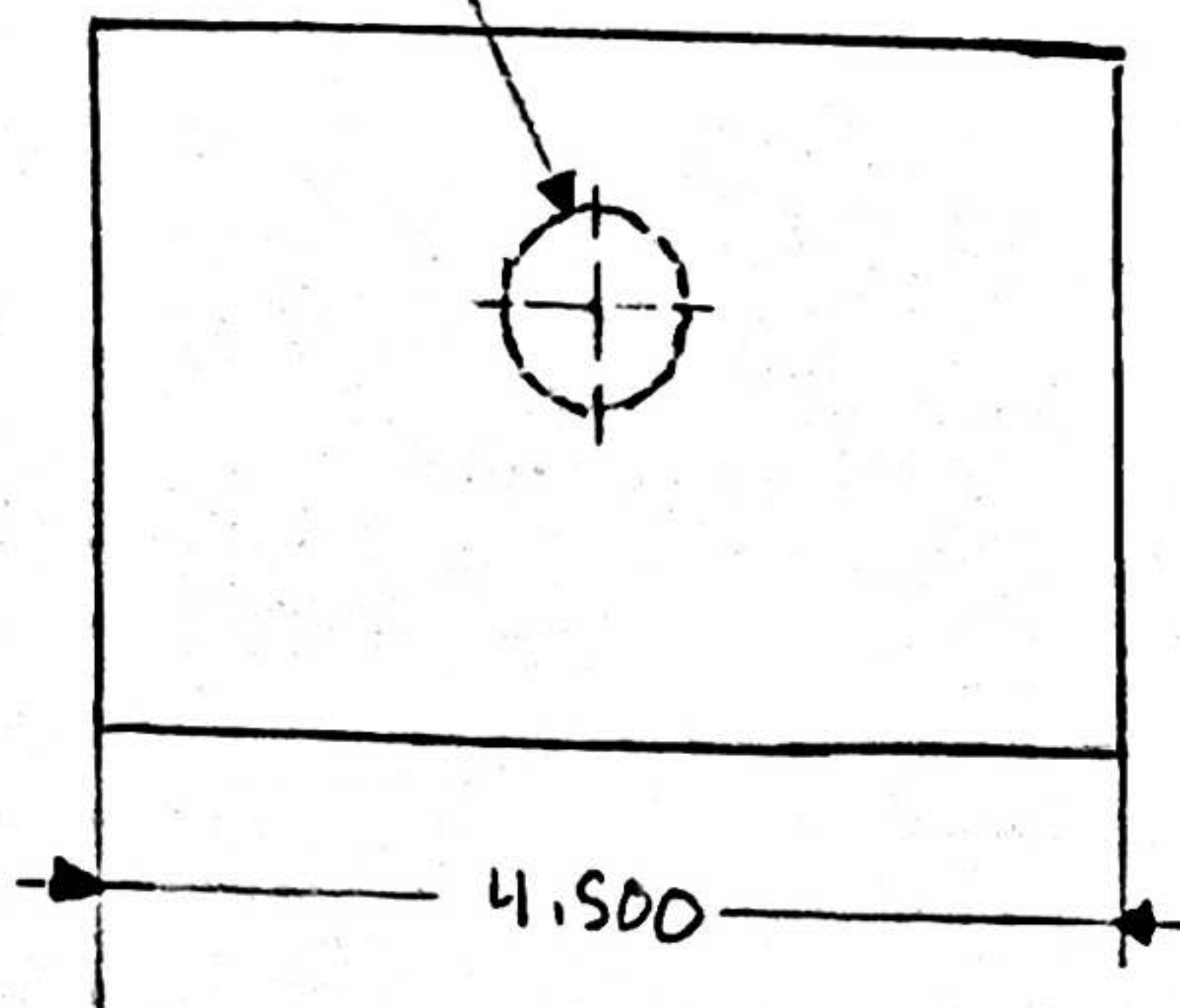


Mason jar lid

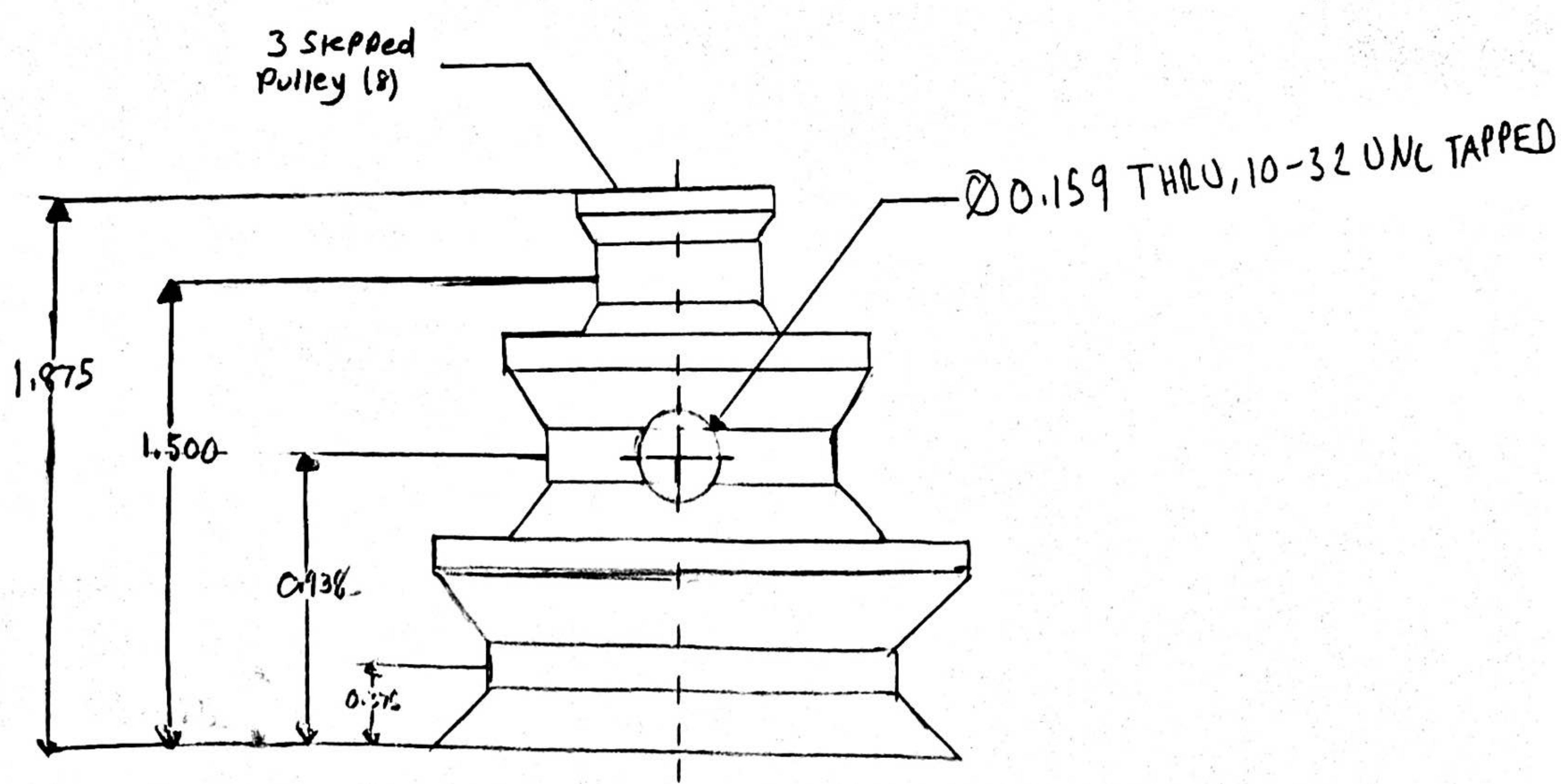
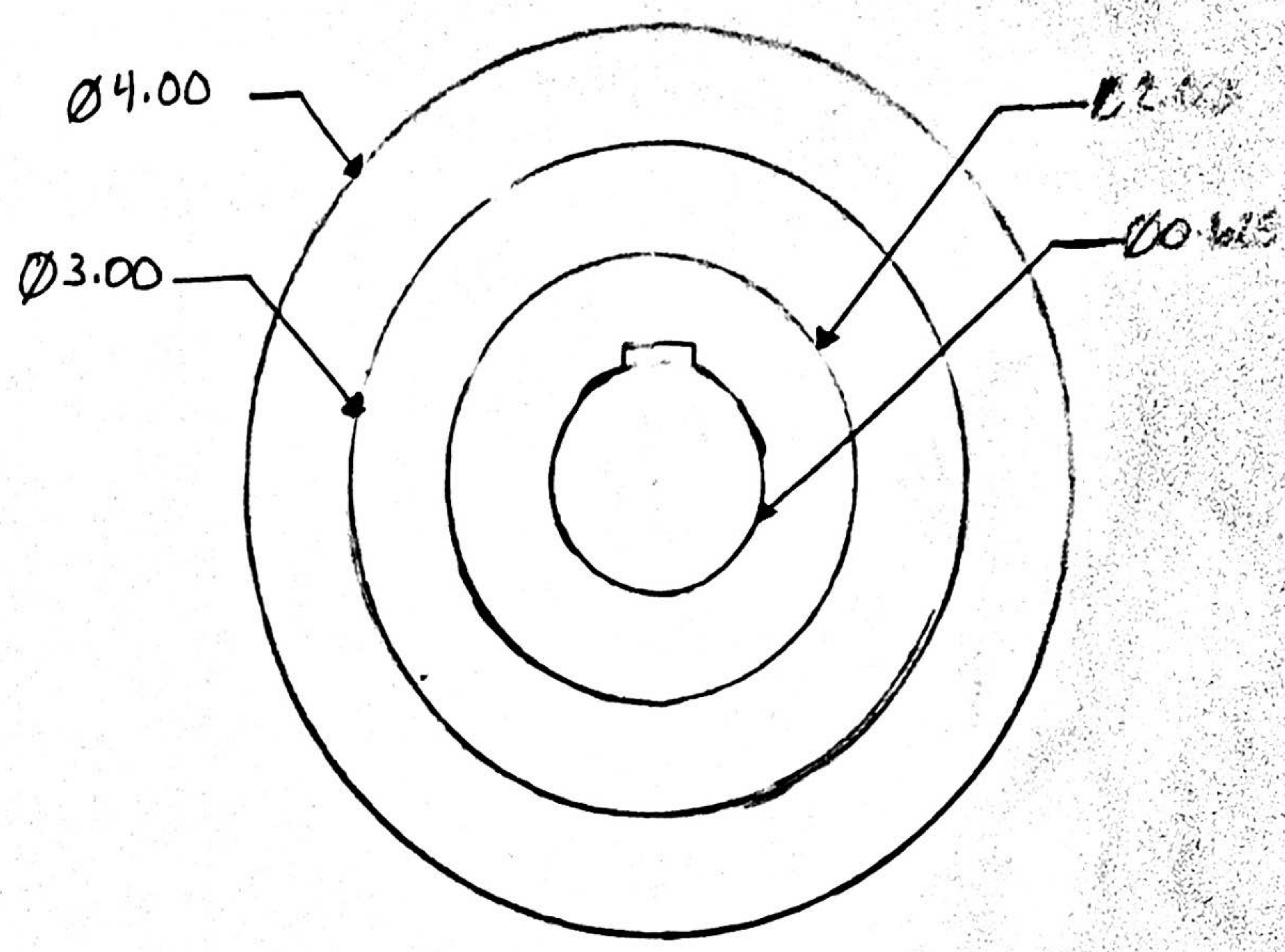




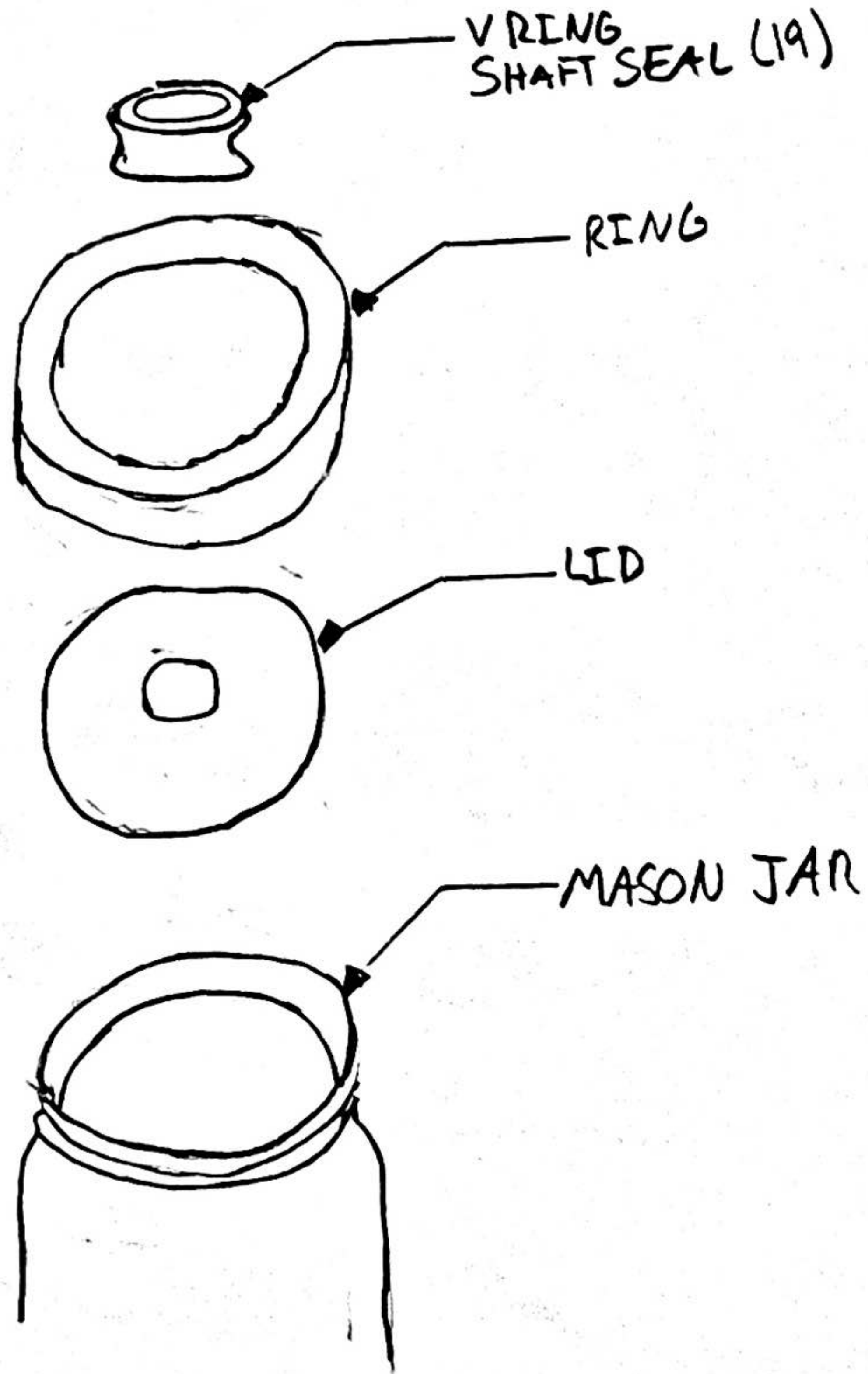
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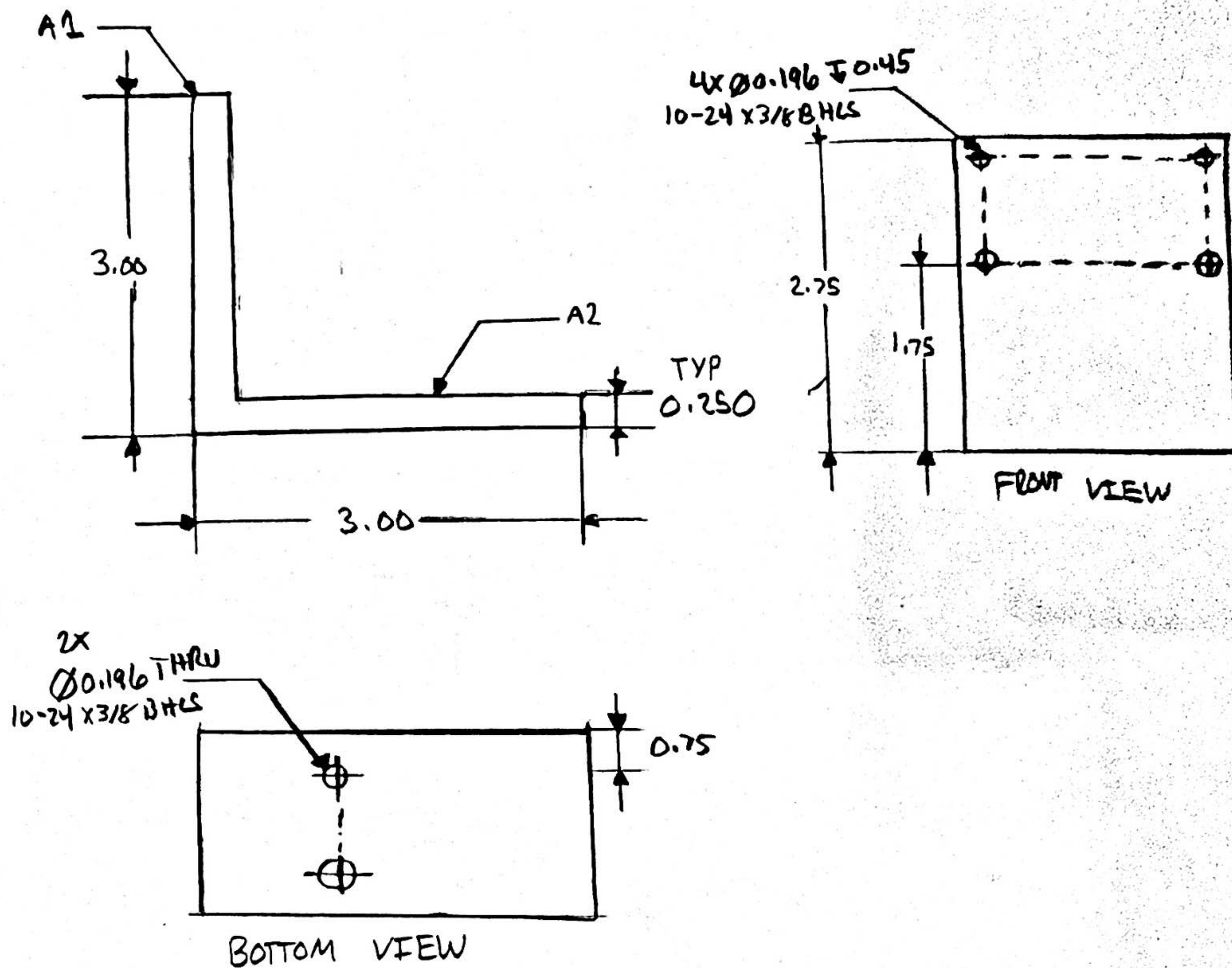
3 Stepped Pulley



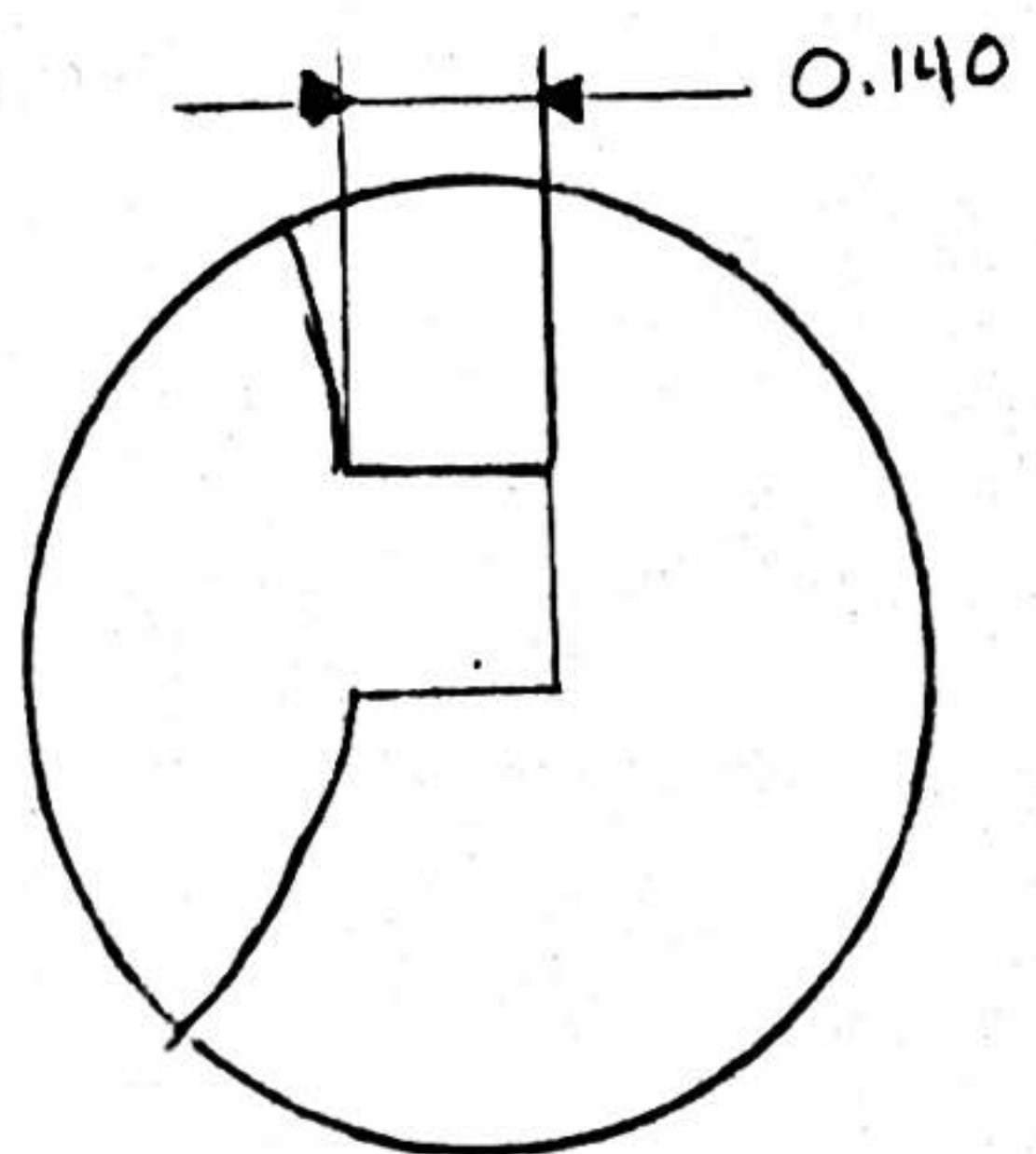
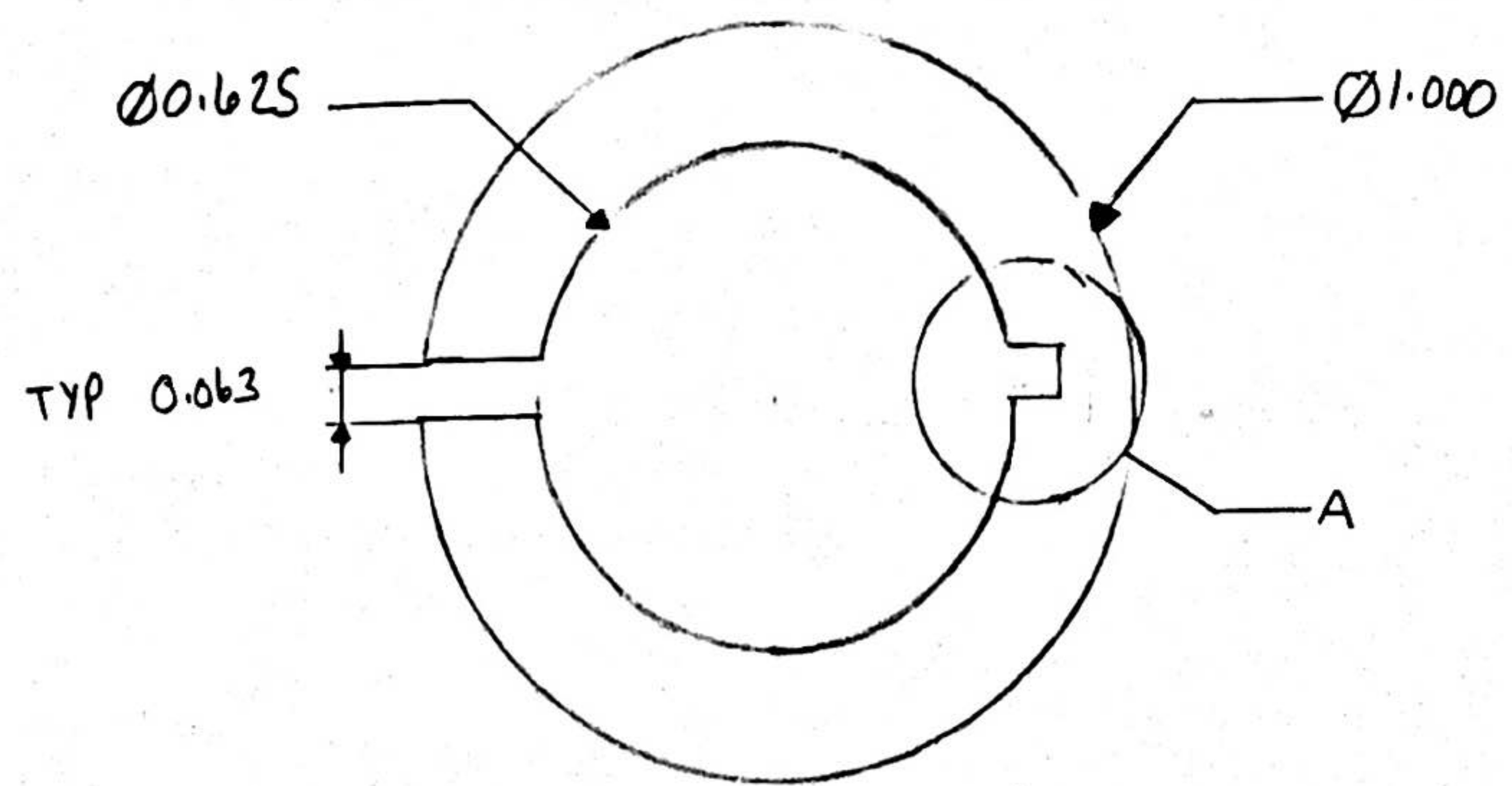
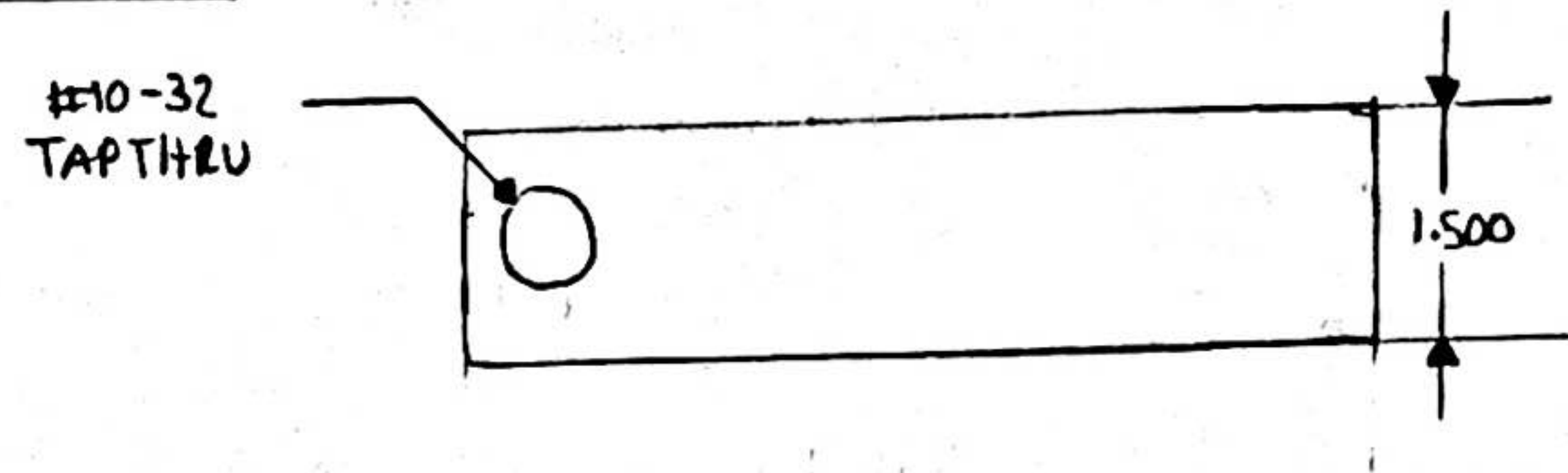
LID ASSEMBLY



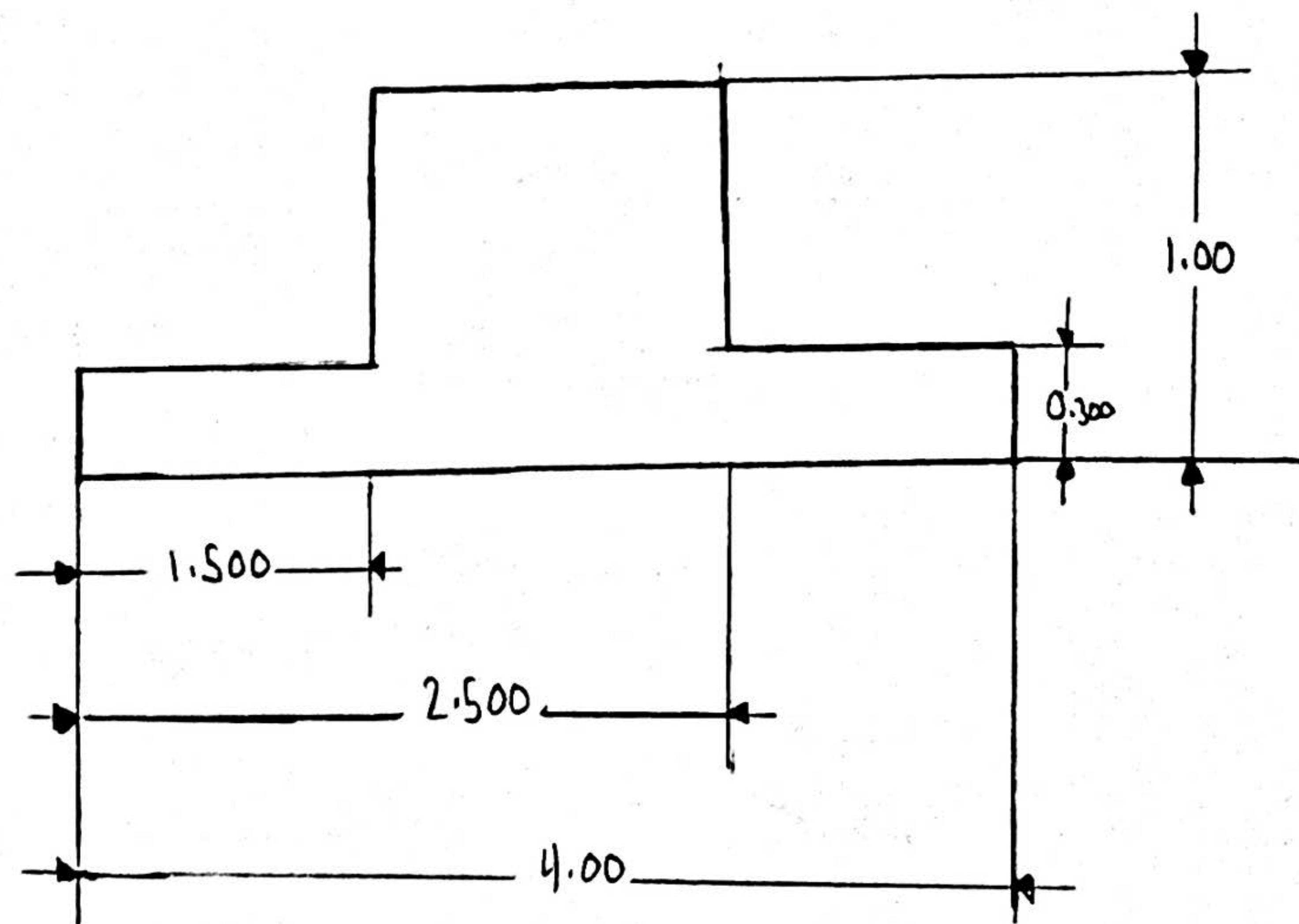
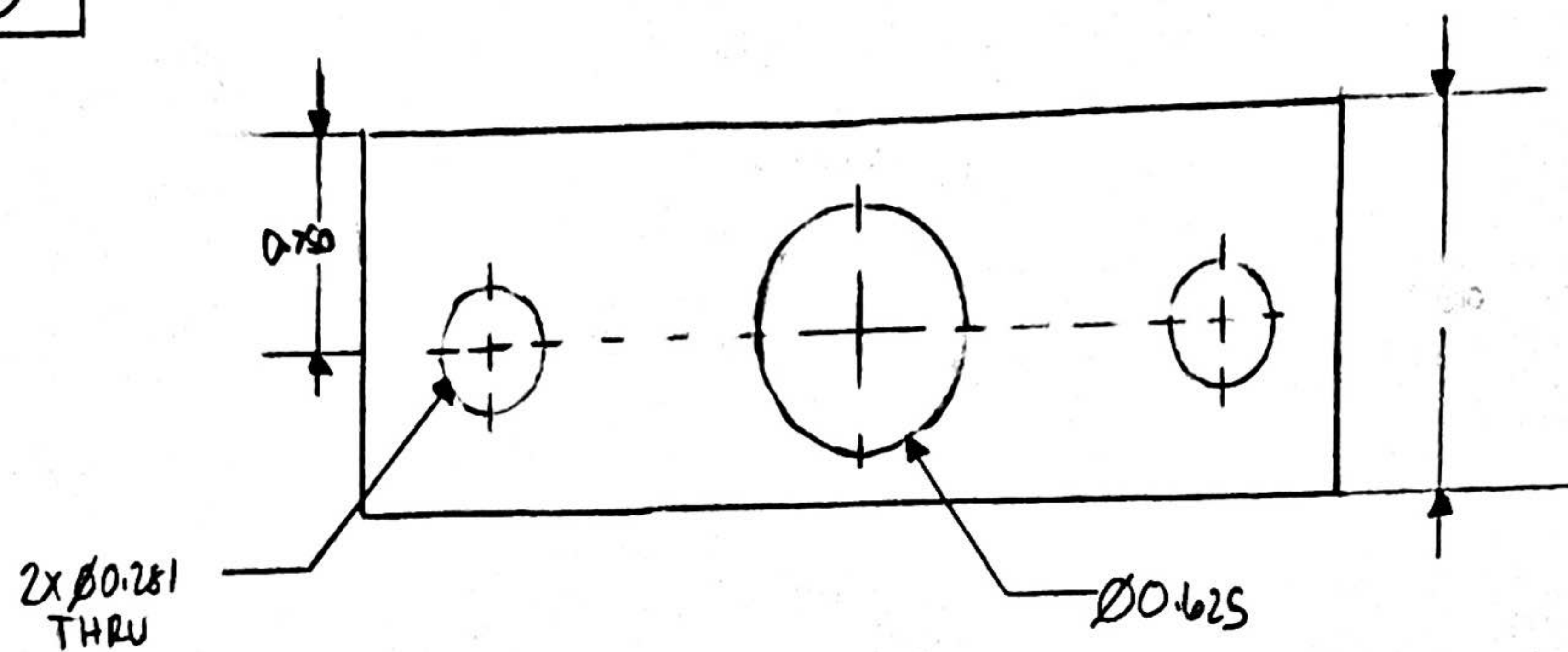
90° ANGLE

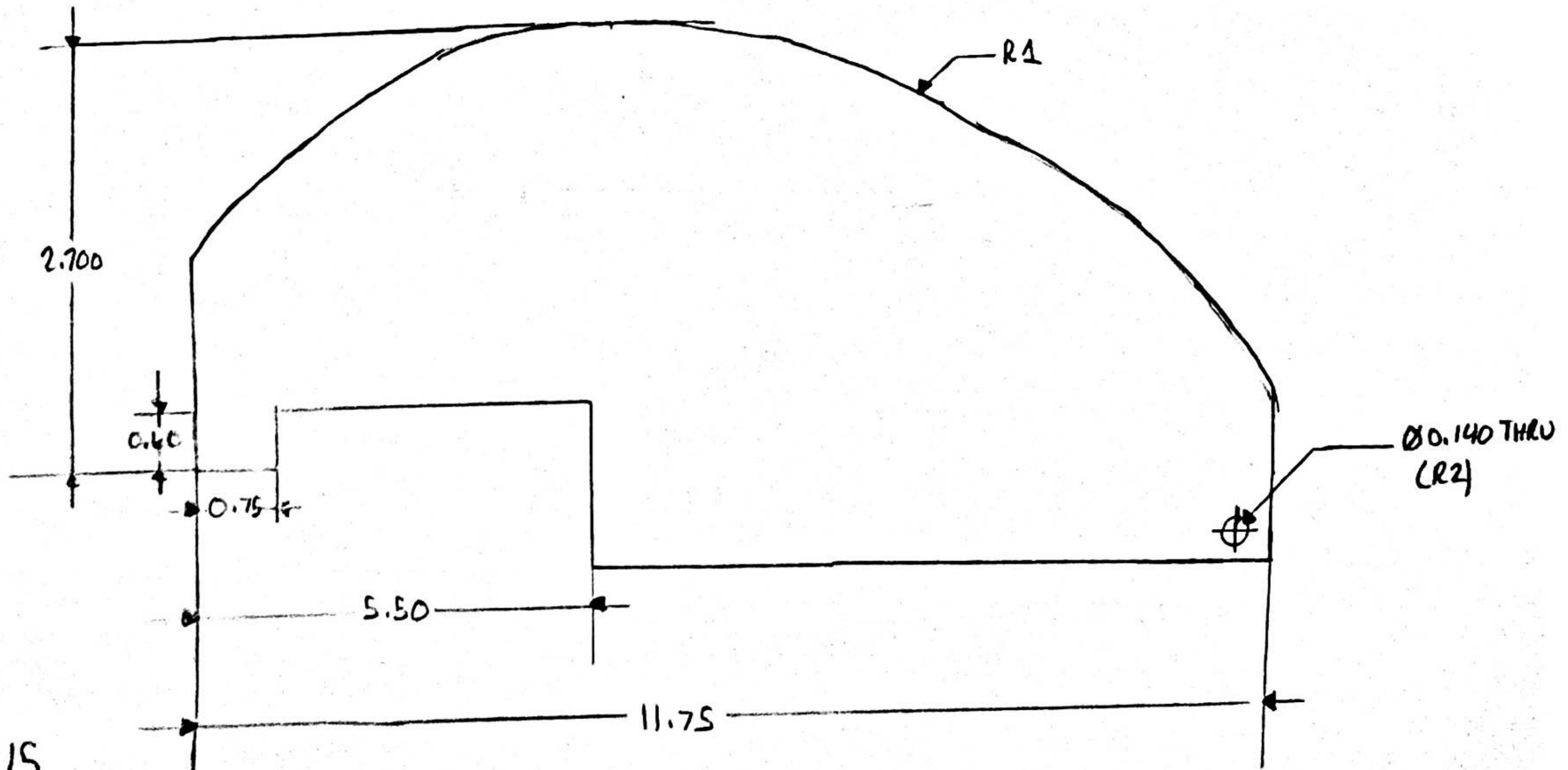
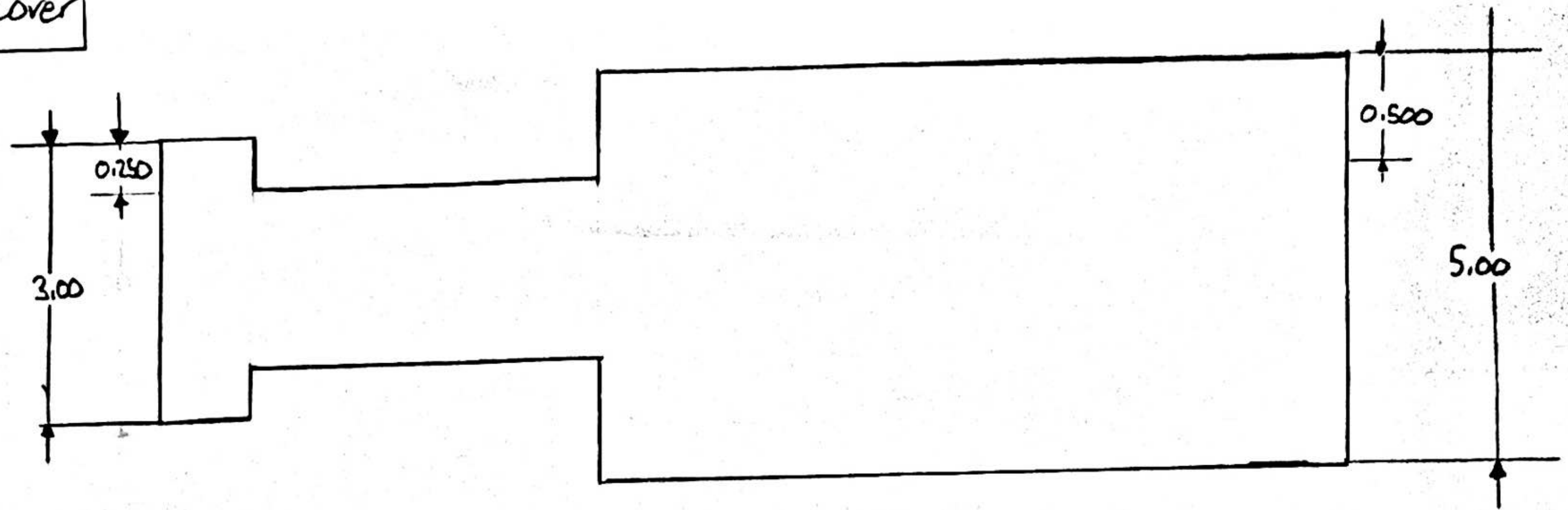


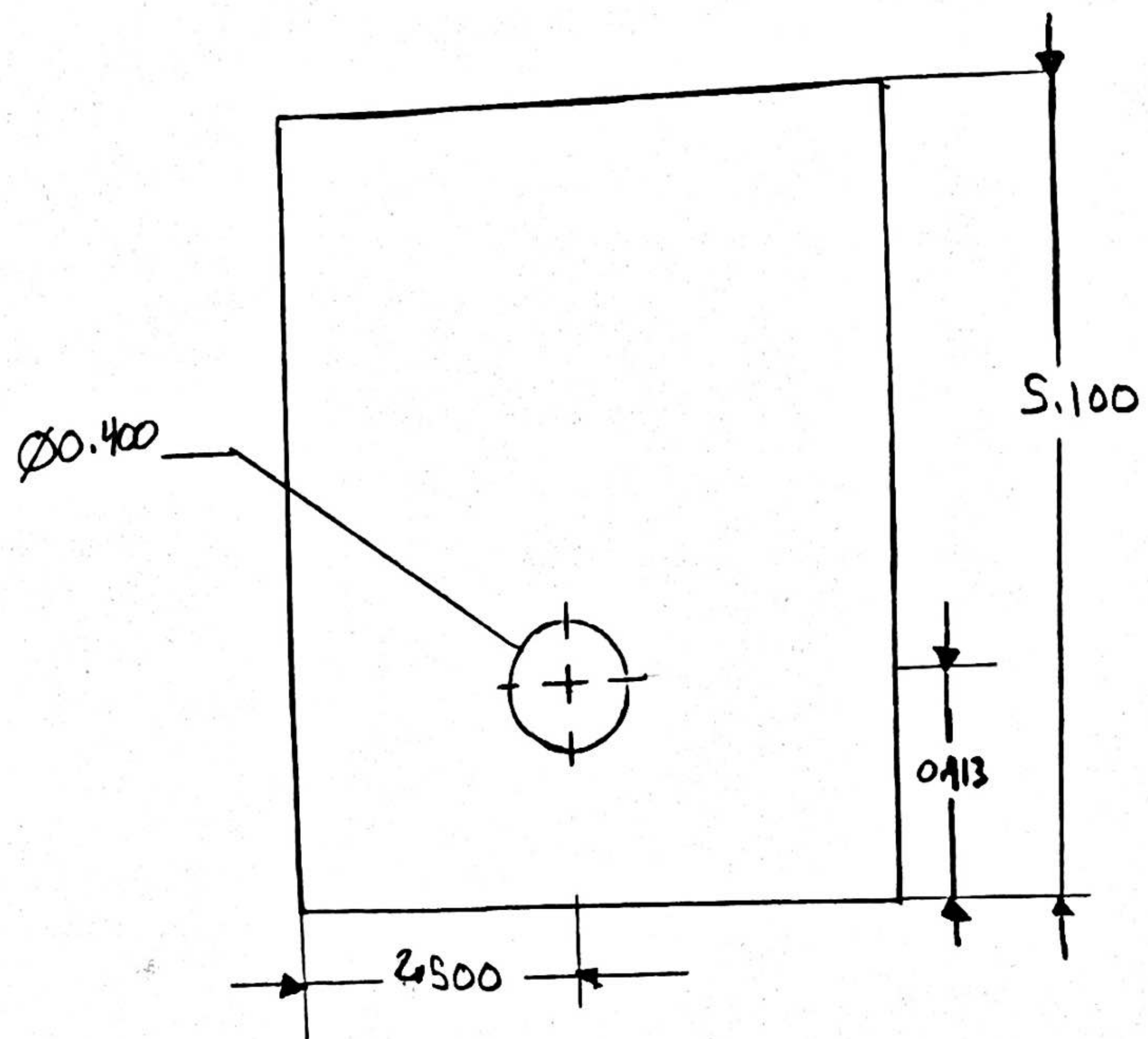
Clamping Shaft Collar

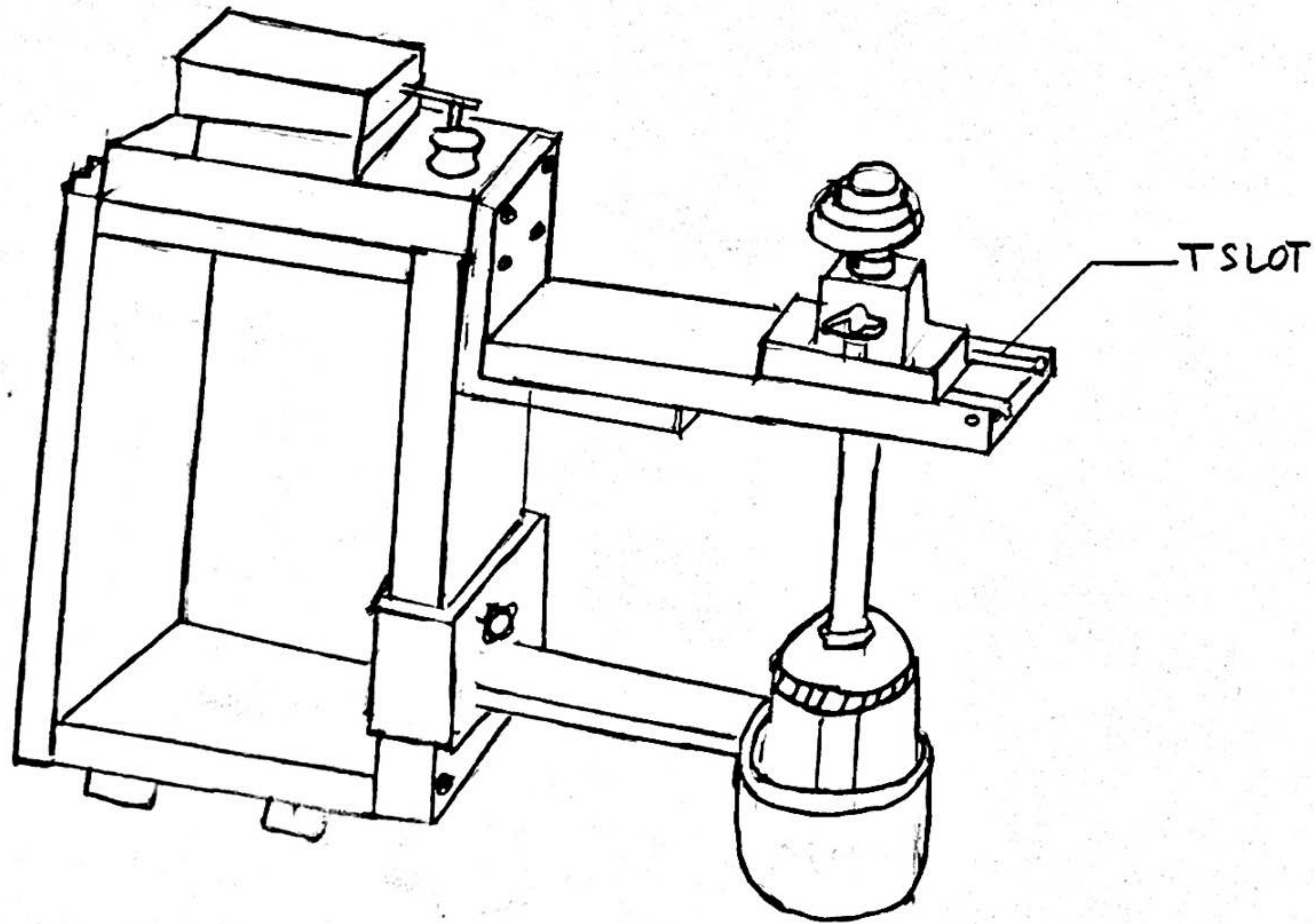


Bearing Housing









5B. Matthew's Concept Modifications

Matthew's Concept Modifications

This design required a handful of dimensional changes, structural redesigns to components, and sketch drawing adjustments for readability.

Base Modifications

The first modification made was to the belt/tensioner system. This modification required adjusting dimensions of the modified base features. The dimensions of the holes for the platform supports and shaft insert in the base were modified to accurately keep tension on the 14" belt. The belt was chosen for its beneficial material properties, such as abrasion, tear, water, and oil resistances, and its inexpensive cost relative to other elastomers. The belt's material disadvantages are irrelevant to this application [1]. Based on Page 1, the center distance from the flywheel to the tensioner is 1.25" and the center distance from the flywheel to the shaft is 5.377". As seen on Page 5, the highest point of the bearings is 0.594" from the base, obtained from adding the height of the spacer and both bearings. To determine the worst-case scenario for the belt-to-tensioner heights, the relative height of the belt at the flywheel is the lowest point at the flywheel, 0.05" from the base. The relative height of the belt at the shaft is at the highest point at the shaft, 0.85" from the base. As seen on Page 8, the worst-case scenario for the belt indicates that it reaches a height of 0.186", not close to the total height of the tensioner assembly. Additionally, hidden lines were originally in section view B-B. Those have been removed to abide by proper drawing standards.

Flywheel Modifications

The second modification was to the flywheel. Rather than welding additively to the flywheel to create a retaining lip, it is simply stronger, faster, and less expensive to manufacture if the original flywheel is turned on a lathe and a groove is cut out of the center for the belt to rest on. The flywheel also has a bottom lip to prevent the belt from rubbing against the stationary base and generating unnecessary friction, seen on Page 2. The groove is 0.05" deep, where the belt is only 0.03" thick, allowing for wiggle room to prevent the belt from slipping off the flywheel. The groove depth is limited by the counterbore on the flywheel for the piston-flywheel connecting rod.

Tensioner Arm Modifications

The third modification was to the tensioner arm. Since the original tensioner design did not fully engage with the belt to keep tension, the tensioner arm was extended from 0.4" to 0.625" so that two bearings instead of one can sit on top of each other and always be fully contacting the belt, depicted on Page 3. This modification was crucial to the functionality of the mixer as the belt must be under tension to operate. This change allows the tensioner arm to always fully contact the belt.

Shaft Sketch Orientation Modification

The fourth modification was the orientation of the shaft drawing sketch. The side view of the shaft was improperly projected from the top of the shaft, and so the side view was rotated by 90° to address this inconsistency, shown on Page 4.

Tensioner Arm Construction Modifications

The next modification was to the tensioner construction, Page 5. The original key did not contain the color coding for the bearing, as it was defined in an earlier drawing. In the revised drawing, the key defines each color used, also considers the new tensioner assembly construction with two bearings instead of one, and the updated, longer screw to also account for this change.

Lid Functionality Modifications

The next modification is intended to address a functionality problem for the lid construction. The 3 parts for the lid construction were originally only designed to have the lid and lid adapter act as one piece. However, the new design called for the lid, lid adapter, and blades (along with rubber gasket for content insulation) to be merged into one independent assembly outside of the mixer, Page 6. This is done by the addition of more sealant between the 3-piece set. It is acceptable to attach the blades and the rubber gasket to the lid adapter with only sealant because they bear no load. Within the OTS blade part, there exists an internal bearing that spins the blades independently of the rest of the assembly. The independent 3-piece lid can be detached from the mixer assembly, threaded onto the mason jar, sealed, all while the blades being able to spin freely and independently of the sealing plate because of the internal bearing from the manufacturer when purchased. This separate lid assembly makes this design detachable, cleanable, and interchangeable with different blade mixers and adapters. This new design allows the lid assembly to attach to mason jars and seal them, while also having extending notches that slide and lock into an L-lock in the lid platform.

Lid Platform Isometric View

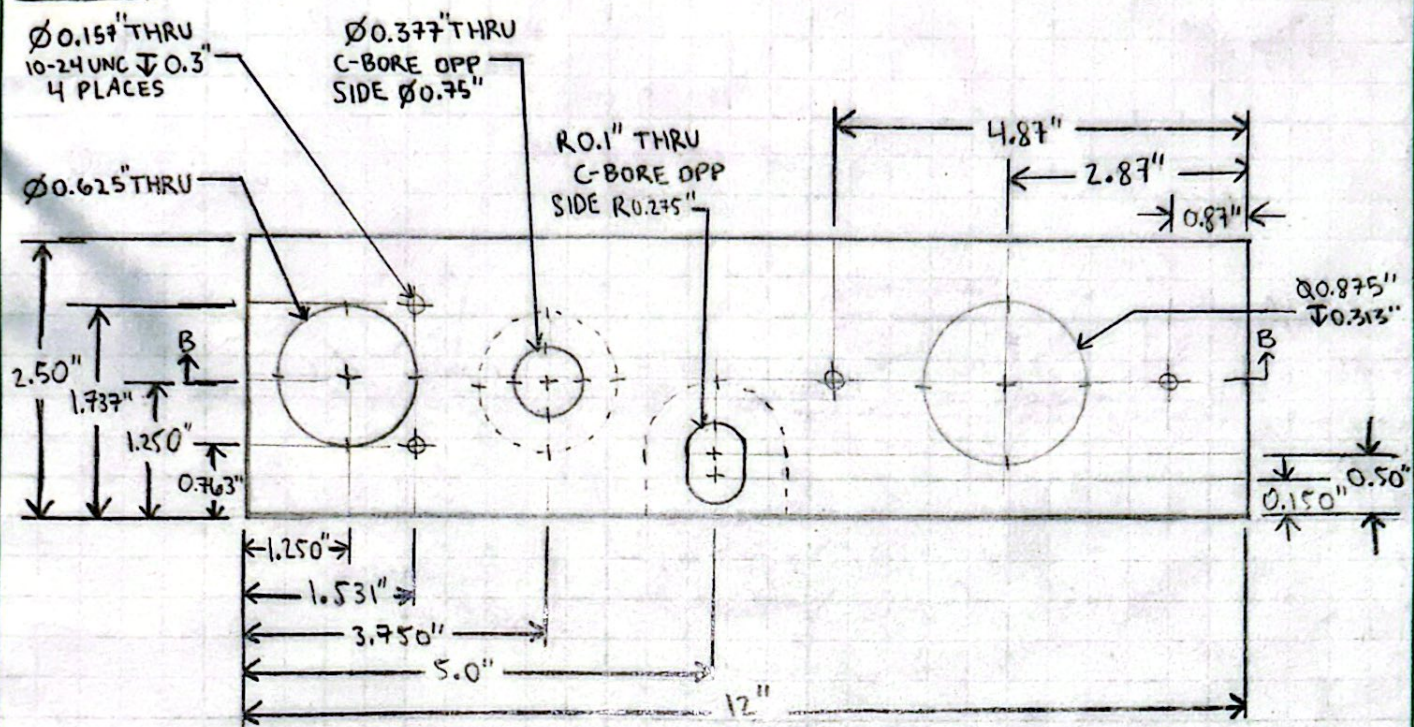
Page 7 features a minor modification, only including an isometric sketch of the lid platform for readability and understanding in part geometry when considering repeatability for others.

References

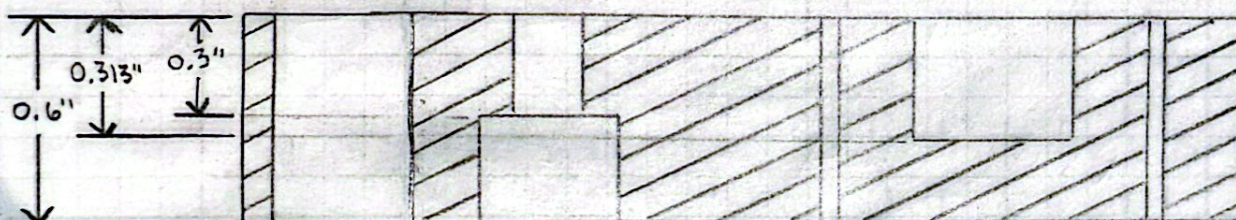
[1] “The Pros and Cons of Nitrile Rubber, NBR or Buna-N.” *Martin’s Rubber Company*, 6 Feb 2016, <https://www.martins-rubber.co.uk/blog/the-pros-and-cons-of-nitrile-rubber-nbr-or-buna-n/>. Accessed 25 June 2026.

BASE (MODIFIED) AIR ENGINE BASE

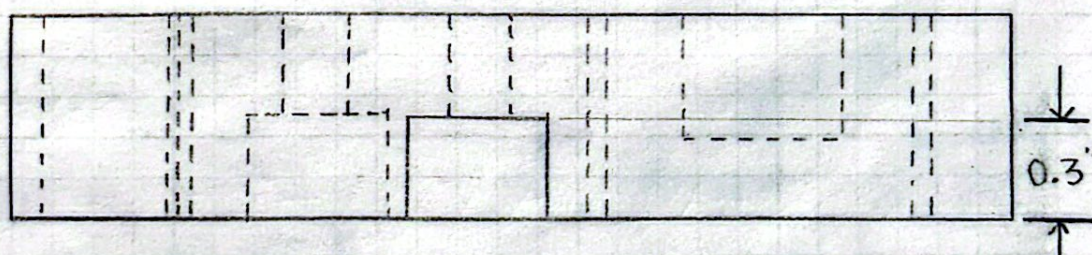
TOP



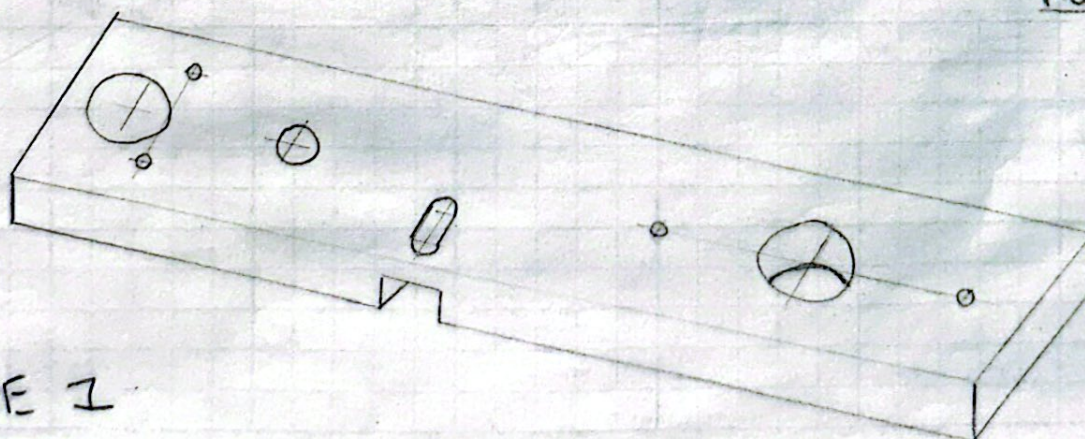
SECTION B-B



SIDE



ISOMETRIC



FLYWHEEL (MODIFIED AIR ENGINE FLYWHEEL)

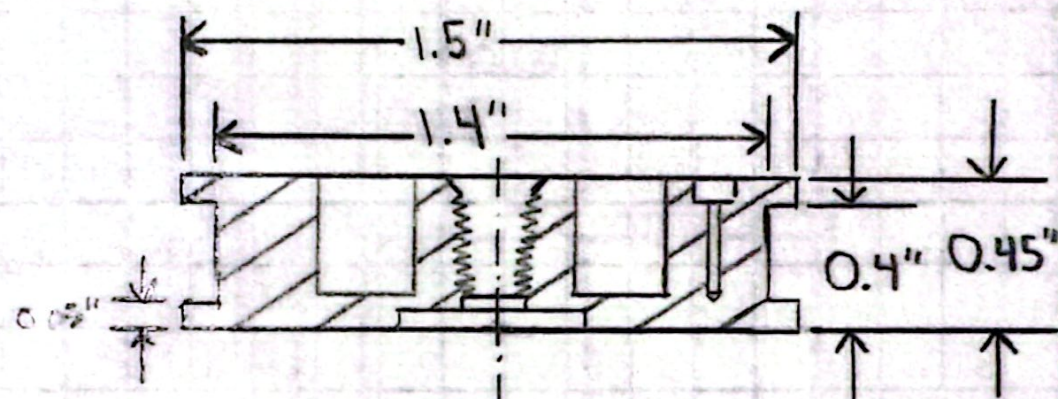
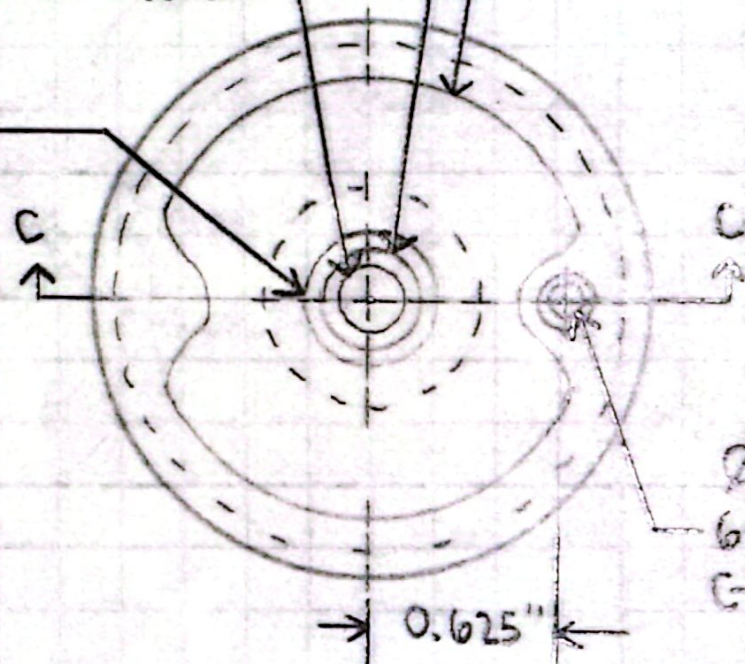
TOP

SECTION C-C

$\varnothing 0.161$ " THRU
10-24 LH UNC THRU
C-BORE OPP SIDE $\varnothing 0.252$ " ± 0.070 "
C-BORE OPP SIDE $\varnothing 0.650$ " ± 0.050 "

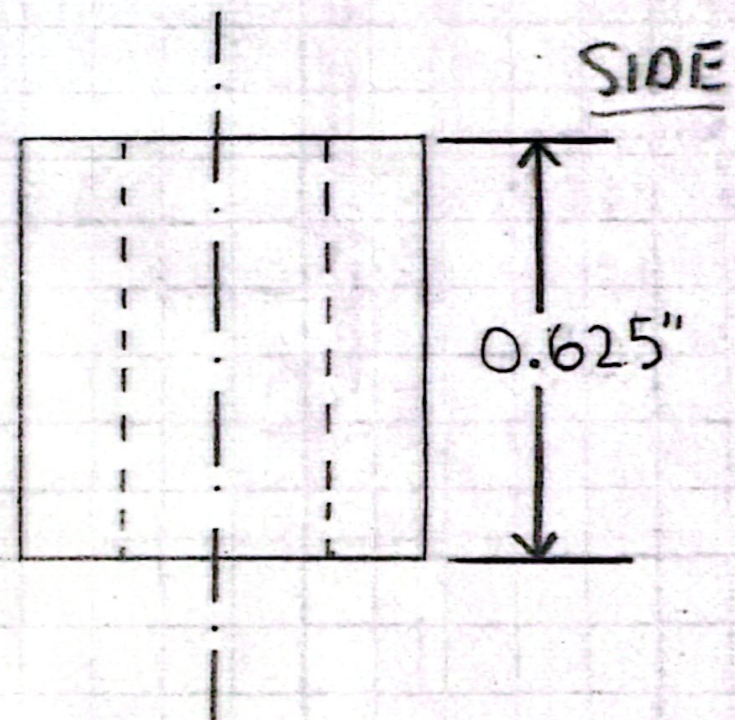
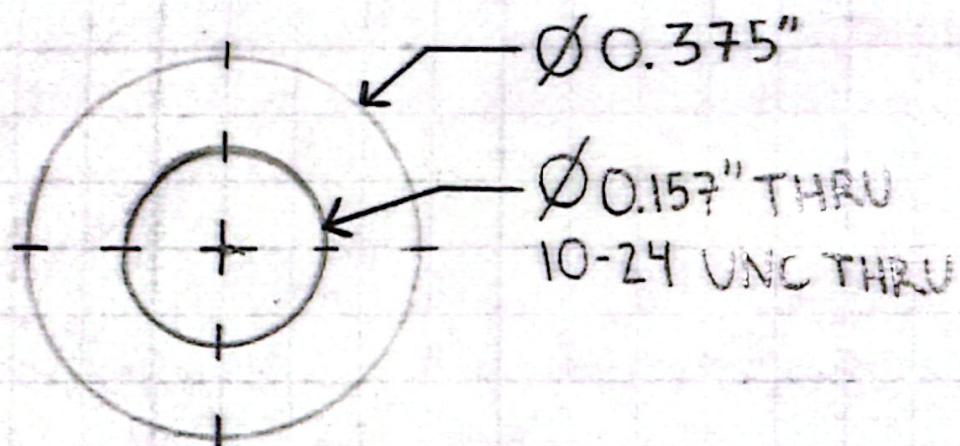
C-SINK $\varnothing 0.261$ "
MACHINE PROFILE
ON CNC

$\varnothing 0.375$ "



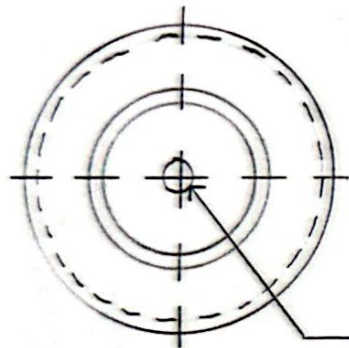
TENSIONER ARM

TOP

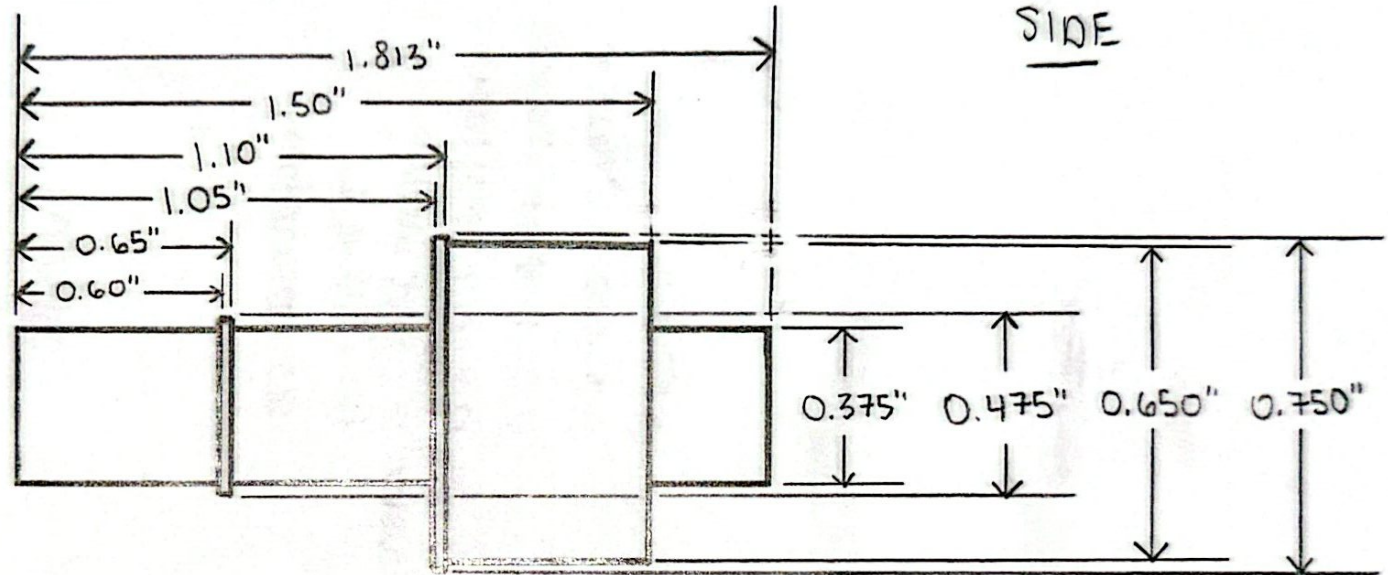


SHAFT

TOP

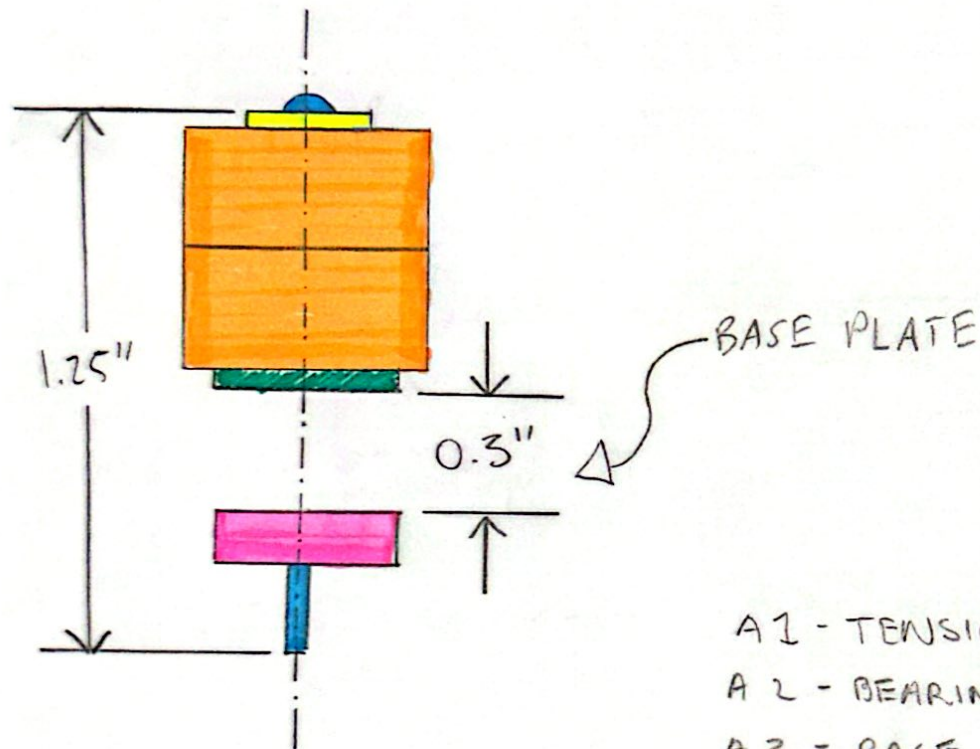


$\varnothing 0.157" \downarrow 0.35"$
10-24 UNC $\downarrow 0.3"$



TENSIONER CONSTRUCTION

SIDE



KEY

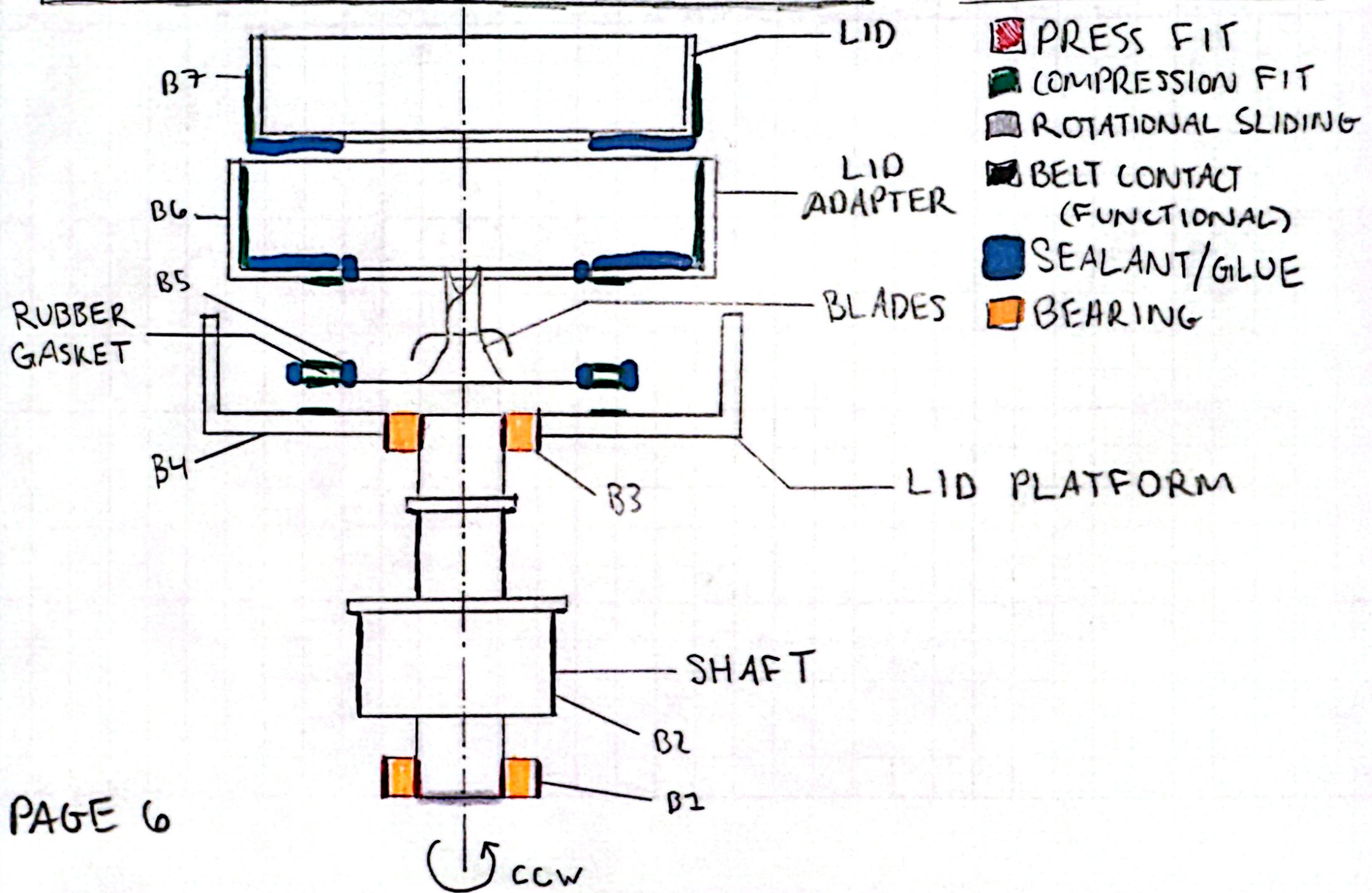
- SCREW
- TENSIONER ARM
- BEARING
- SPACER
- NUT

- A1 - TENSIONER ARM
- A2 - BEARING
- A3 - BASE
- A4 - NUT
- A5 - FLYWHEEL

- B1 - BEARING
- B2 - SHAFT
- B3 - BEARING
- B4 - LID PLATFORM
- B5 - RUBBER GASKET
- B6 - LID ADAPTER
- B7 - LID

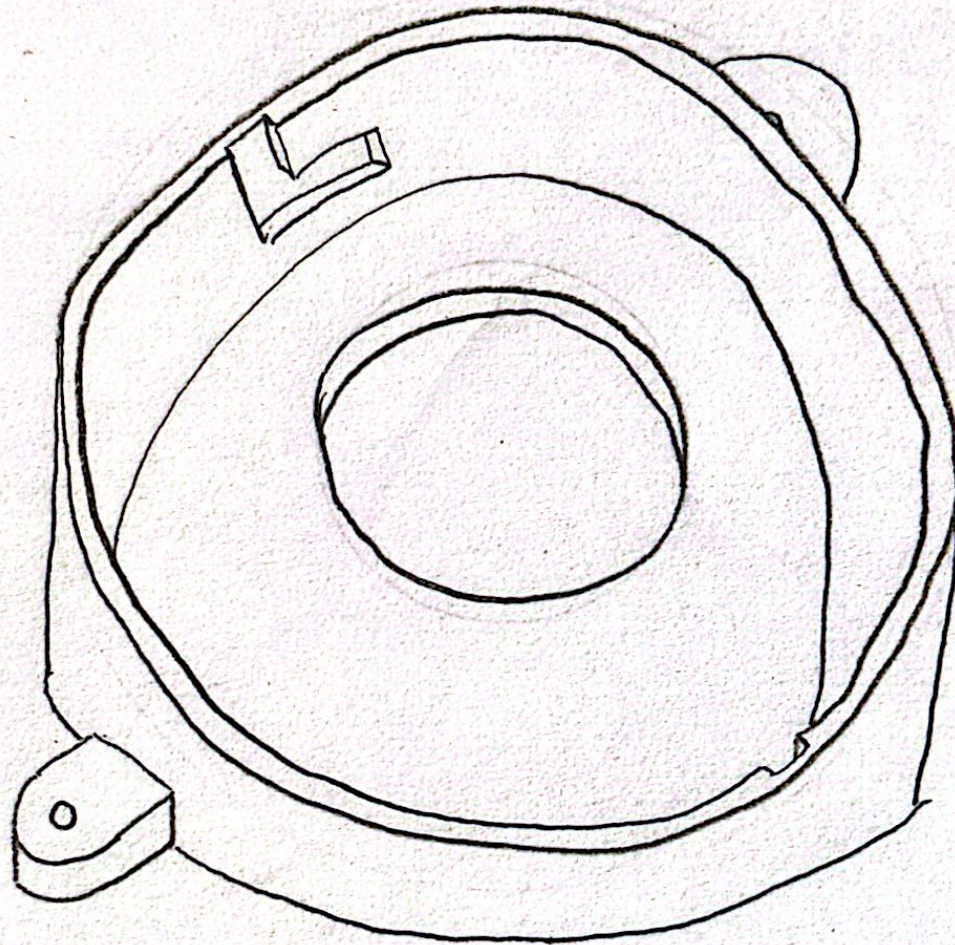
LID/SHAFT CONSTRUCTION

SECTION VIEW



LID PLATFORM

ISOMETRIC



5C. Nicholas's Concept Modifications

5D. Om's Concept Modifications

Om's Concept Modifications

This design required minor changes to part selection, math clarifications, and dimensional adjustments.

Belt Tension

The first modification made was to the tension between step pulley 1 and step pulley 2. The modification required obtaining a new stock length for the base plate and conducting calculations to determine the center distance between two diameters to ensure that the belt is maintaining tension while the mixer is functioning. The length of the stock needed to be increased from 6 inches to 12 inches to account for the distance between the pulleys. Additionally, the width of the stock needed to be decreased from 5 inches to 4 inches to account for the \$100 budget. The new stock and price were obtained from Online Metals [1]. To determine the center distance between the two pulleys, an equation for center distance is used as shown in (1).

$$C = \frac{K + \sqrt{K^2 - 32(D - d)^2}}{16} \quad (1)$$

In (1), C is the center distance between two diameters, D is the largest diameter, and d is the smallest diameter. K is a temporary variable to simplify (1). The equation for K is shown in (2) where L is the pitch length of the v-belt.

$$K = 4L - 6.28(D + d) \quad (2)$$

Both equations [2] were used to determine the center distance between the pulleys to maintain tension in the belt. After substituting L for 20 inches, D for 3.5 inches, and d for 2 inches into (1) and (2), the center distance between the two pulleys to maintain tension in the belt is approximately 5.6 inches, as shown in Page 1. For releasing belt tension, it is a simple process by sliding the belt up or down the pulley to achieve the desired speed ratio.

Stepped Pulley Material and Alignment

The second modification made was changing the material for the stepped pulley to be food safe. The original material for the stepped pulleys was zinc alloy, which breaks down to acidic foods. The new material for the stepped pulleys was aluminum alloy, which was found through Taig Tools. This new material is considered food-safe by the FDA; however, it also has the problem of corroding to acidic food [3].

To fix this issue, the center hole for the mixing attachment of the hinge platform will be adjusted to minimize the amount of liquid that spills through the hole, as shown in Page 2. This will minimize the amount of liquid that goes through the hole and into the pulley, which will

minimize corrosion. The fitting between the mixing attachment and the center hole will be a tight interference fit to decrease the excess space of the hole, while allowing room for sliding in the rod.

Hinge Mechanism

The third modification was to the hinge mechanism, specifically retaining its 90-degree angle during operation. While the mixer is functioning, vibrations are expected as the air engine is transferring power through the pulleys into the mixer. This would cause the hinge mechanism to vary in its stationary position, which could affect the speed adjustment. Instead of just having a dowel pin attachment to the hinge platform and hinge attachment, a kit consisting of one pin and two door hinge bushings from AutoZone was used to attach the two hinge pieces [4], as shown in Page 3. Using the combination of hinge bushings and the pin not only connects the hinge mechanism, but it also prevents wear in the metal and maintain structural alignment [5], so the hinge mechanism will maintain its 90-degree position despite vibrations in the mixer.

Mounting Legs and Support Rod

The final modification was to the mounting legs and support rod. In the section view drawing, it was shown that the outer diameter for the sleeve bushing was the same as the mounting legs and the support rod. This was a mistake in the drawing because it is meant for sleeve bearings to be pressed into the holes they will occupy. The inner diameter for the sleeve bushing is 0.25 inches, so the diameter of the hole for the support rod and mounting legs were adjusted, and the proper section view is shown in Page 4.

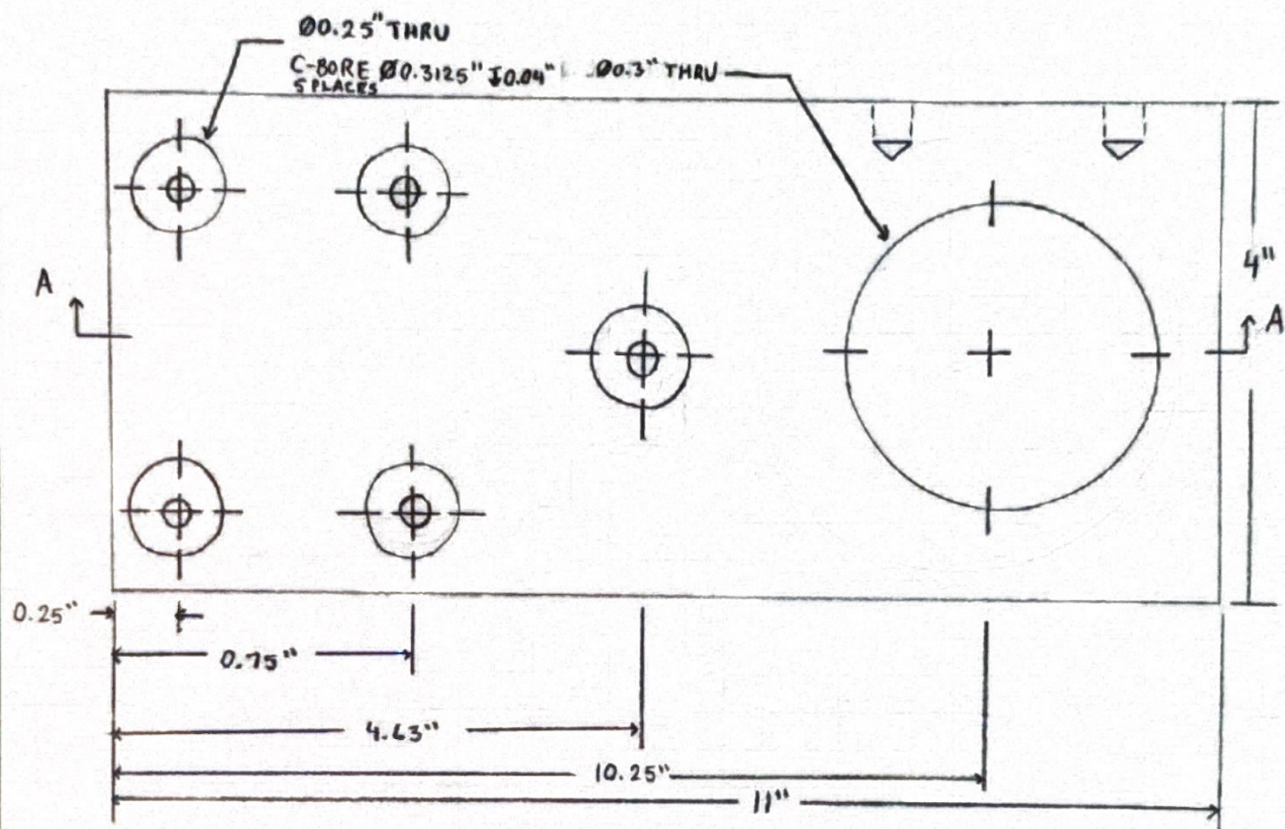
References

- [1] OnlineMetals.com, “1/8 in. x 4 in. Aluminum Rectangle Bar 6061-T6511 Extruded,” *OnlineMetals.com*. [Online]. Available: <https://www.onlinemetals.com/en/buy/aluminum/0-125-x-4-aluminum-rectangle-bar-6061-t6511-extruded/pid/1131>. [Accessed: Jul. 4, 2026].
- [2] York Industries, “Center Distance and Belt Length,” *York Industries*. [Online]. Available: <https://www.york-ind.com/technical-resources/timing-belts/center-distance-belt-length.html>. [Accessed: Jul. 4, 2026].
- [3] Marlin Steel Wire Products, “Food Safe Metals for Sheet Metal & Wire Forms,” *Marline Steel Wire Products*. [Online]. Available: <https://www.marlinwire.com/blog/food-safe-metals-for-sheet-metal-wire-forms>. [Accessed: Jul. 4, 2026].
- [4] Dorman Products, “Door Hinge Pin & Bushing Kit 38390,” *AutoZone*. [Online]. Available: <https://www.autozone.com/p/dorman-door-hinge-pin-bushing-kit-38390/17370>. [Accessed: Jul. 4, 2026].

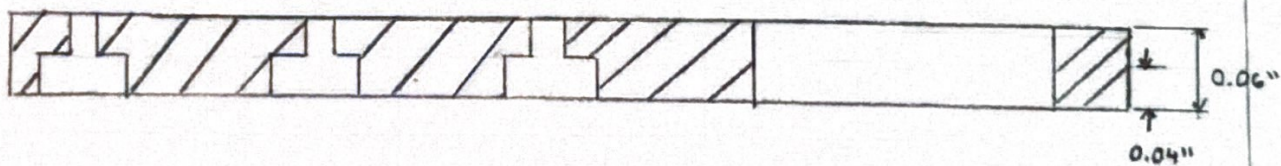
[5] Lily Bearing, “What Are Bushings?” *Lily Bearing*. [Online]. Available: https://www.lily-bearing.com/resources/blog/what-are-bushings?hs_amp=true. [Accessed: Jul. 4, 2026].

Base Plate

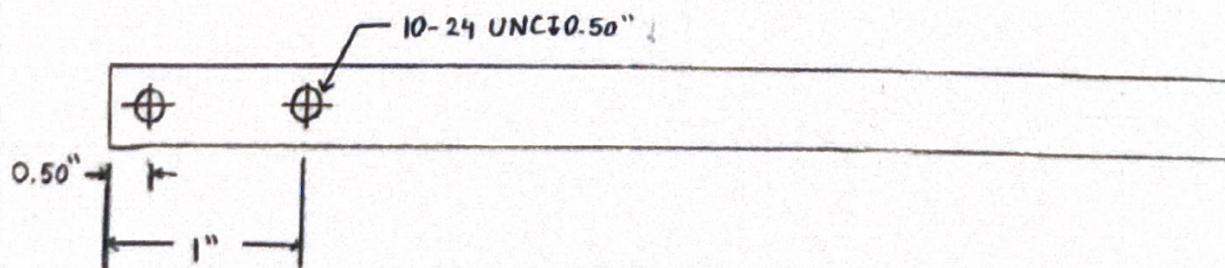
Top:



Section A-A:

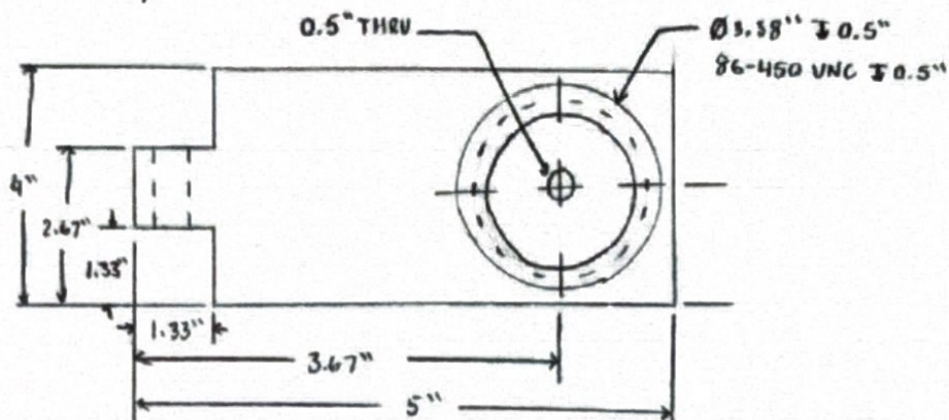


Side

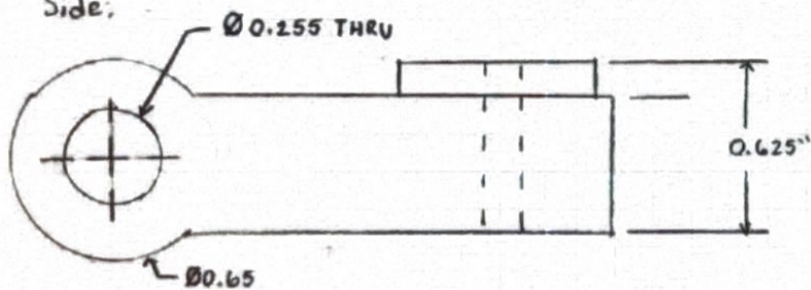


Hinge Platform

Top:

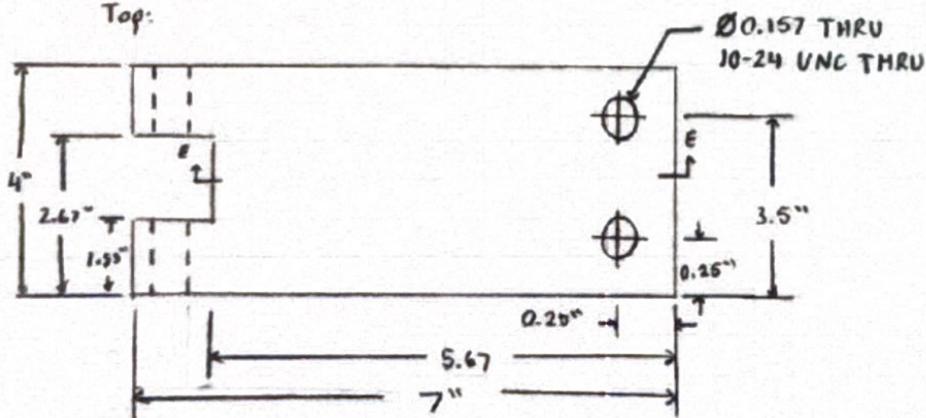


Side:

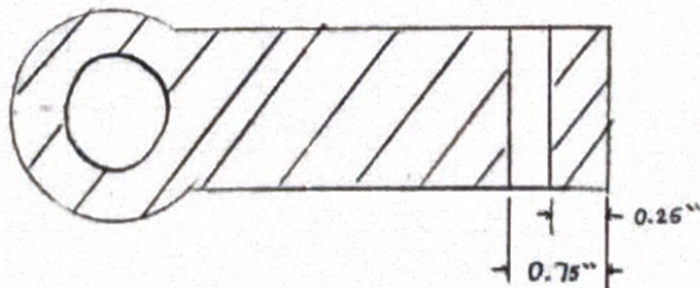


Hinge Attachment

Top:

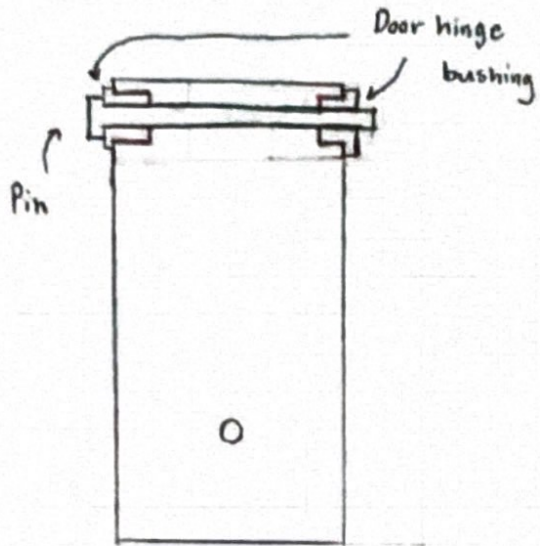


Section E-E:

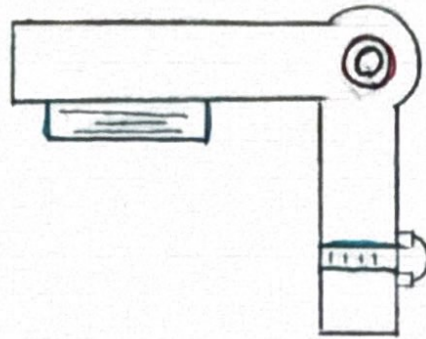


Hinge Mechanism Combination

Top:



Side:



■ Screw Fit

■ Interference Fit

■ Press Fit

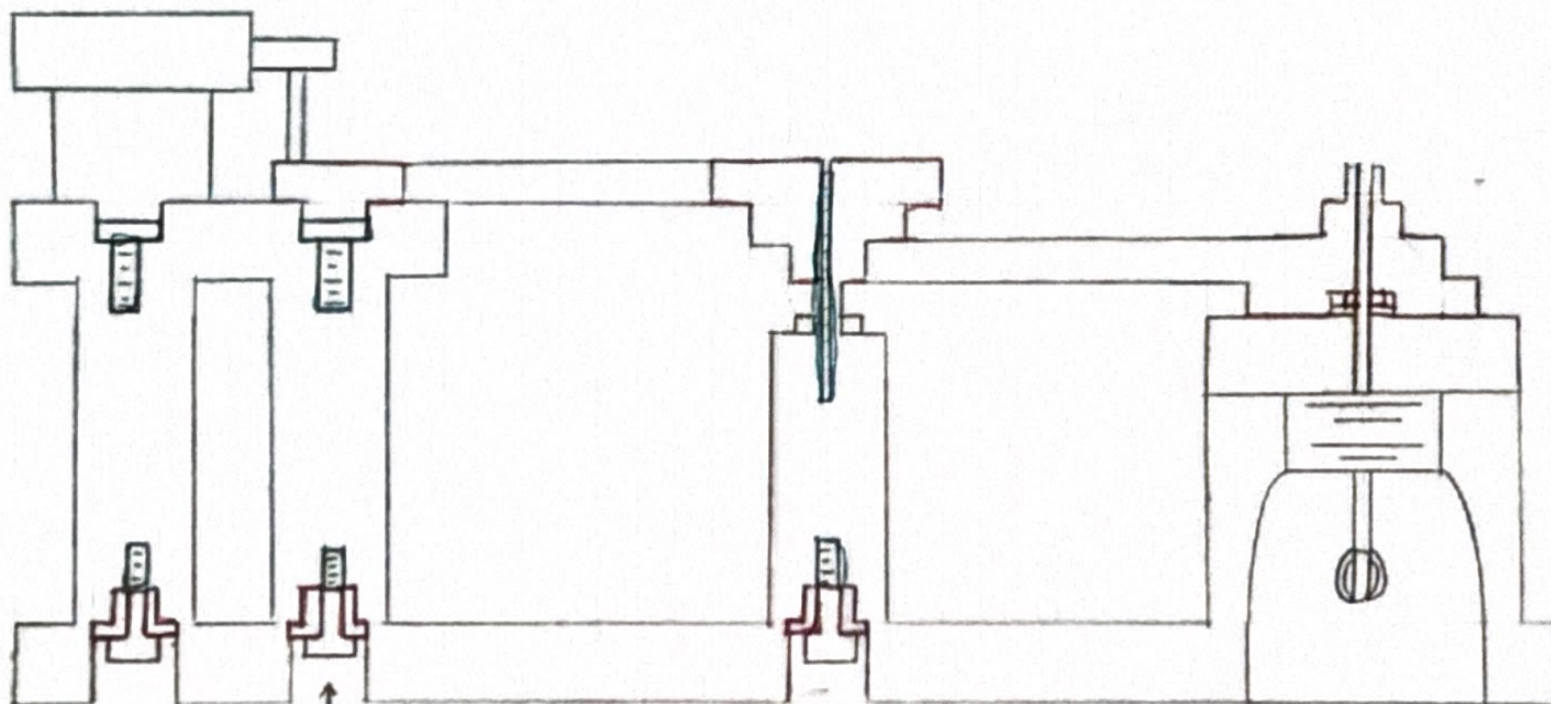
Section View

Rotational Sliding

Press fit

Screw Fit

Interference Fit



Adjusted Drawing for Bushings