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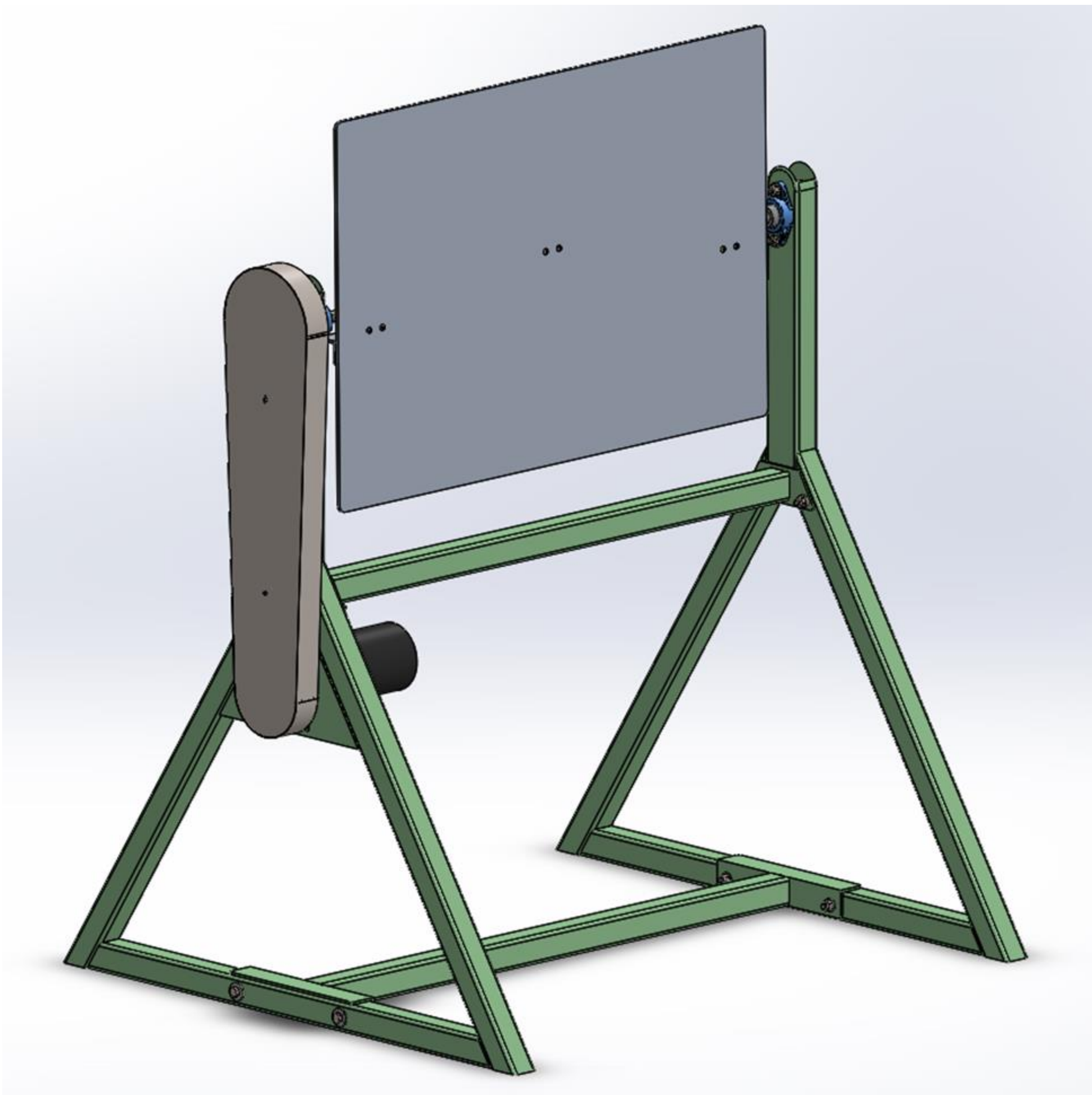
Shellfish Bag Maker

Trevor R. Reher
trevor_reher@yahoo.com

Shellfish Bag Maker



By

Trevor Reher

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Introduction

The purpose of this proposal is to propose new design of a machine that will cut shellfish bag material to a specific length. The owner of Babare Brothers Shellfish Farm is looking for a new machine that is more efficient than the current machine being used on his farm. The following pages highlight the process and analysis for designing this machine, along with documentation of how the machine would be constructed if built.

Motivation

Babare Brothers Shellfish Farms needs a more efficient machine than what is currently being used. The machine's purpose is too spool and cut oyster/clam bagging material to a specific length.

Function Statement

A new machine is needed to accept a continuous feed of bagging material for clam and oysters that can produce individual bags.

Requirements

The new design must meet the following requirements as specified by the client; they were based on improvements from the current machine in use. The bulleted list below outlines the improvements and features that the new machine must meet.

- Take up less than 25ft^2 of floor place
- Able to plug into an 110v power outlet
- Reassembly time takes less than 20 minutes
- Preforms at least 10% more efficient than the current bag cutter
- Needs to weigh in at less than 300lbs
- Can handle 60-80 bags at a time
- Maximum height of machine does not exceed 72 inches
- Budget is no more than $1500, on parts and material, not including design time and labor
- Bags must be 56 inches in length after being cut. Tolerances of ± 1 inch
- External tool to cut material after winding process
- The machine must be self-supporting. Required more than 70 lbs. to tip over at center of the shaft.

- Able to cut 60-80 bags within 10 seconds
- Powered by electric motor as per customer

Engineering Merit

The design of the bag maker involves many aspects of engineering. The machine requires a drive train system in order to transmit power from an electric motor to the driving shaft of the spooling device. The design will involve a v-belt system of pulleys and a tensioner to perform the transfer of power from the electric motor. The motor must be properly sized to ensure enough power to spin the spooling device. Strength of materials and welding calculations will be used to measure the strength of the frame that will house the drive train.

Scope of Effort

The scope of this project is going to focus on the drive train of the machine. The machine will require an electric motor driven by a set of pulleys will a V-belt. The drive train will require bearings for the driving shaft of the spooling device.

Success Criteria

The project will be successful if the machine produces bags to the desired size of 54 in ± 1in, performs at least 10% more efficient than the current machine and can handle 60-80 bags at a time on the machine. If all the requirements are met the project is viewed as a success.

Design and Analysis

Approach: Proposed Solution

The approach is to rework the existing machine being used to spool and cut bag material. The existing machine can be seen in the Appendix G-3. The current machine uses a good concept of a spinning board to get the material to the desired length. Then using a serrated knife the material is cut between two 2x4's on one side of the machine.

The new design is guided by the wants of Drew Babare, the owner of Babare Brothers Shellfish. The new machine will be similar to the current machine in use, in that it will have the same idea of a spinning board, and belt driven system; however the new machine will be self-supporting. The owner also specified that there needs be a more efficient way to cut the material; rather than just using a serrated knife. Compared to the current machine used this new machine will be safer to use, because a belt guard will be added to keep the user from becoming entangled in the drive train.

Description

Figure 1: Video of Oyster/clam bag machine being used by Babare Brothers Shellfish Farms Video Taken By: Trevor Reher

Benchmark

The current machine used to spool the material has been in use for the last 15+ years. The machine rotates at an average of 52.6 RPM, and can handle a max of 60-70 bags at a time. The cutting process is done by a serrated knife. Cutting time of 60-70 bags varied from 0.33 – 0.58 bags/second, with an average cutting time of 0.48 bags/second. The significant cutting time variation stems from the time it takes for the operator to cut the bags. The operator may become tired due to the physical nature of the work, this in turn creates a variance in the time taken to cut each bag. See appendix G-2 for benchmark data.

Performance Predictions

With an increase of 7 RPM from the current machine used at Babare Brothers, the new machine will be rotating at 59.65 RPM. An increase of 7 RPM makes the new design 14% more efficient causing the machine to spool at almost 1 bag per second. Calculations can be found in appendix A-1.

Description of Analyses

The analyses for the shellfish spooler focuses on the force it takes to get the material off the spool. This force is used to determine the horsepower (HP) and torque need by the electric motor. After finding the HP and torque the electric motor can be selected. After selecting the motor the v-belt design will be completed to determine the ratio needed to produce an output RPM of 60.

Additional calculations of strength of materials will be needed in calculating the shear and normal stress on the bolts that contain the parts in motion. Strength calculations will be used to determine the size of welds that will be needed to hold the frame together.

Scope of Testing and Evaluation

The best way for testing the performance of the new machine is to cut bags using the machine. Using a stopwatch the performance can be tested by recording the time by the number of bags produced. The calculated value is 59.65 bags in 60 seconds equaling .99 bags a second.

Analysis

The analysis for the machine started with finding the force it takes to remove material from the spool. The force found ranged from 2.5-7.5 lb. A safety factor of 1.33 was used to design for the upper limits of the force needed to get the material off the spool. Using the safety factor of 1.5 the new force was 10 lb. The force of 10 lb. acts at the top of the spinning board 13.5 inches from the center of the shaft. Using statics the torque required was 135 lb.-in or 11.25 lb.-ft. With torque found using the equation T = (P/Speed) the HP of the motor can be found. The HP needed is 0.128 hp. The hand calculations for motor size can be found in appendix A-2.

The calculations in A-2 shows the motor needs a minimum HP of 0.128, and 135 lb.-in of torque. The motor selected is a Bodine AC electric gear motor with ¼ HP supplying 162 lb.-in of torque. This motor has the closes HP and torque values needed to drive the machine.

With the motor selected, the v-belt drive train can be designed. The motor input RPM of 85 RPM is ideal for a reduction ratio of 1.41 to 60 RPM. A driving sheave size of 4" was selected and driven size of 5.7" for the drive train. The size selected was guided by having good belt contact around the sheaves. The actual reduction ratio is 1.425 determined by the sheave size with an actual output RPM of 59.65. The center distance of the machine varies by 20.95 – 23.35". The minimum belt length is 57.14" and maximum belt length is 61.96". The average belt length was calculated to be 59.55" and the closest belt available was 59". With the sheaves sizes being similar the angle of wrap for the 4" sheave is 175.54˚ and 184.45˚ for the 5.7" sheave. Because the drive train has a low RPM input the belt speed was calculated to be 89 ft./min. in Robert L. Mott's *Machine Elements in Mechanical Design* textbook he recommends using an alternative way to transmit power at low speeds such as chain for gears. Because the maximum torque the motor will be applying is 162 lb.-in the low belt speed will be fine to use. Visit appendix A-3, A-4 and A-5 for hand calculations.

The parts transmitting all the torque needed to take material off the spools is a 3/16 square key way. 316 stainless steel was chosen as the key material because the machine could be with-in 500 ft. to a salt water bay. The 316 stainless steel is better for resisting corrosion than the 304. The minimum length was calculated to be 0.395", both pulley hubs are over 1", therefore the key length will be just the length of the hub. Visit in appendix A-9 for hand calculations.

For the machine to be self-supporting the force being applied to the spinning board must be smaller than the force to tip the machine over. With the machine having a center of mass of 160lb acting 22.5" from the bottom of the machine at the center. It will take 59lb to tip the over at the edge of the spinning board 60" from the ground. Another tipping force was found at the shaft of the machine, because this is the highest point on the machine a person could push from. If a person were to apply more than 73.3lb the machine would tip over. A design requirement specified by the owner was, it takes more than 70lb of force to tip the machine over at the shaft. All the tipping forces found were high enough where the base of the machine would not have to be widened. Visit appendix A-8 and A-11 for hand calculations.

The shellfish bag maker shaft has three stainless tabs welded to it. The weld size was calculated on each side of the tabs using a 2" weld length and a vertical shearing force of 120.4 lb. the calculated weld size was 0.002". The weld size is very small and will just be a single pass weld. The calculated force of the tab was an extreme because it was only analysis as one tab taking all the force rather than being divided by three tabs. Visit appendix A-14 for hand calculations.

The frame of the machine is constructed from steel tube that will be welded together. The highest force the machine will feel is the motor on the machine locks up and isn't spinning. The torque would be 162lb-in and the affected area would be where the side legs of the machine are connected to the tops sides. Using an equation listed in Robert L. Mott's, textbook the weld size would be 0.005". Again like the welded tabs to the shaft the force on the machine are rather small because the motor is relative small at ¼ HP. The whole machine will be welded together with a single pass weld. Visit appendix A-13 for hand calculations.

The shaft of the machine has a three tabs with two thread holes for bolts to hold the spinning board to the shaft. The bolts experience two types of loading vertical shear and a normal force from the torque. The six bolts were analysis under the condition that the board was locked up and the maximum torque was being applied of 162 lb.-in and 20 lb. weight of the aluminum plate that is the spinning board. The material was the bolts is 316 stainless steel with a yield of 30ksi. The shear stress was 705.4 psi for one bolt with the 20 lb. load. The normal force in tension from the moment was a force of 135.3 lb. divided by a diameter of 0.19" gave a normal stress of 4772 psi for one all under all the load. None of the bolts will fail because there under the yield of 316 stainless steel. Visit appendix A-11 for hand calculations.

The shellfish bag maker is power by 110v to power the gear motor that is driving the pulley system. A circuit was drawn to the build to under how the machine must be wired. See appendix A-15.

Design:

Below are concept designs modeled in SolidWorks. The first design was presented to the owner as an idea of what the machine could possibly look like. The second image is the completed redesign of the machine.

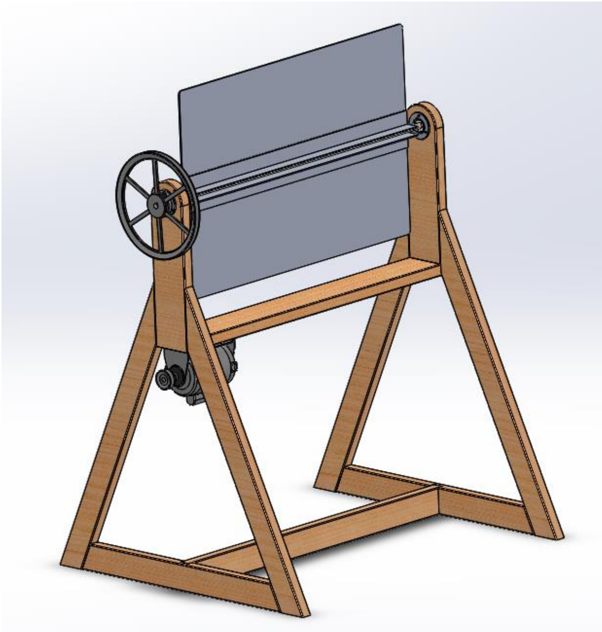


Figure 2: Oyster/Clam bag concept design 1

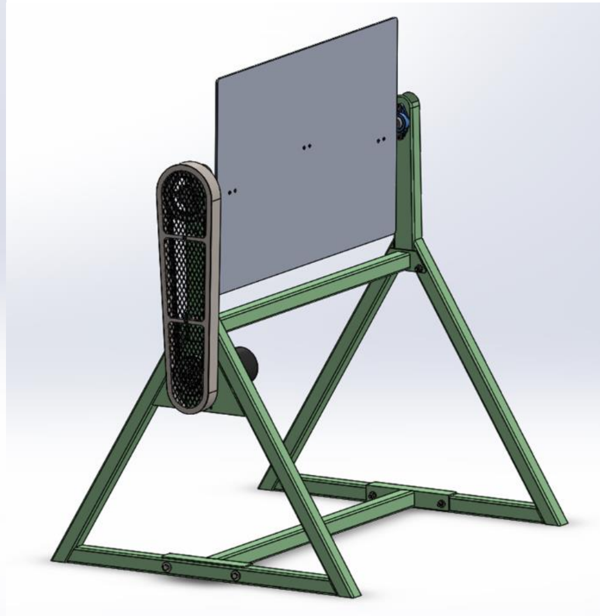


Figure 3: Oyster/Clam bag concept design 2

Design 1 and 2 are similar in appearance but the stands are composed of different materials. The first design was modeled using cedar wood for the frame. The cedar design doesn't work as well as steel for disassembly and reassembly. The clamping force for the wood would change every time a screw is taken in and out. For the steel the clamping force wouldn't change because the bolts are going through a thread hole.

Calculated Parameters

For further discussion of calculated parameters see analysis section above

- Calculated efficiency of new machine = 14% — Appendix A-1
- Torque needed to pull material off of spool = 135 lb.-in — Appendix A-2
- Minimum HP required = 0.128 HP — Appendix A-2
- Driving Sheave Size = 4.0" — Appendix A-3
- Driven Sheave Size =5.7" — Appendix A-3
- Machine Calculated Output RPM = 59.65 — Appendix A-3
- Belt Length = 59" — Appendix A-4
- Center Distance = 21.87" — Appendix A-4
- Angle of Wrap Driven Sheave ϴ=175˚ — Appendix A-4
- Angle of Wrap Driven Sheave ϴ=185˚ — Appendix A-4
- Belt Speed = 89.01 ft./min — Appendix A-5
- Material Lengths needed — Appendix A-6
- Material Lengths needed Continued — Appendix A-7
- Tipping Force at Board = 59 lb. — Appendix A-8
- Keyway Dimensions = 3/16 x 3/16 x 1.313 " — Appendix A-9

- Machine Floor Space = 14.67 ft^2 Appendix A-10
- Bolt diameter check for spinning board Appendix A-11
- Tipping Force at shaft = 73.3 lb. Appendix A-12
- Weld size = single pass weld Appendix A-13
- Weld size for shaft tabs Appendix A-14
- Drawing of the circuit for the machine Appendix A-15

Device Shape:

The shape of the design is similar to the previous machine used at Babare Brothers Shellfish Farms. The width of the machine is being minimized by using a face mount motor, mounted inside between of the legs. By using a face mount motor, a belt tensioner is being eliminated because the mounting plate has slots, because of this the motor is able to move vertical to tension the belt. The bearing selected are flange mount bearing with two set screws. The set screw provide a level of safety in the machine by not let the shaft move either direction if the belt fails. The stand is made from welded box steel ensuring a rigid construction and will have a power coated finish to prevent rushing. After testing is complete and the machine works perfectly it will be painted or power coating to protect it from rusting.

Device Assembly, Attachments

The machine is going to have two primary methods of attachments. The sides of the frame are going to be welding together using a gas metal arc welding (GMAW). By welding the sides of the machine it will save time in the construction process because of the angles in the sides of the machine would require more time to drill holes to install fasteners rather than welding. The side welding drawing can be seen in Appendix B-10 and B-11. Similar to the side, the upper and lower cross members will be welded together than bolted to each side of the sides. This can see seen in the exploded view in B-25.

Many of the other parts are going too fastened to the frame of the machine. When viewing the exploded view (B-25), it's shown all the remaining components are fastened to the machine.

Tolerances, Kinematic, Ergonomic, etc.

The tolerances for the machine vary from component to component. The sides of the machine are going to be welded together with a tolerance of 1/32. The holes drilled in the sides of the machine will have tolerance of + 0.020. The holes center location will need to be with in ± 0.010 to ensure proper alignment of the shaft. The flange mounted bearing can accommodate 2° of shaft misalignment, therefor the tolerance for shaft alignment are ± 2˚.

The high tolerance area are the shaft keyway and keyways. The keys are undersized by 0.002 for a tight fit. The key way on the shaft will be cut using a 3/16 end mill for as close of a dimension to 3/16 as possible. The tolerance is plus 0.005" and nothing less than 3/16 for the shaft keyway.

Technical Risk Analysis, Failure Mode Analyses, Safety Factors, Operation Limits

By the machine being belt driven, a guard must be added for protection from clothes and body part coming entangled with the machine is running. An added level of safety in the machine, is that is it run by a foot peddle, the peddle lets the operator be away from the machine while it is running.

Methods, Construction and Manufacturing

Construction

The Construction of the Shellfish Bag Maker frame will be made from box 2x2” and rectangular 2x3” steel. The steel will need to be cut to length and welded together using gas metal arc welding (GMAW) process. In addition to the frame being welded, the shaft that holds the board that spins will need to have three tabs welded to it. The tabs will use the same welding process as the frame.

The bearings and cross members are going to fastened using a 7/16-14 nuts, bolts and washers. The reason for using 7/16-14 on most of the components is for ease for disassembly and reassembly. The users won’t have to have a variety of tools on hand to work on the machine. The face mount electric motor won’t be using 7/16-14 thread because the motor comes pre tapped with ¼-28 threaded holes for mounting. Lastly the spinning board will use six 10-32 counter sunk bolts to mount the board to the three tabs.

Description

After the sides of the machine and shaft has been manufactured the machine will all fasten together. The sides of the machine will fasten together by the shaft and two cross member bars. The shaft will work act as a cross member because the flange mount bearings have set screws prevent the shaft from sliding in either direction. The AC gear motor will fasten to the side of the machine on a welded plate. Both pulleys will attract with a keyway and set screw. Lastly the spinning board mounted to the tabs on the shaft will be fastened to the tabs.

All the sub-assembly’s on the machine will be welded together then all the parts and sub-assembly’s will be fastened together using 7/16 – 14, 1/4 – 28 or 10-32 bolt, nuts and washers.

Drawing Tree, Drawing ID’s

The Shellfish Bag Maker Consist of two major assemblies, the frame and drive train. The drawing tree lists all the parts that need to be made along with drawing ID. The ID’s are listed in the upper right hand corner of the title block. The drawing three can be found in appendix B-1.

Parts list and labels

The parts list in appendix C-1 shows the parts need to construct the Shellfish Bag Maker. The Table shows the part number for the parts the need to be bought, along with the vendor they will be purchases from. All parts have a quantity listed with them and for the raw material the length of material needed.

Manufacturing issues

There have been a few manufacturing issues that have happened thus far into the build. The first issue was using the CNC plasma table; the machine was having a hard time cutting with in tolerance of the DXF file. To fix the issue a phone call had to be made to the manufacture of the machine, Torchmate. After speaking to technical support the issue was resolved and cutting with in the tolerance needed was working once again.

Another issue was the stainless steel shaft stock that was used. The stock ordered was measured to be 0.751”. This measurement was found after the shaft mounting tabs had been welded to the shaft to prevent it from being able to be put into a lathe and turned down to the proper diameter of 0.749. To fix this issue many hours of hand sanding had to be done to remove the extra 0.002" of material. Also a keyway was going to be milling into the shaft. The designer figured that the key depth would just be ½ the height of the key. This was found to be incorrect and the depth the key needed to be milled in was 0.012" more than noted in the drawing.

The tabs that are welded to the shaft were to have a milled in radius for better fitment for being welded to the shaft. Upon trying to mill the radius it was observed that it was going to take too much time to mill the radius. To fix this issue an angle of 41˚ was selected to side mill in to the part for the weld fit up. The 41˚ was found using SolidWorks because side of the tab needed to have the same spacing to filling in with weld. This fix shaft manufacturing time by an estimated 2 hours.

Related to this issue was the tabs that were tig welded to the shaft. After welding the tabs to the shaft one of the tabs warped over to one side causing it to become out of tolerance. Currently this issue is being addressed; a solution hasn't been found yet.

Discussion of assembly

The assembly of the shellfish is rather simple once all the parts have been manufactured. The side of the machine will need the flange mounted bearing fastened first then the shaft and be installed through the bearings. Next the two cross members will need to fastened to the sides of the machine. Once the sides and the cross members are fastened together the frame will stand freely. After the machine is free standing mount the AC gear motor to the mounting plate and fasten in loosely to be moved up and down. Attach the driving pulley to the motor using key and set screw and the driving pulley to the shaft. Side the motor to its highest position and slip the belt between the two pulleys. Hold the motor down and fasten the mounting bolts tightly so the motor can't slide up. Lastly install the slipping board on to the tab that are welded to the shaft. The exploded view drawing will labeled parts shows how the machine will be assembled, B-25.

Manufacturing Process

The manufacturing process began with cutting all the material for the project. It seems best to cut all the material on the horizontal band saw before the machine shop became busy with other students trying to use it. After all the material was cut the construction of the frame began. First, the top tube had the necessary holes drilled into them and the radius cut into the tops. Next all the parts were cleaned and prepared for welding.

A welding fixture was made using a welding table where pieces of angle iron were welded to the table and c-clamps were then used to clamp the tubing to the angle iron. The picture below shows how the fixture looked. Once all the tubes were in place the frame was tack welded together on one side then flipped over, tacked, and then welded out completely. This process was repeated for the second side of the frame.

Figure 3: Welding Fixture

Figure 4: Lower Cross-member

After the side were complete the cross members began. The mounting bracket for the upper cross member were plasma cut and the lower mounting brackets were machined. Each cross member was tack welded together and c-clamped onto the sides so the bolt wholes could be transfer punched. Figure 4 show how this processes looked for the lower cross member.

The next phase was machining the shaft for the drive train. The first step was facing and chamfering the each end of the shaft then milling the keyway could began. Milling the keyway required a vice to be dialed in on the machining and changing the vice jaws so that it was clamp the shaft tightly. After clamping the shaft, a 3/16 end mill was used to cut in the keyway. Figure 5 shows the keyway being machined.

Figure 5: Key way being cut

After the shaft was finished being machined, the shaft mounting tabs were machined using a milling machine. There were three tabs that needed to be made, the tabs were face on one side then faced to an overall length of 2 inches. Next an angle of 41˚ was side milled for better fitment for welding. After milling in the angle the holes were laid out using blue dye and center drill and then drilled. Following the holes was threading the holes to the 10-32 threads that drawing called out. After completing the tabs, the shaft and tabs were welded together. The figure below shows how the welded turned out on the shaft.

Figure 6: Welded Shaft Assembly

After completing the shaft, the motor mounting plate was plasma cut and then tact welding into place for a mockup of the drive train. After bolting on the shaft, pulleys, bearing and motor everything fit like it was designed to. All the parts were removed and then the motor mounting plate was welding into place. Figure 7 shows the mockup of the drivetrain. The picture show how the drivetrain will look without the belt cover installed.

After mocking up the machine, the electrical wiring had to begin. There was issue trying to locate a good spot to mount the electrical box. After about 2 or 3 hours of trying to find a good location it was realized that the electrical box could be mounted directly to the motor by using a piece of treaded pipe. By mounting the electrical box in this location it saved time and money because there was no needed for additional fasteners and a bracket didn't need to be made. Figure 8 shows the before and after of mocking up the electrical box compared to the final painted electrical box with the proper fitting for connecting the wires.

Figure 7: Drivetrain Assembly Mockup

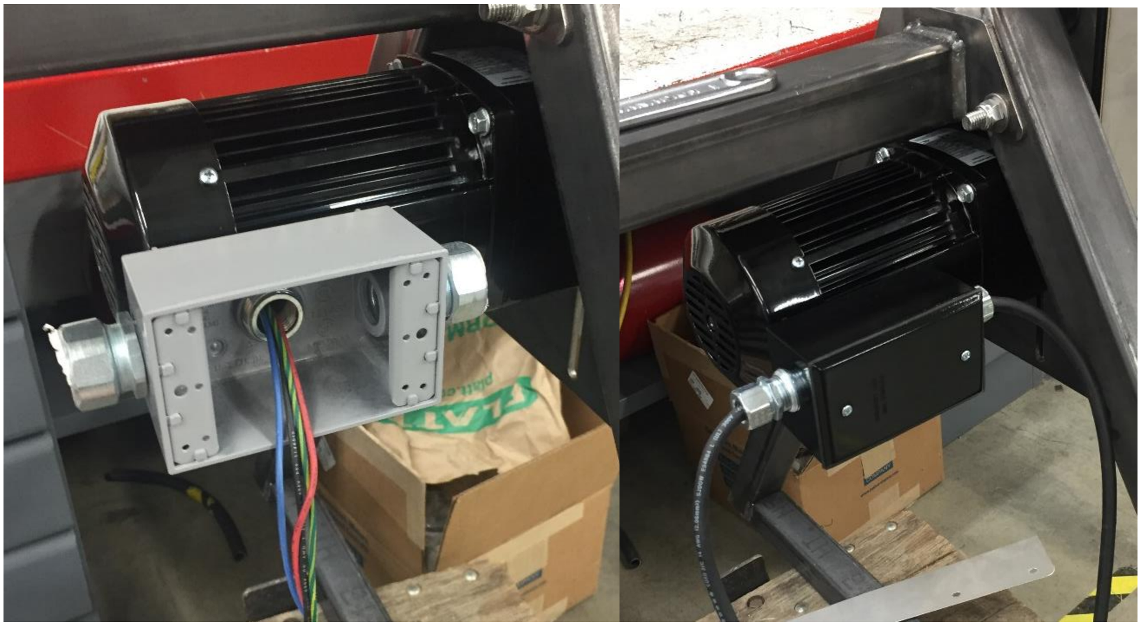


Figure 8: Electrical Box before and after

After completing the wiring the machine was tested and worked smoothly on the first try. The last item that needed to done to the machine was cap the open ends of the tubing. Using a tig welder and 14 Ga sheet metal, caps were cut and welded to the frame. After welding the caps on, the welds needed to be ground off for a smooth finish. Figure 9 shows the finished machine before being disassembled for painting.

Figure 9: Finished machine before paint

Figure 10: Primed frame parts

After the final mockup of the machine it was disassembled and has since been primed and has had one coat of hunter green sprayed on it. After coating the machine with one coat of paint there was issues with the paint. It was sprayed on too heavy causing runs in a few spots. This issue was fixed by taking lighter coats about 1-2 minutes apart. The machine will have an additional second coat of paint but before that can happen the frame needed to be sanded lightly. The machine had a second coat of paint and the manufacturing of the machine was deemed complete. Below is a image of the finished machine.

Figure 11: Finished Machine

Testing Report/Methods

The testing report of the Shellfish Bag maker can be found in Appendix F. The appendix houses a testing report that discusses anything testing related to the machine. The testing of the Shellfish Bag Maker consisted of using the machine as it was intended. The overall testing concluded that the machine was 2.97 times faster than the current machine being used on the farm. With just a large improvement the machine was deemed a success.

Budget/Schedule/Project Management

Proposed Budget

The customer has set the budget for the production of the shellfish bag maker at $1500 for construction materials.

Discuss part suppliers, substantive costs and sequence or buying issues

For the ease of designing, many of the components were taken from McMaster-Car. The component taken from McMaster-Car that were used to perform calculation will be order from them. The nuts, washers, and bolts will be bought locally through Fastenal or Tacoma Screw. The raw material that will be used to construct the frame are going to order through Haskin Steel.

For substantive costs, the Shellfish Bag Maker is powered by a 1/4 HP AC gear motor costing $449.08. The cost high due to the fact that the motor is a gear motor.

Determine labor or outsourcing rates & estimate costs

Nothing will need to be outsourced in the production of the Shellfish Bag Maker because the builder of the machine made sure he had the necessary skills to do work in order to build the machine.

Labor

Based off the predicted hours from the schedule in the budgeting section, the shellfish bag maker project will take 193 hours. With an hourly rate of $25 the total project will cost $4825.00 in labor.

Estimate total project cost

The estimated total cost for the project is listed below in the bill of materials in appendix D-1. The total cost is estimated at $1,292.77for all the materials to build the machine.

Funding source

The entire project is being funding by the owner of Babare Brothers Shellfish Farms.

Proposed schedule

The proposed schedule can be found in appendix E-1. The schedule is broken into eight months October – June. Each months has four boxes that represent a week for each given month. A diamond symbol was used to designate when the following section is going to be completed by.

On the schedule January to March in when the construction of the shellfish bag maker will occur. The most time consuming part to build will be the side of the machine. The sides will be built first before the welding lab gets too busy with other senior projects. On the schedule the side assemblies must be finished by the end of the third week in January. The other welded assemblies can be done when the welding lab is busy because there much smaller than the sides of the machine. The sides will take up the other 4x8 welding table this is why they must be completed first.

The estimated construction time is 45.00 hours for all parts of the machine. The machine is schedule to be finished being built by the first week in March, to ensure time to fine tune the machine for the deadline the Wednesday before finals week. The build schedule is rather tight by having 2-3 components built each week. With the number of welding projects is best to get much of the big welding jobs out of the way and focus as the smaller.

The month of April is when the testing will occur for the machine. The test pre materials will be finished the first week of April. Follow the next week the test plan is due. The testing will begin the third week of April and follow into the fourth week in case adjustments need to be made to the machine during testing.

The month of May will be when the deliverable for the final project will be prepared. The Presentation, and website are the most important item that need to get done. Both these items are to be finished by the second week of May. The final project flash drive is to be completed by the last week of May.

Overall the entire project is estimated at 193.00 hours from beginning the proposal to turning in the final flash drive.

Project Management

Human Resources

Drew Babare: Owner of Babare Brothers Shellfish Farms

Roger Beardsley: Professor

Ted Bramble: CWU Professor

Matt Burvee: CWU Lab Technician

Darryl Fuhrman: CWU Professor

Dr. Craig Johnson: CWU Professor

Charles Pringle: CWU Professor

Physical Resources: Machines, Processes, etc.

The physical resources that will be utilized are the welding/power technology lab for the welding and sheet metal equipment. The CWU machine shop's for machining and the tools for taping, drilling, and grinding.

Soft Resources: Software, Web support, etc.

SolidWorks software was predominately used in the designing and documenting process of making the Shellfish Spooler. The software offered good estimating capabilities for weight, center of mass, and size. Microsoft Word and Excel were used to make spread sheets and documents for all aspects for this project.

Financial Resources: Sponsors, Grants, Donations

The owner of Babare Brothers Shellfish Farms is fully funding this project.

Discussion

Design Evolution

From the beginning of the quarter it was known the project would take many hours. At the beginning the machine was going to involve a wooden frame like the one currently being used at the shellfish farm. Realizing the machine needed to be disassembled and reassembled it would be better to use a metal frame. Steel was picked over aluminum for cost reasons and weldability. The builder had more experience in welding steel than aluminum. With the steel frame the design was rather simple two side shaped similar to an upside down Y and two upper and lower cross members holding the side together. The upper and lower cross member design change after consulting with lab technician Matt Burvee the new design used steel brackets welded to cross members rather than using a cross member with a welded cap and threaded holes. The change in design meant using steel brackets will drilled hole for fasteners to bolt thought with a nut. The design change made making the components much more simple and saving time to build them.

With the frame all sorted out the next obstacle was determining the size the motor needed to be. Using a fish scale it took between 2.5 – 7.5 pounds to get the raw material off the spool it came on. Using statics and a design factor of 1.33 it took 135 lb.-in of torque to remove the material from the spool. Wanting the new machine to rotate at 60 RPM the required horsepower was calculated to be 0.128. A motor needed to be selected that had more or equal to the output of 60 RPM's needed to transfer the torque. A Bodine AC electric gear motor with ¼ HP supplying 162 lb.-in of torque was select to power the machine. With the electric motor have a nameplate RPM of 85 a pulley reduction was design to bring the speed down to 59.65 RPM the closest to 60RPM it could be. The sizing of the motor was most stressful part of the design process because the cost of the motor was over 1/3 of the entire budget to build the machine.

The electric motor was powering a 49" long shaft that was going to be originally supported by brass brushing. After realizing that the brass bushing wouldn't be able to withstand the load a flange mounting bearing was select instead. The flange mounted bearing will save time in production because two less parts would have to house the brash bushings. The selected bearing provided a level of safety by having two set screws that would prevent the shaft from sliding back and forth if the belt failed. The flange bearing required a 7/16 bolt for mounting. For the ease of disassembly and reassembly all the frame bolts were changed to 7/16-14. The change would require the users to need fewer tool when working on the machine.

Overall the design evaluation didn't change much from the first concept. Many parts were changed so that they could be bought rather than made. By buying as many parts as possible it allows the owner to have a part number for replacing parts rather than paying someone to make them.

Project Risk analysis

The risk analysis for this machine is relatively low. The machine features a belt cover to prevent the user from becoming entangled and if the belt breaks it won't fly off and hurt someone. Statics analysis was used to determine the force it would take to tip the machine over. If the motor locked up the maximum force it would feel at the edge of the spinning board is 12lb. the force it would take to tip the machine over at that point is 59lb. This ensures that if the machine ever locked up it wouldn't pull its self over.

A safety factor of 1.5 was used when sizing for the weld size on the frame. After preforming the necessary calculations the weld size was 0.005”. For this reason any single pass weld will be greater than 0.005” providing enough strength in the frame.

When the operator is running the machine he or she will be about ten feet away. The machine is run off of a foot pedal switch. By keeping the operator away it gives them safety from the spinning board that is rotating at 60 RPM.

Successful

Based off the calculations and SolidWorks modeling the Shellfish Bag Maker should be successful. All the necessary calculations were double checked by Professor to ensure they were done properly. The modeling shows that in a perfect world all the hole and parts fit and align correctly.

Next phase

The next phase will be the building phase. From the schedule in appendix E-1, the building stage will begin in January and end in March. By last Wednesday of winter quarter there will be a working machine.

Conclusion

For the Shellfish Bag Maker there is no doubt that the machine will be built and work in the scheduled time frame. Based off the analysis of the drive train the machine is estimated to be 14% more efficient than the current machine being used on the shellfish farm. The calculations ensure that the machines drive train can handle the torque needed to get the job done taking the raw material off the spool it arrived on. The cutting process will be modernized but using a mini circular saw rather than a serrated knife. The change in cutting practices will save time and be safer than using a 12in knife. Many hours have been spent on the analysis of the project exploring different ways to improve the design to make it faster than before. There is no doubt that the new design will work better and be faster that the current machine being used.

Acknowledgements:

Acknowledgement of appreciation go out to the following people that help and contributed to this project.

- Drew Babare, for his financial backing and support throughout the project.
- Roger Beardsley, for brainstorming ideas and check math calculations.
- Matt Burvee, for helping with finding the best parts to be used and brainstorming better designs.
- Dr. Craig Johnson, for helping with material section and ideas.
- Charles Pringle, for helping understand concept that haven’t been taught yet and check math calculations.

References:

Mott, Robert L. Machine Elements in Mechanical Design. 5th ed. Upper Saddle River, N.J.:

Pearson/Prentice Hall, 2014. Print

Appendix A – Analyses

Trevor Reher | MET 495A | 10-16-2015

Given: Current machince RPM = 52.6, Customer wants 10% faster
Find: New RPM of RPM
Solution

$$52.6 \text{ RPM}(1.10) = 57.9$$

Closest whole number RPM = 58

- round the out put RPM to an even 60 RPM
- with 60 RPM the machine will spool 1 Bag/Second.

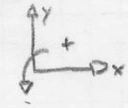
The New out put RPM of 60 will provide an increase in efficenty of 14%

$$\frac{60 \text{ RPM}}{52.6 \text{ RPM}} - 1 = .140 = 14\%$$

A-1: Hand Calculation increase in efficiently

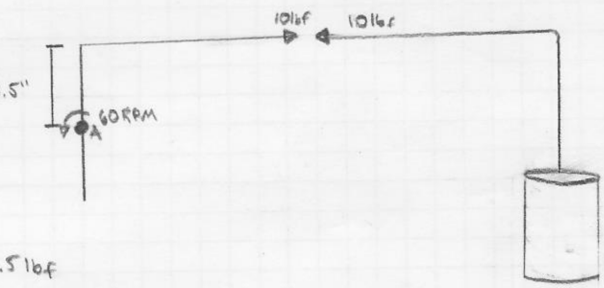
Trevor Reher | MET 495 A | 10-15-2015

Given: Force Range of 2.5 - 7.5 lbf Coming from spool
moment of 13.5 in.



Find: Hp Need for motor

Solution:



- Spool force = 2.5 - 7.5 lbf
- using a Design safety factor of 1.33
- upper limit force = $(7.5\,lb_f)(1.33) = 9.97 \approx \underline{10\,lb_f}$

$\circlearrowleft \Sigma M_A = 0$; $(-10\,lb_f)(13.5\,in) + T_A = 0$

$T_A = 135\,in\text{-}lb_f = 11.25\,ft\text{-}lb_f$ $\qquad 1\,hp = 550\,ft \cdot lb/s$

$\text{Torque} = \dfrac{\text{Power}}{\text{Rotational Speed}}$ $\qquad$ 9-7 pg 321 Mott

$11.25\,ft\text{-}lb = \dfrac{P}{60\,RPM}$

$\left(60\,\frac{Rev}{Min}\right)(11.25\,ft \cdot lb)\left(\frac{1\,Min}{60\,sec}\right)\left(\frac{2\pi\,rad}{1\,Rev}\right) = P$

$70.69\,ft \cdot lb/s = P$

Convert to hp $\quad 70.67\,ft \cdot lb/s \left(\dfrac{1\,hp}{550\,ft \cdot lb/s}\right) = 0.128\,hp$

Motor size = 0.128 hp Minimum

A-2: Hand Calculations for electric motor HP.

Trevor Rener | Senior Project | 11/15/2015 | 1/2

Belt Design

Given: 85 RPM input, Center Distance Range: 22.46-24.56" Ideal output of 60 RPM

Find: Belt Design.

$$\text{Ratio} = \frac{\text{input}}{\text{output}} = \frac{85\,RPM}{60\,RPM} = 1.416$$

Reduction Ratio = 1.416

Drive Pulley Size = 4.0" Part # = 6204K25

$$\boxed{D_1 = 4.0''}$$

$$\text{Ratio} = \frac{D_2}{D_1} \Rightarrow D_2 = D_1(\text{Ratio})$$

$$D_2 = (4.0'')(1.416)$$

$$D_2 = 5.66''$$

Closest Actual Size => $\boxed{D_2 = 5.7''}$ Part # 6204K35

Actual output Speed

$$\frac{\text{input RPM}}{\left(\frac{D_2}{D_1}\right)} \Rightarrow \frac{85\,RPM}{\frac{5.7''}{4.0''}} = 59.65\,RPM$$

Actual output = 59.65 RPM

Belt Length Center Distance Range = 22.46" - 24.56"

$$L = 2C + 1.57(D_2 + D_1) + \frac{(D_2 - D_1)^2}{4C}$$

$$L_{min} = 2(22.46'') + 1.57(5.7'' + 4.0'') + \left(\frac{(5.7'' - 4.0'')^2}{4(22.46'')}\right)$$

$$\boxed{L_{min} = 60.15''}$$

$$L_{max} = 2(24.56'') + 1.57(5.7'' + 4.0'') + \frac{(5.7'' - 4.0'')^2}{4(24.56'')}$$

$$\boxed{L_{MAX} = 64.37''}$$

A-3: V belt design 1/2

Trevor Reher | Senior Project | 11/15/2015 | 2/2

To allow Room to Stretching

Belt Length = 61" Part # 6186K161 ;

Actual Center Distance at 51" Belt Length.

$$B = 4L - 6.28(D_2 + D_1)$$

$$B = 4(61") - 6.28(5.7" + 4.0")$$

$$B = 187.08"$$

$$C = \frac{B + \sqrt{B^2 - 32(D_2 - D_1)^2}}{16}$$

$$C = \frac{187.08" + \sqrt{187.08^2 - 32(5.7" - 4.0")^2}}{16}$$

$$C = 23.36'$$

Actual Center Distane = 23.35"

Angle of Wrap

$$\theta_1 = 180 - 2\sin^{-1}\left(\frac{D_2 - D_1}{2C}\right) = 180 - 2\sin^{-1}\left(\frac{5.7" - 4.0"}{2(23.36")}\right)$$

$$\theta_1 = 175.54°$$

$$\theta_2 = 180 + 2\sin^{-1}\left(\frac{D_2 - D_1}{2C}\right) = 180 - 2\sin^{-1}\left(\frac{5.7" - 4.0"}{2(23.36")}\right)$$

$$\theta_2 = 184.45°$$

A-4: V belt design 2/2

Trevor Reher	Senior Project	11/15/2018	1/1

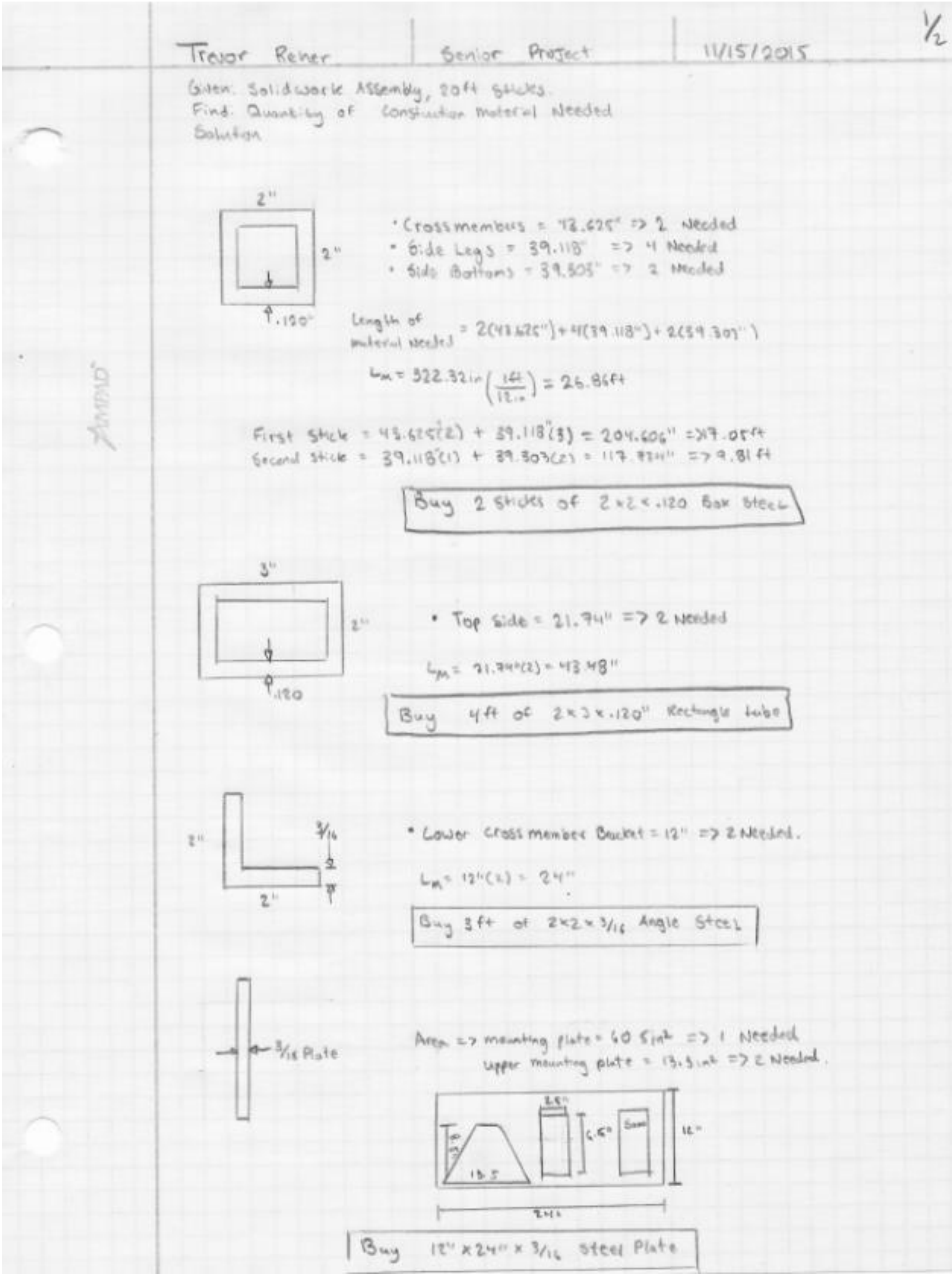
Given: 85RPM, 4.0" pulley
Find: Belt Speed
Solution:

$$\text{Belt Speed} = V_b = \frac{\pi D_1 N_1}{12}$$

$$V_b = \frac{\pi (4.0\,in)(85\,RPM)}{12}$$

$$\boxed{V_b = 89.01\ ft/min}$$

A-5: Belt Speed Calculation



½

Trevor Rener | Senior Project | 11/15/2015

Given: Solidwork Assembly, 20ft sticks.
Find: Quantity of Construction material Needed
Solution

2" × 2", .120"

- Crossmembers = 43.625" => 2 Needed
- Side Legs = 39.118" => 4 Needed
- Side Bottoms = 39.303" => 2 Needed

Length of material needed = 2(43.625") + 4(39.118") + 2(39.303")

$L_m = 322.32\text{in}\left(\frac{1\text{ft}}{12\text{in}}\right) = 26.86\text{ft}$

First Stick = 43.625"(2) + 39.118"(3) = 204.606" => 17.05ft
Second Stick = 39.118"(1) + 39.303"(2) = 117.724" => 9.81 ft

Buy 2 Sticks of 2×2×.120 Box Steel

3" × 2", .120

- Top side = 21.74" => 2 Needed

$L_m = 21.74"(2) = 43.48"$

Buy 4ft of 2×3×.120" Rectangle tube

2" × 2", 3/16

- Lower cross member Bracket = 12" => 2 Needed.

$L_m = 12"(2) = 24"$

Buy 3ft of 2×2×3/16 Angle Steel

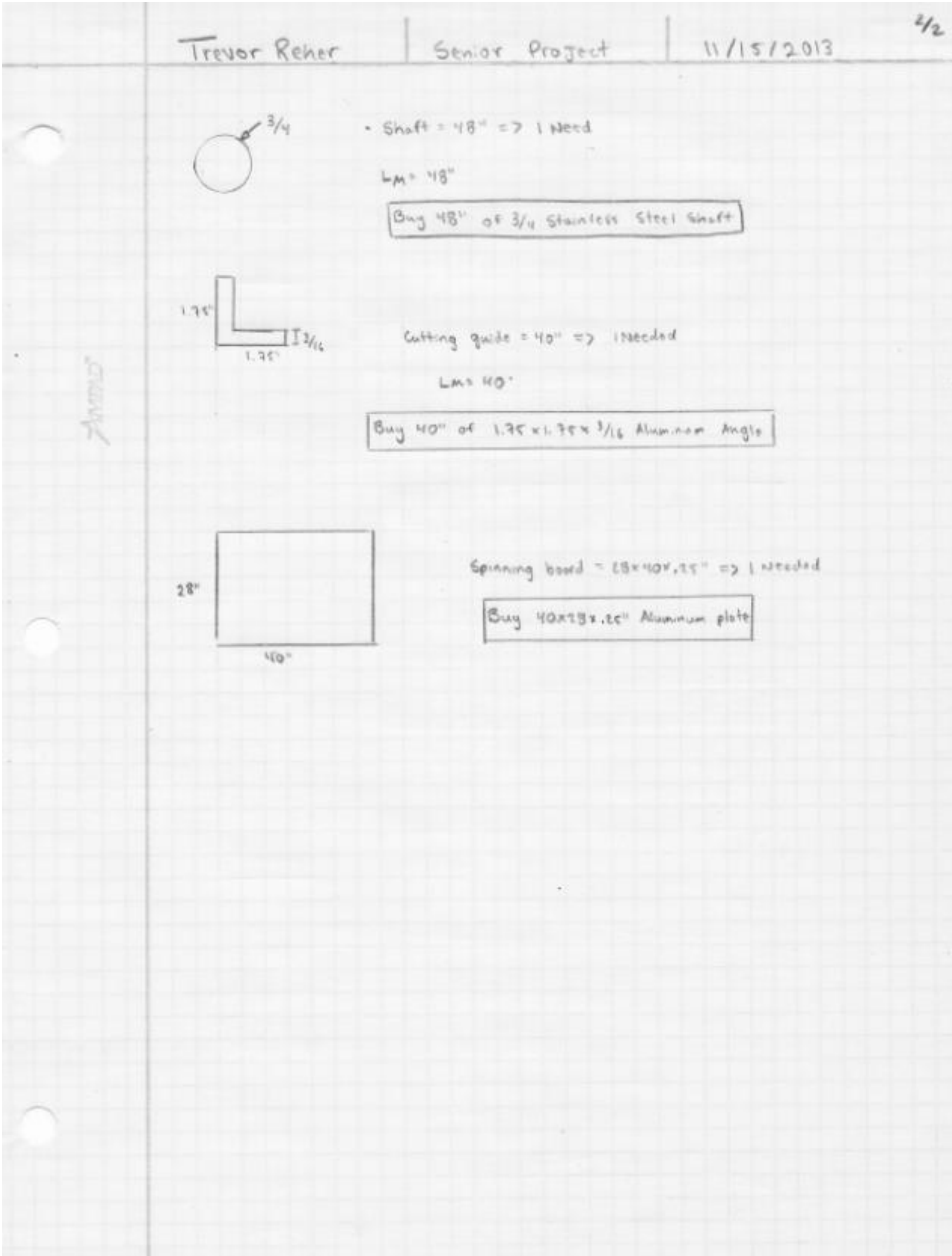
3/16 Plate

Area => mounting plate = 60 in^2 => 1 Needed
upper mounting plate = 13.5 in^2 => 2 Needed.

2.5", 6.5", 13.5, 12", 24"

Buy 12"×24"×3/16 Steel Plate

A-6: Material Length ½



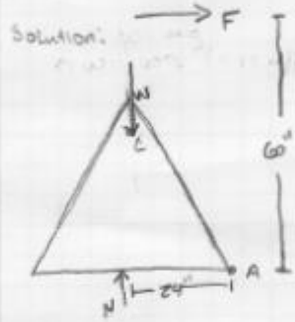
A-7: Material Length 2/2

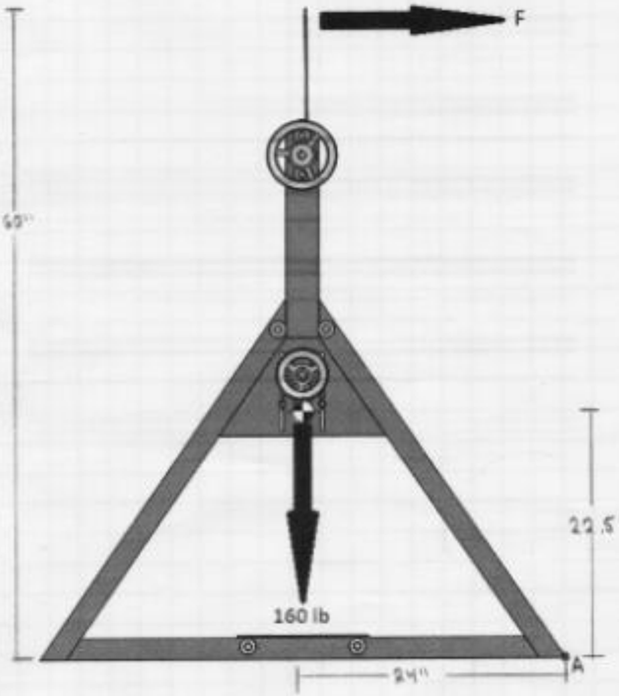
Trevor Reher | Senior project | 11/10/2015

Given: 160lb acting at the Center of Mass.

Find: The force F it would take to over turn the Machine. AT Point A

Solution:

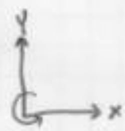




$\Sigma F_x = 0$

$\Sigma F_y = 0$

$\Sigma M_A = 0$



$\Rightarrow \Sigma F_y = -W + F_N = 0 \Rightarrow F_N = W$

$\circlearrowleft \Sigma M_A = W(22") - F(60") = 0 \Rightarrow W(22") = F(60")$

$\Rightarrow F = \dfrac{160\,lb\,(22")}{60"} = 59\,lb$

$\Rightarrow$ IF F > 59 lb, THE MACHINE WILL HAVE A TENDANCY TO ROTATE ABOUT POINT A

A-8: Frame Tipping Force

Given: 162 lb-in of torque, 1.313" Hub length, 3/16 x 3/16 Key Size, 3/4" Shaft,
Find: Minimum length of key
Solution:

Safe factor = 3

Because Machine could possibly near salt water 316 Stainless Steel.

$S_y = 35\ ksi$
$S_u = 85\ ksi$

Compression Because key material is stronger than hub Material.

$\sigma_d = \frac{S_y}{N}$ pg 429

$\sigma_d = \frac{35\ ksi}{3} = 11.66\ ksi$

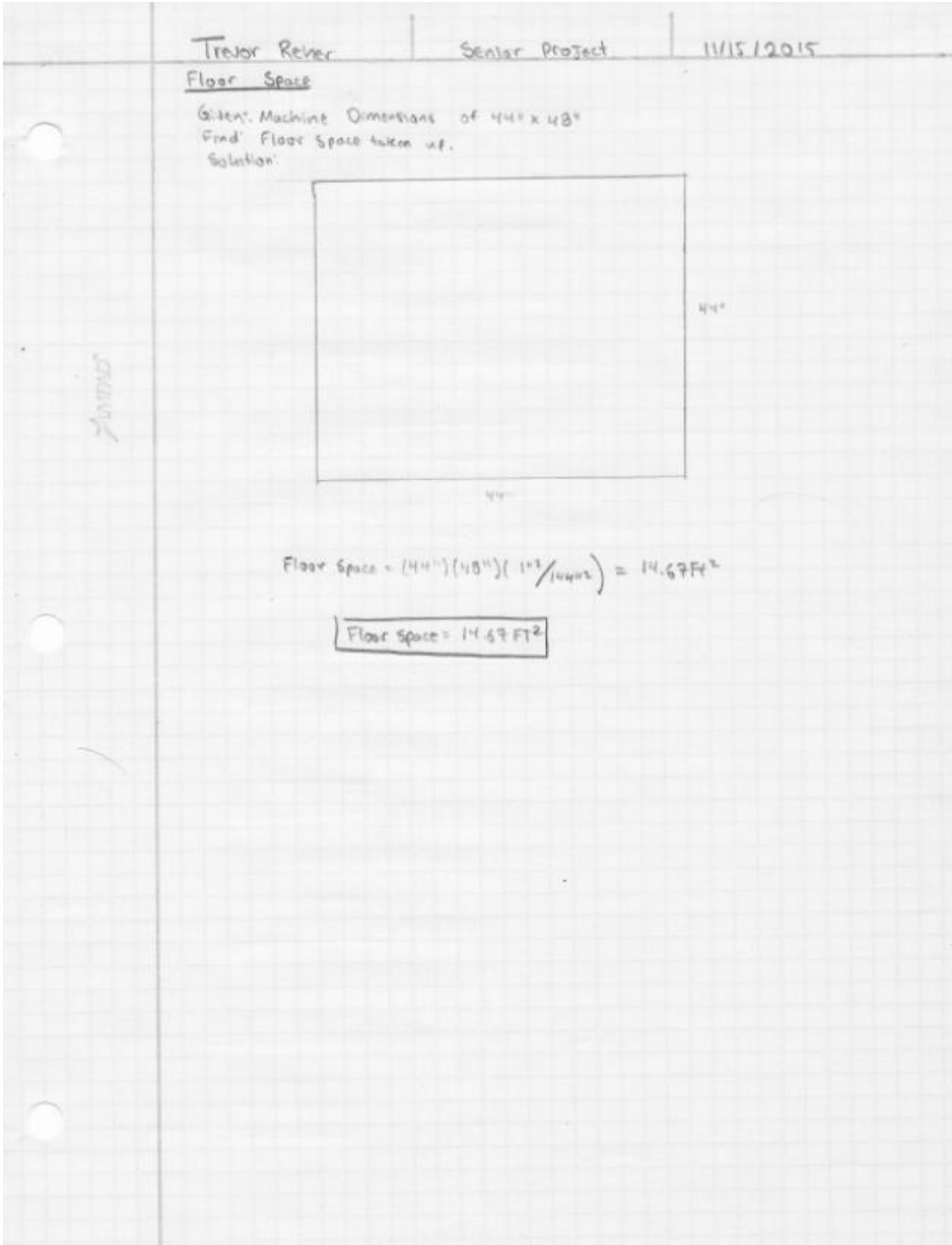
$L_{min} = \frac{4T}{\sigma_d D H}$ Eq. 11-4 pg 429

$L_{min} = \frac{4(162\ lb\text{-}in)}{(11.66\ ksi)(.75)(3/16)}$

$L_{min} = 0.395\ in$ use full hub length.

Key Dimension = 3/16" x 3/16" x 1.313"

A-9: Key Dimensions



Trevor Reher | Senior Project | 11/15/2015

Floor Space

Given: Machine Dimensions of 44" x 48"
Find: Floor Space taken up.
Solution:

$$\text{Floor Space} = (44'')(48'')\left(\frac{1 ft^2}{144 in^2}\right) = 14.67 ft^2$$

Floor Space = $14.67 FT^2$

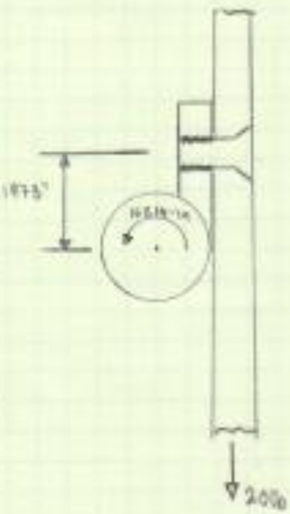
A-10: Floor Space

Trevor Reher | Senior project | 11/21/15 | 1/1

Given: 162 lb-in of torque at Shaft, 20 lb Weight of Aluminum plate, Bolt Diameter of 0.19", # of Bolts = 6
Bolt Material 316 stainless, yield = 30 ksi

Find: will the Diameter of 0.19" will this size Bolt work

Solution:



$\tau = \frac{F}{A}$ • 20 lb is creating a Shear stress

$\tau = \frac{20 lb}{\frac{\pi}{4}(.19 in)^2}$

$\tau = 705.4 psi$ on single Bolt

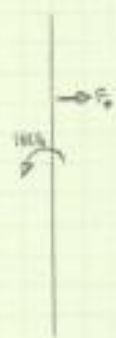
✓ 705.4 psi is less than 30 ksi
Bolt will work in Shear

• 162 lb-in, is creating a normal stress.

$\frac{(162 lb\text{-}in)}{1.1973 in} = 135.3 lb$

The 135.3 lb is acting at the Center of Bolt.

FBD



$\sigma = \frac{F}{A}$

$\sigma = \frac{135.31 lb}{\frac{\pi}{4}(.19)^2}$

$\sigma = 4772 psi$

✓ 4772 psi on Single Bolt

The highest stress on a single Bolt is 4772 psi, Because there is six Bolt this would be 4772 psi divided by 6. 0.19" Diameter Bolts will work.

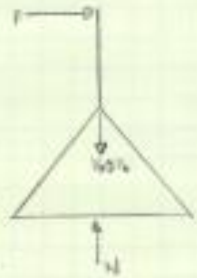
0.19" Diameter will work

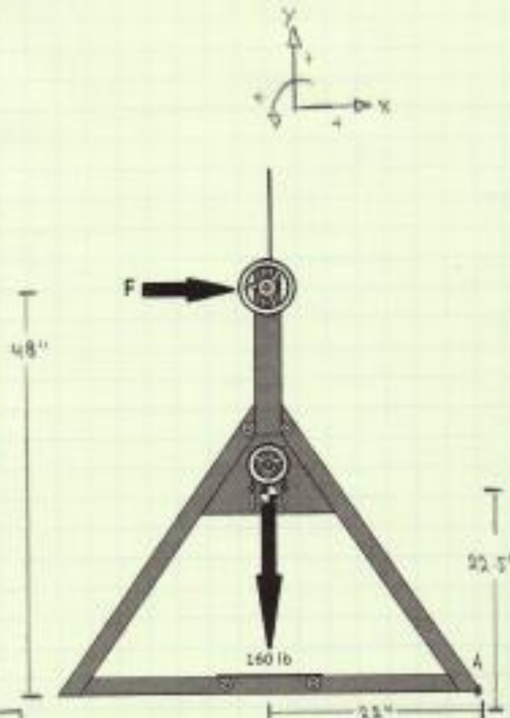
A-11: Spinning Board Bolt Size

Trevor Reher | Senior Project | 11/21/2015 | 1/1

Given: Frame Weight of 160lb with the Following Dimensions.
Find: Force to tip machine at Shaft at Pt. A
Solution:

$\Sigma F_x = 0$
$\Sigma F_y = 0$
$\Sigma M_A = 0$





$\Sigma F_y = -W + F_N = 0 \Rightarrow F_N = W$

$\circlearrowleft + M_A = W(22") - F(48") = 0$

$W(22") = F(48")$

$F = \frac{160lb(22")}{48"}$

$F = 73.3\ lb$

If $F > 73.3$ at the center of the Shaft the machine will tip

A-12: Tipping Force at Shaft

Trevor Reher | Senior project | 11/20/15

Given: Torque of motor = 162 lb-in, SF = 1.5, 3x2x.120" tube
Weld Length of 3.81 in.

Find: Weld Size.

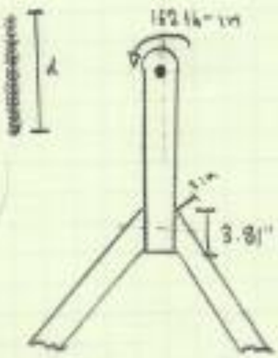
Solution:

Safety factor for torque = 162 lb-in(1.5) = 243 lb-in

Force per inch weld = f

$$f = \frac{Tc}{J_w}$$

$$J_w = \frac{d(b^2 + d^2)}{6}$$



$$f = \frac{243\,lb\text{-}in(3.81in/2)}{\frac{3.81in(3in^2 + 3.81in^2)}{6}}$$

$$f = 31\ lb/in$$

Allow force per inch of leg A-36 => 9600 lb-in

$$\text{Weld size} = \frac{31\,lb/in}{9600\,lb\text{-}in} = .003"$$

Single pass weld

An weld will be bigger than .003"

A-13: Weld Size Frame

Trevor Reher | Senior Project | 11/21/2015 | 1/1

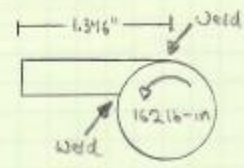
Given: torque of 162 lb-in, weld length of 2"
Find: Weld size
Solution:

$$\frac{162\ \text{lb-in}}{1.346\ \text{in}} = 120.35\ \text{lb}$$

Equation for Vertical Shear

$$f = \frac{V}{A_w} \qquad A_w = 2b$$

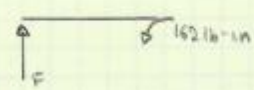
$$f = \frac{120.35}{2(2\ \text{in})} = 30.09\ \text{lb/in}$$



FBD

Allowable Shear Stress 70E Eletrode = 13600 psi

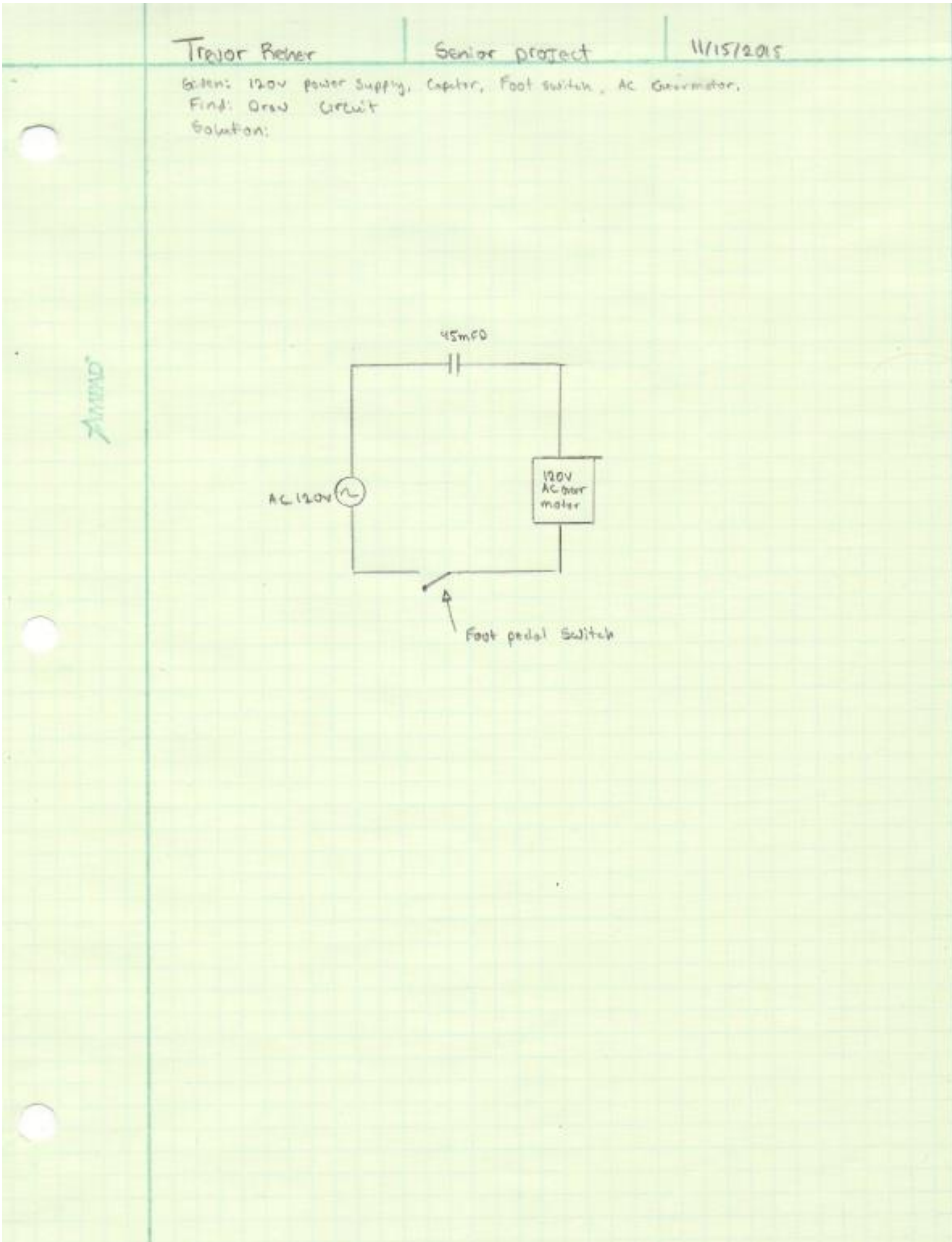
$$\text{Weld size} = \frac{30\ \text{lb/in}}{13600\ \frac{\text{lb}}{\text{in}^2}} = \underline{0.002"}$$



Singe pass weld

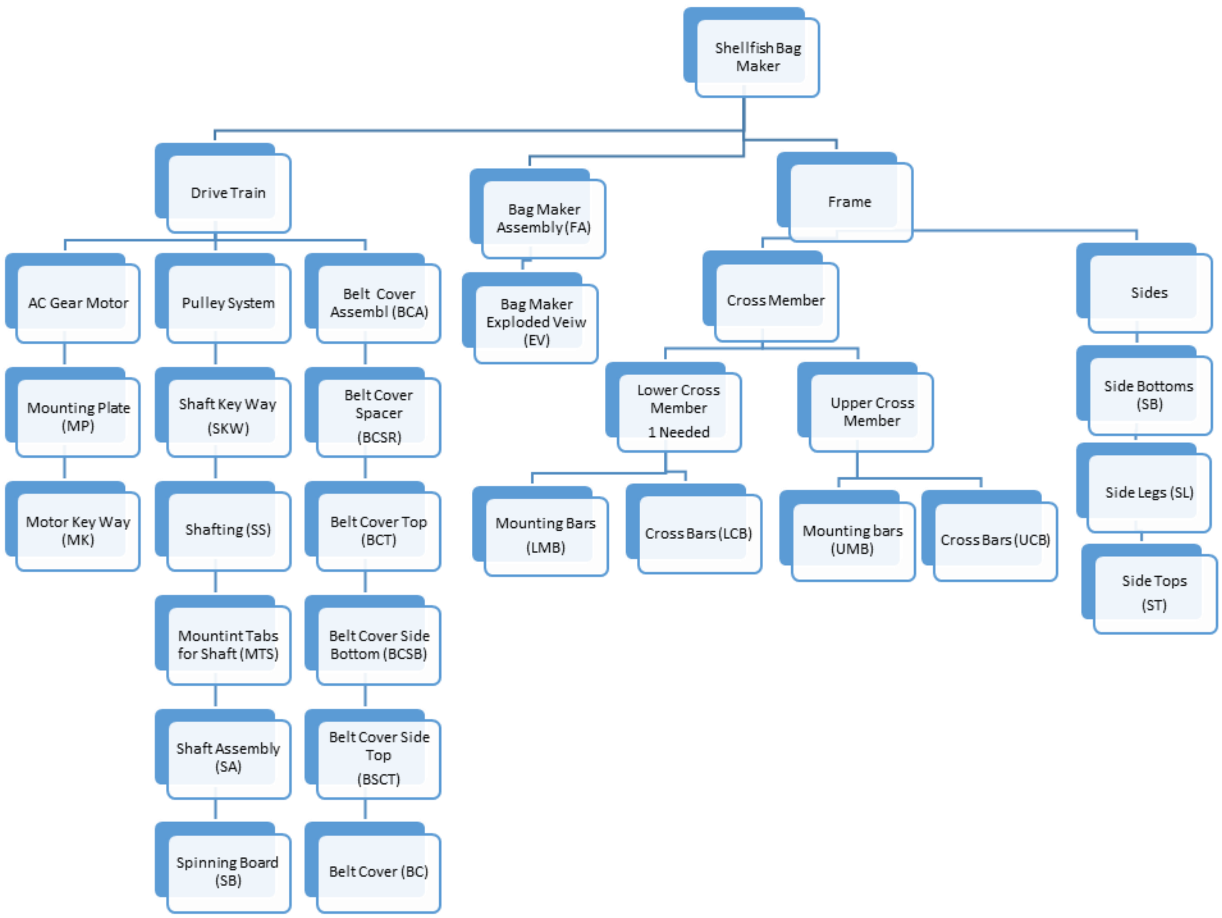
Weld size is so small any weld will be greater than .002"

A-14: Weld Size for Tabs

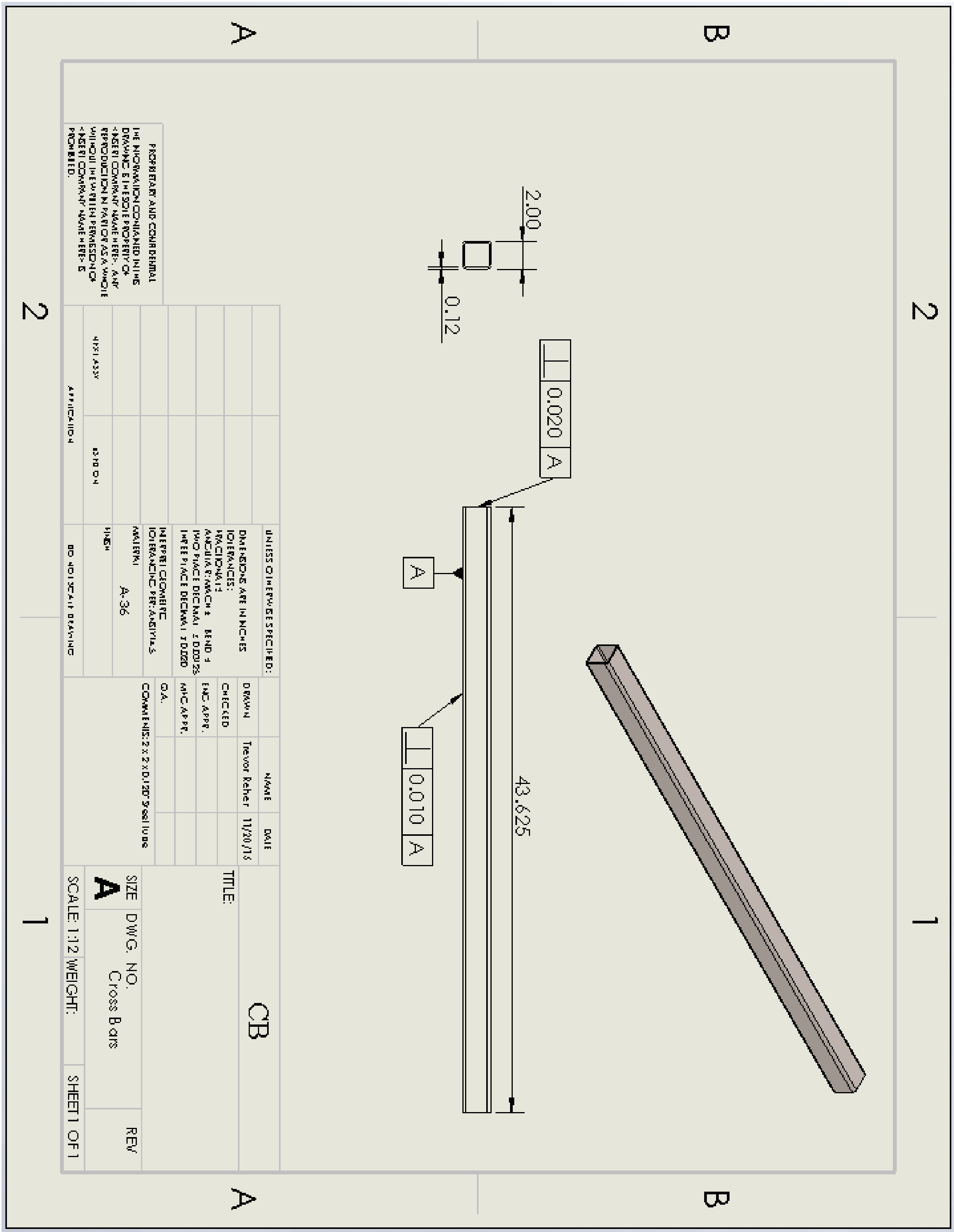


A-15: Circuit Diagram for Machine

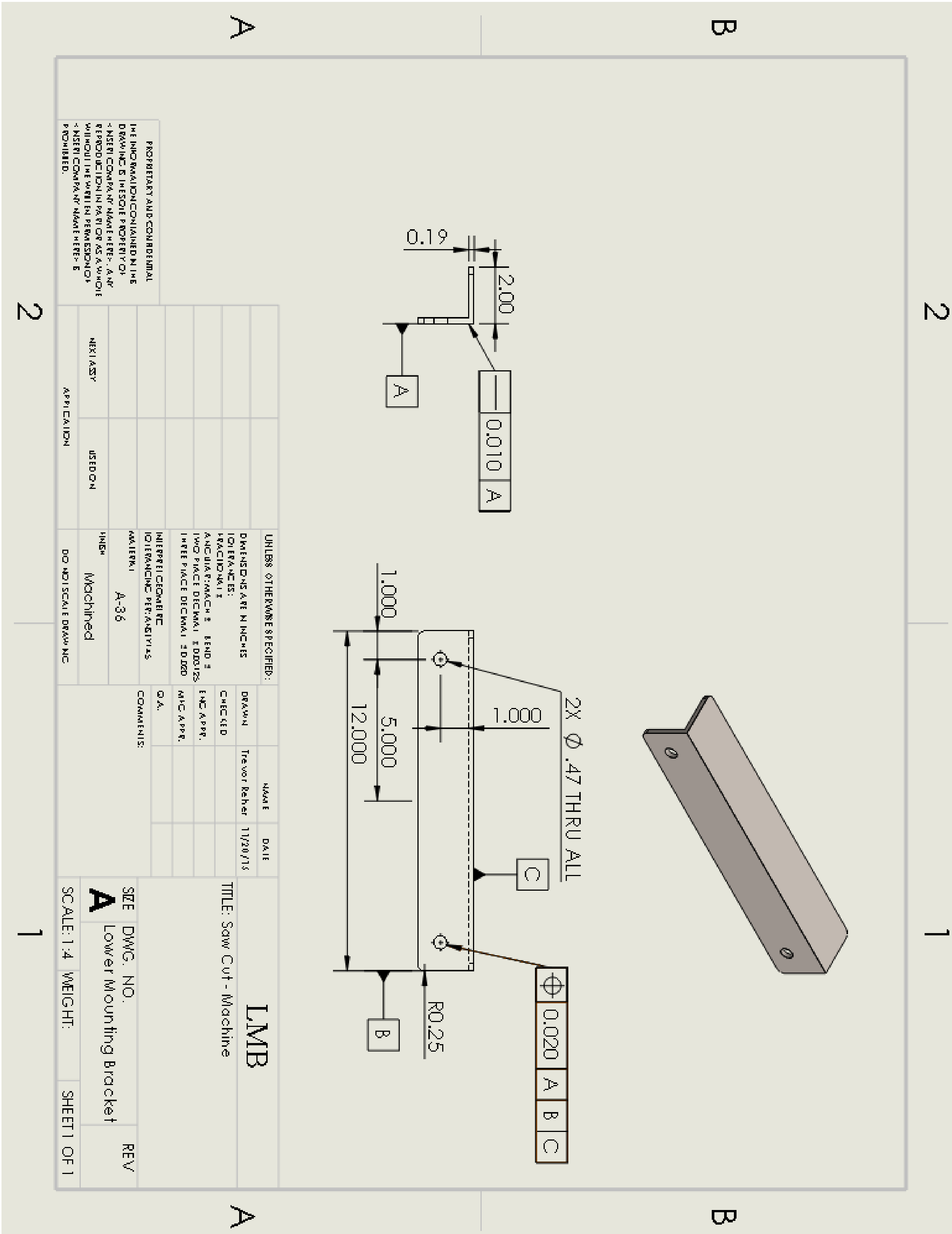
Appendix B – Drawings



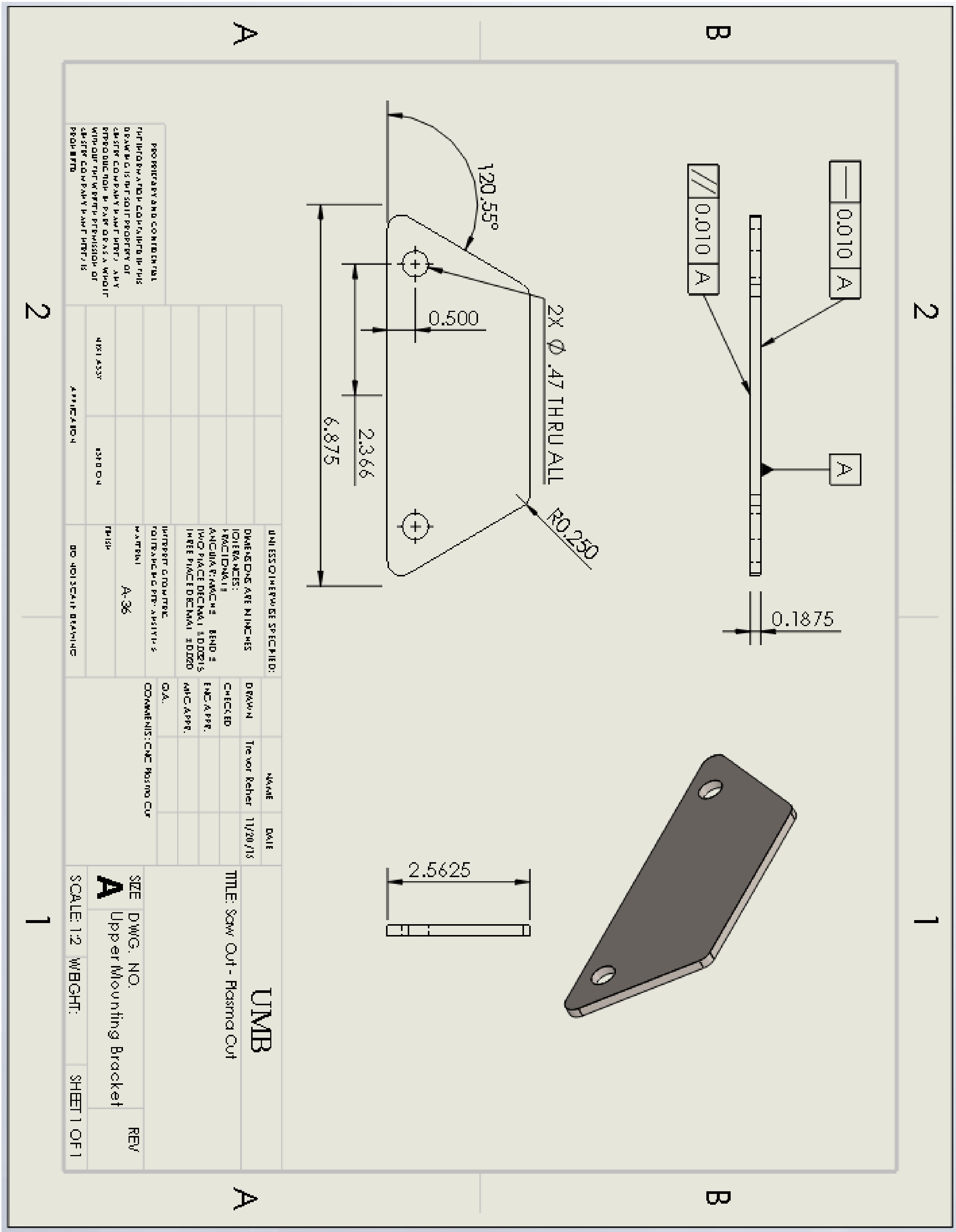
B-1: Drawing Tree



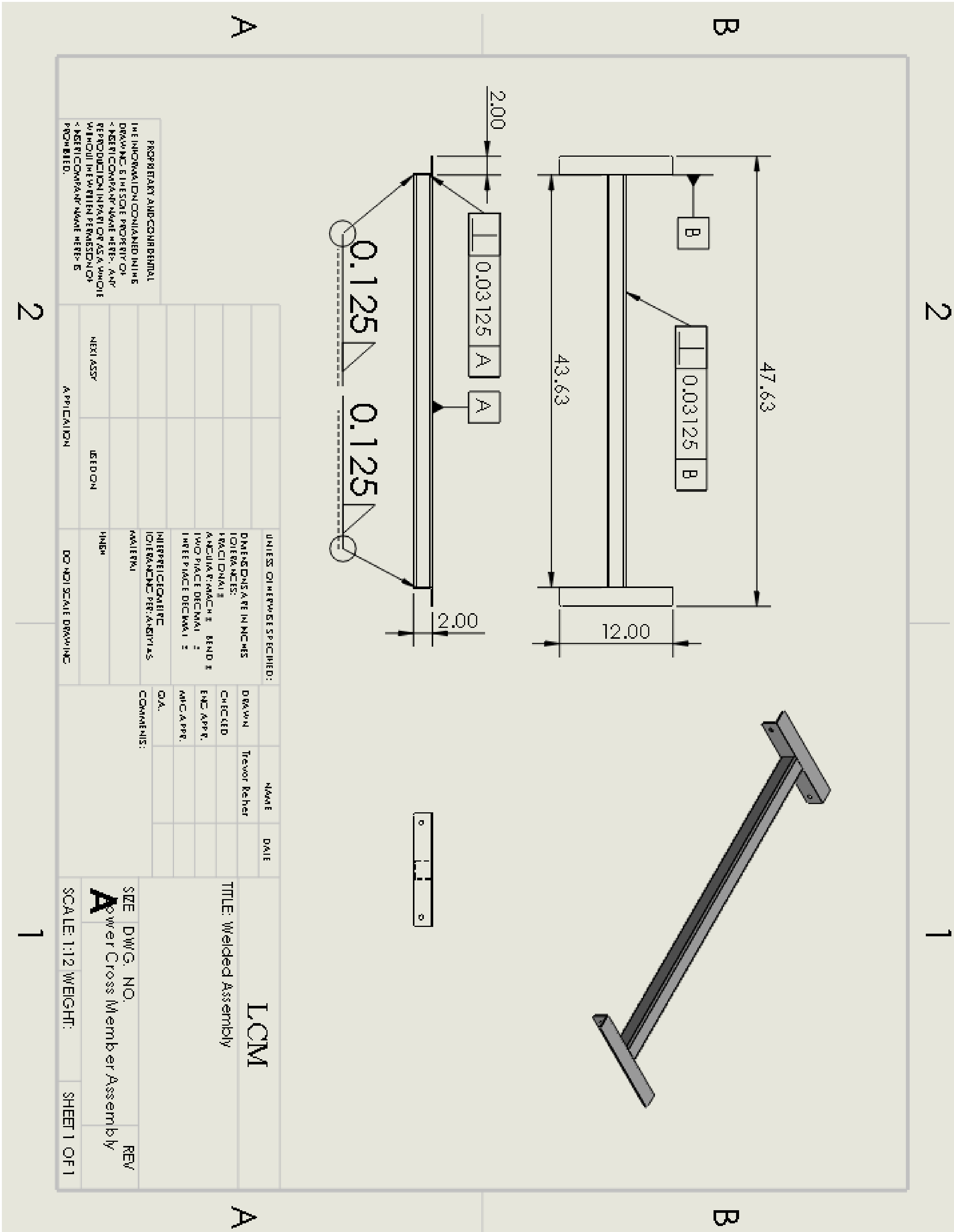
B-2: Cross Bars



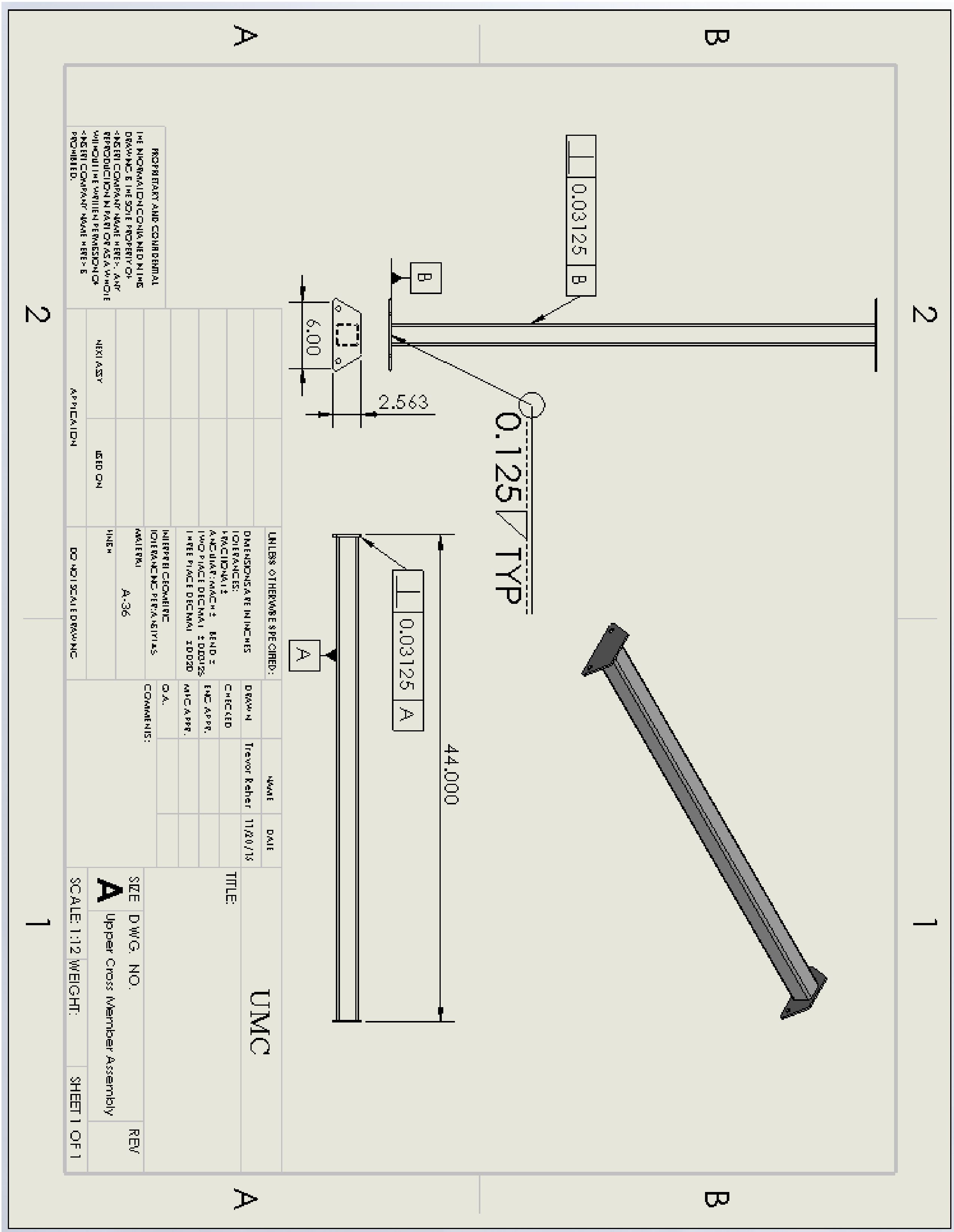
B-3: Lower Mounting Bracket



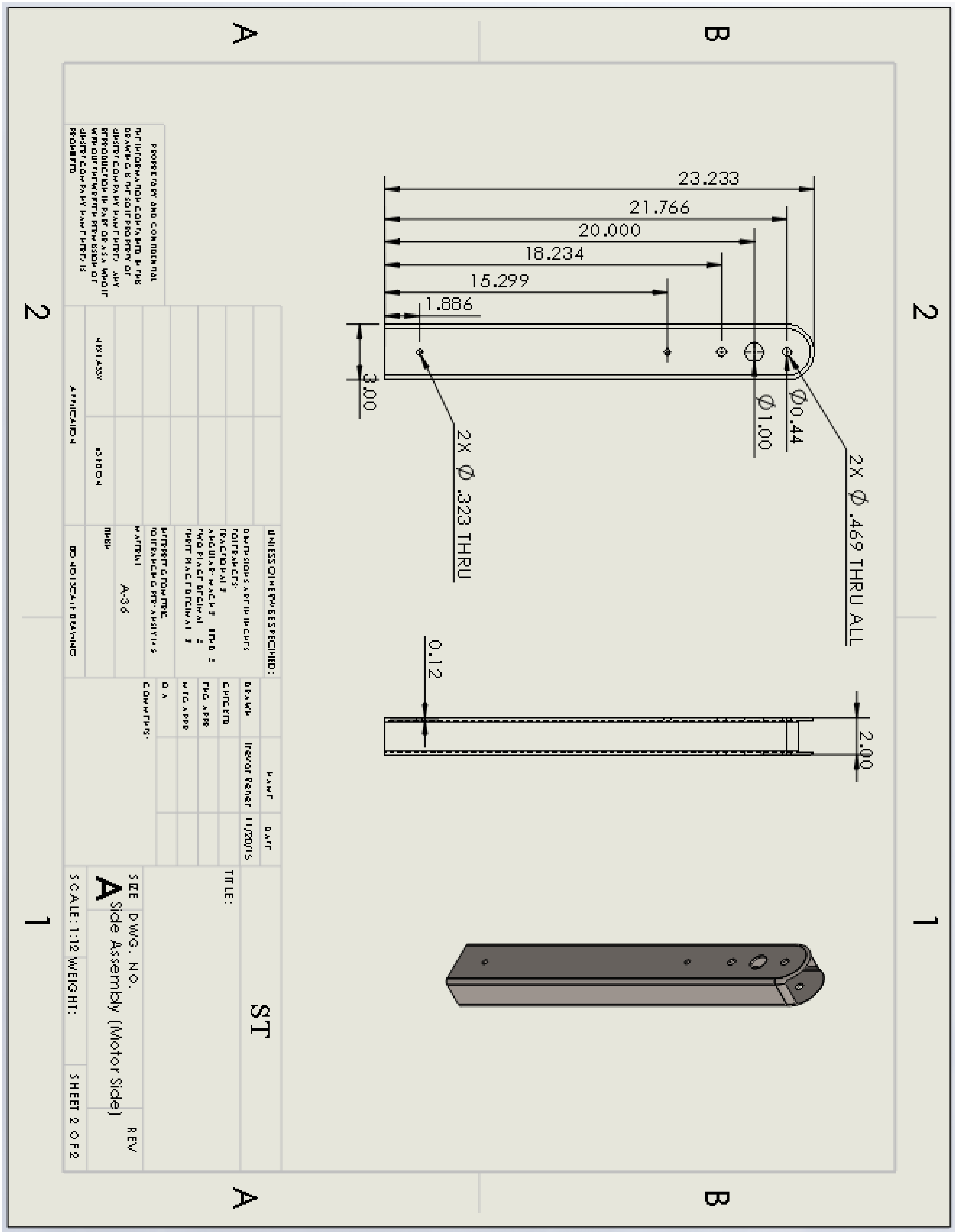
B-4: Upper Mounting Bracket



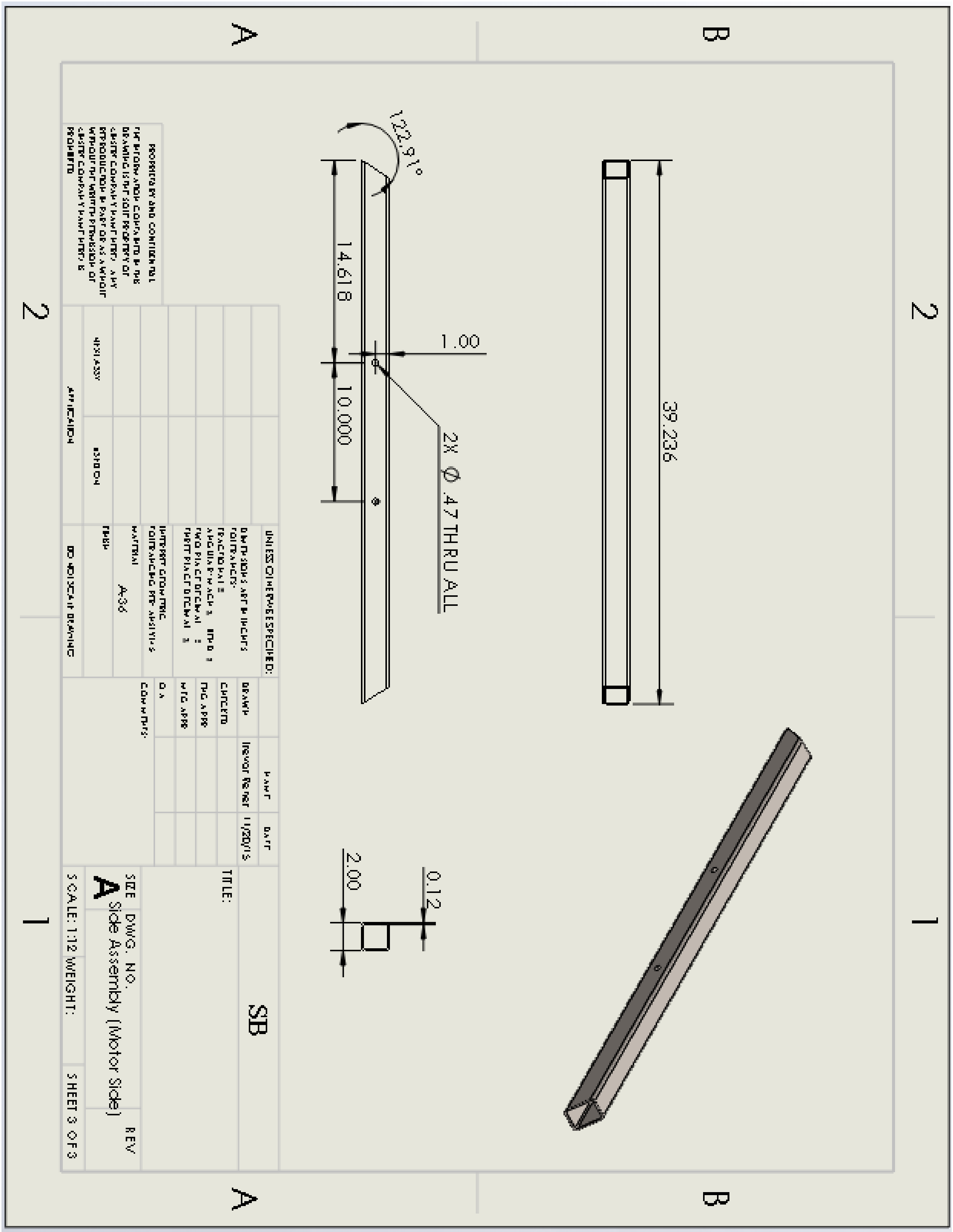
B-5: Upper Lower Bracket Assembly



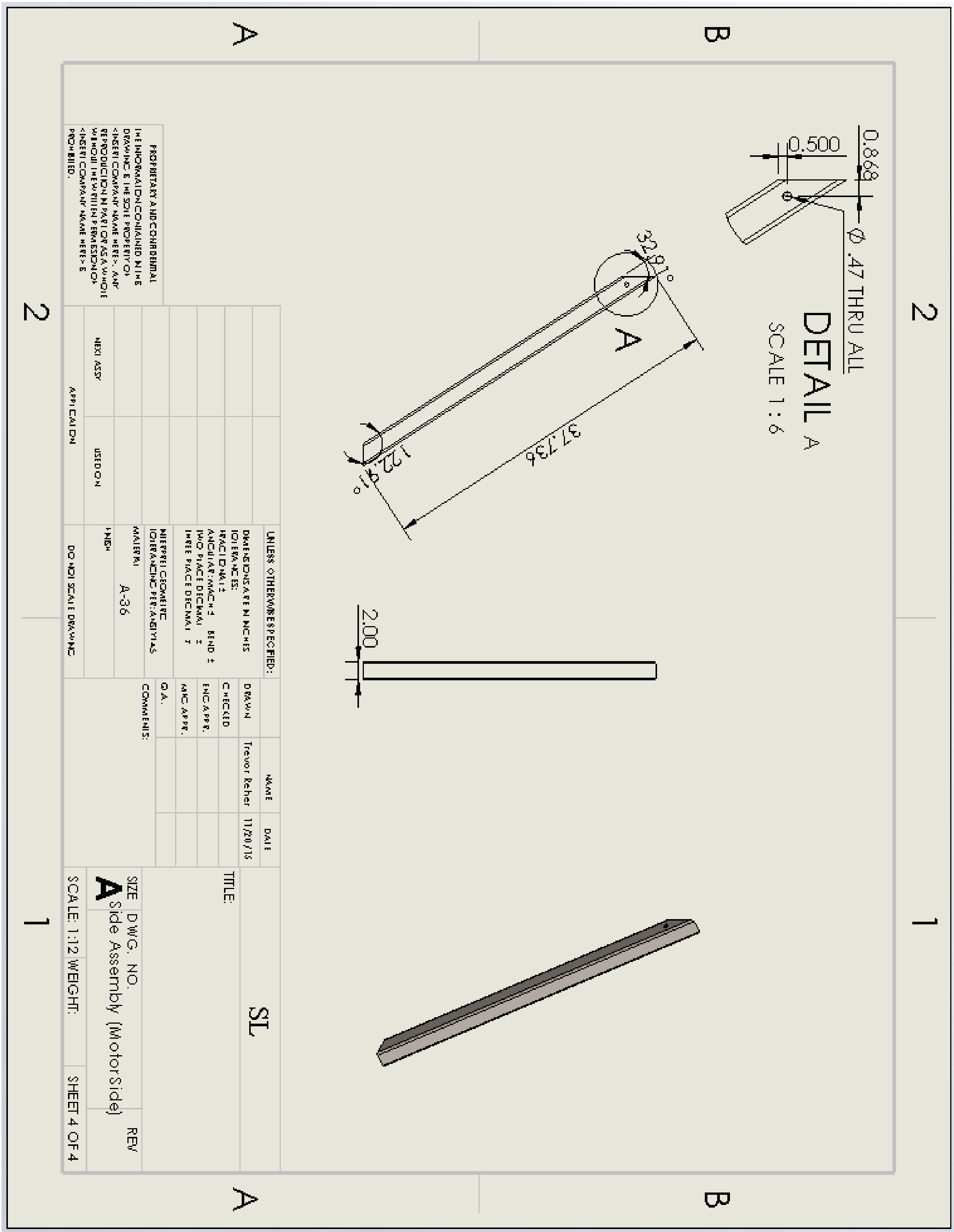
B-6: Upper Mounting Bracket Assembly


23.233
21.766
20.000
18.234
15.299
1.886
3.00
Ø0.44
Ø1.00
2X Ø .323 THRU
2X Ø .469 THRU ALL
0.12
2.00
A-36
ST
Side Assembly (Motor Side)
SCALE: 1:12
SHEET 2 OF 2

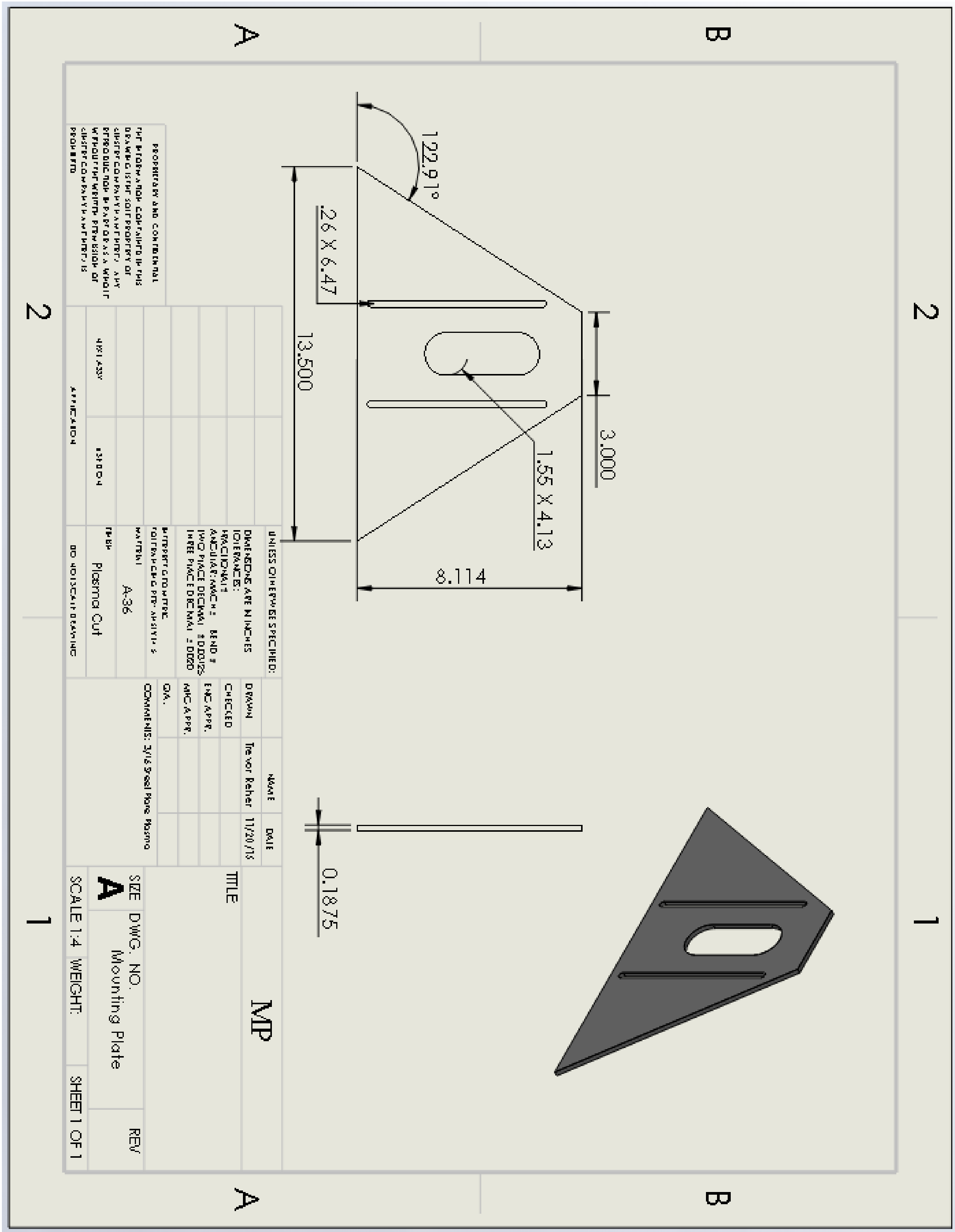
B-7: Side Tops



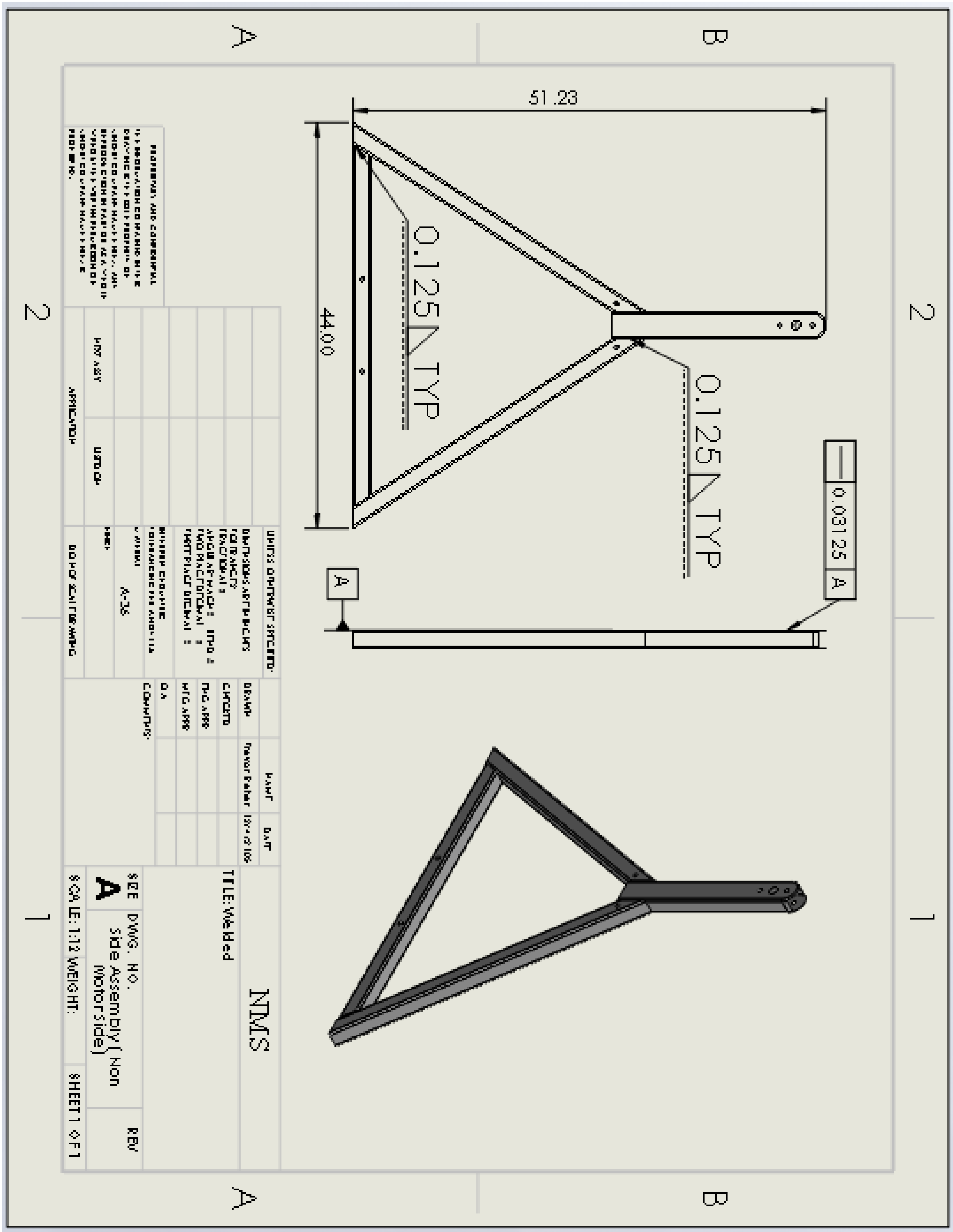
B-8: Side Bottoms


0.868
0.500
Ø .47 THRU ALL
DETAIL A
SCALE 1 : 6
32.91°
A
37.736
122.91°
2.00
UNLESS OTHERWISE SPECIFIED:
DRAWN
Trevor Reher
11/20/15
NAME
DATE
MATERIAL
A-36
TITLE:
SL
SIZE
A
DWG. NO.
Side Assembly (Motor Side)
REV
SCALE: 1:12 WEIGHT:
SHEET 4 OF 4
DO NOT SCALE DRAWING

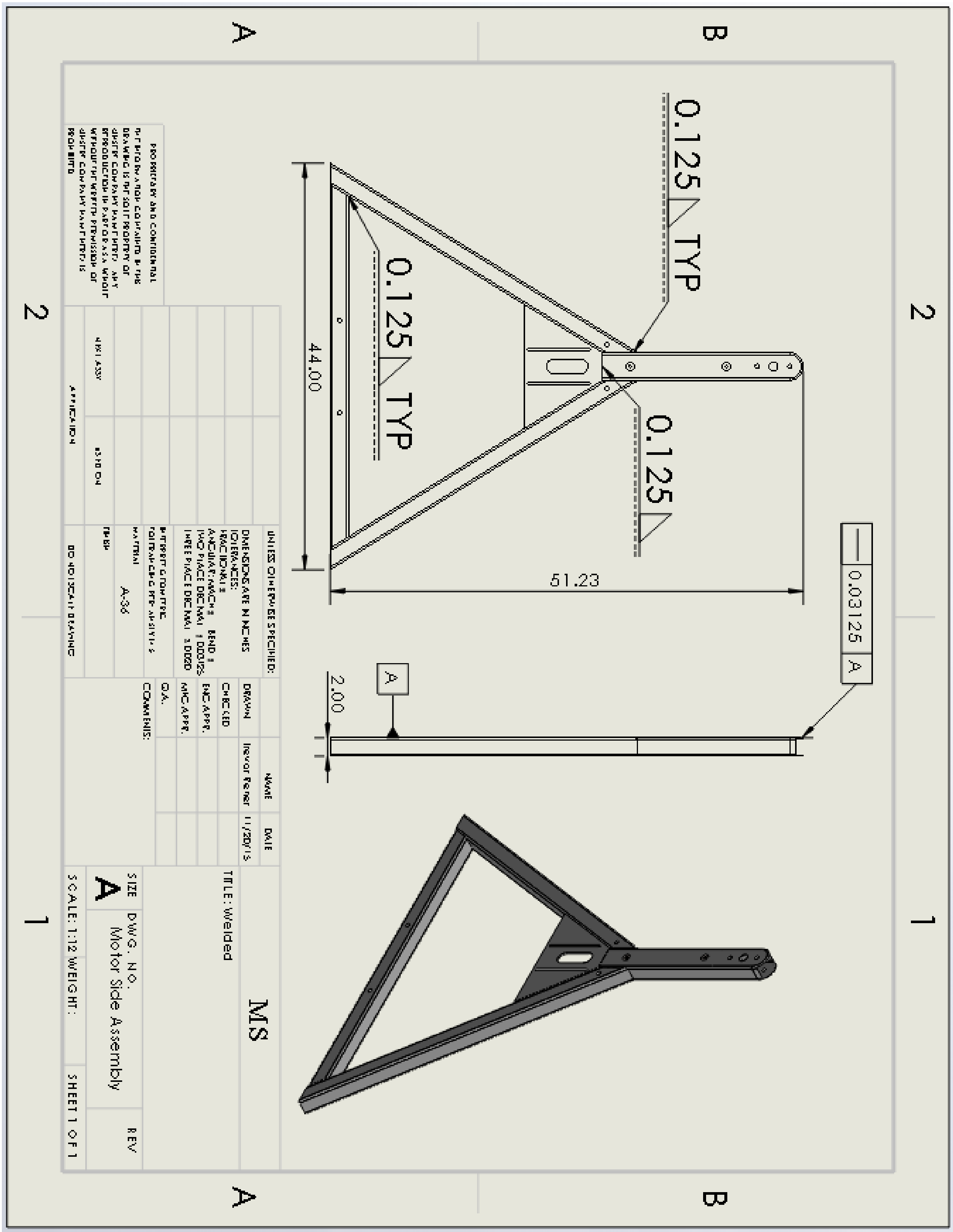
B-9: Side Legs



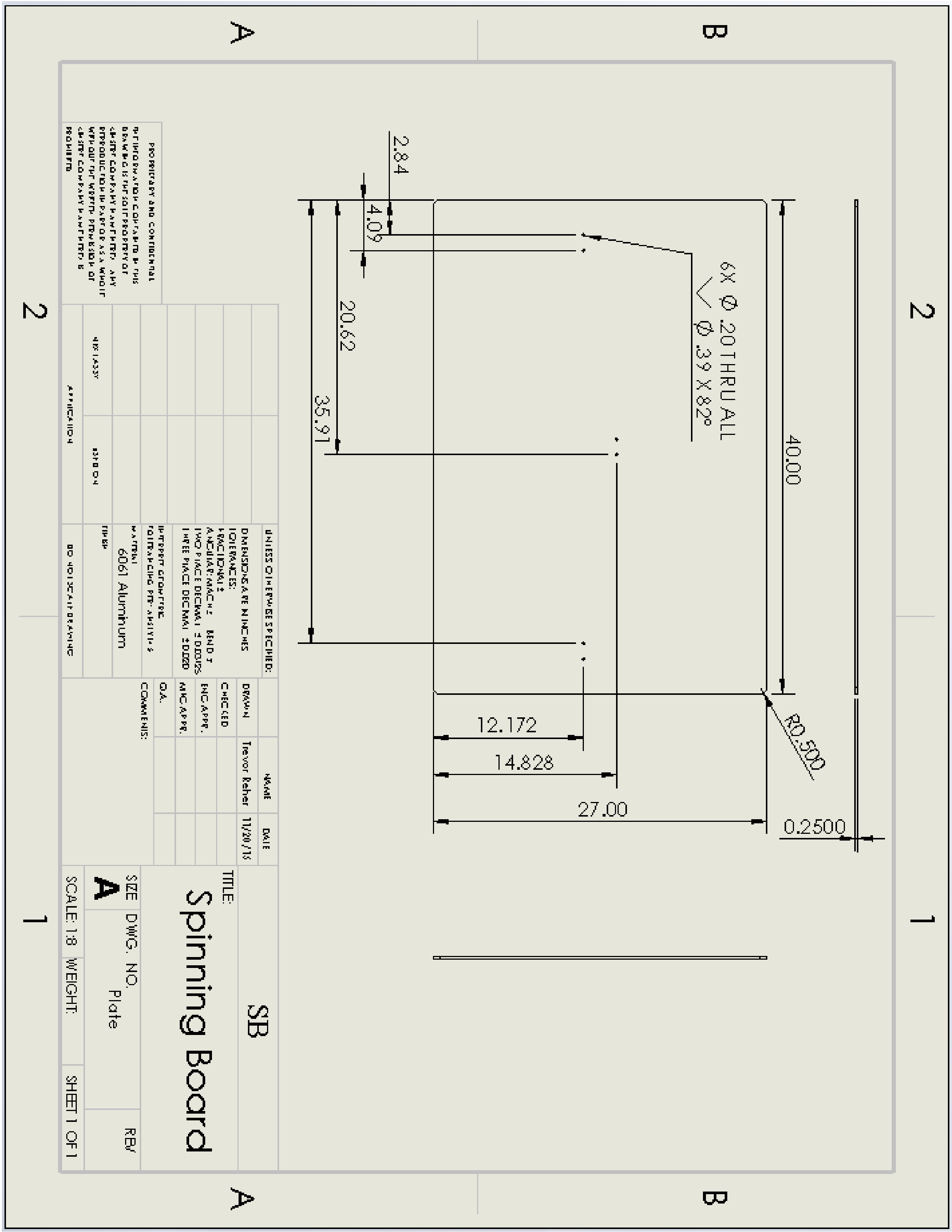
B-10: Mounting Plate



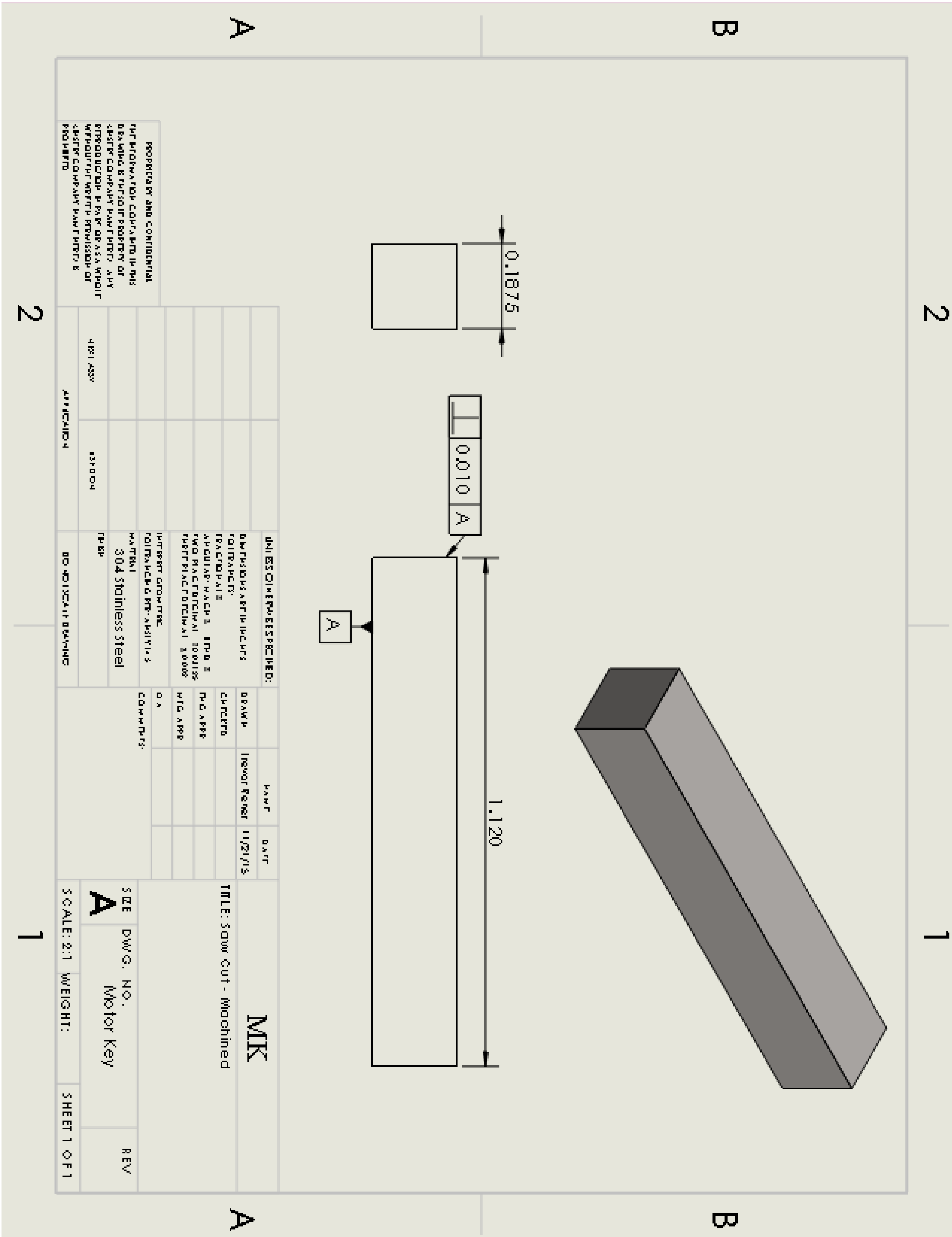
B-11: Non Motor Side Assembly



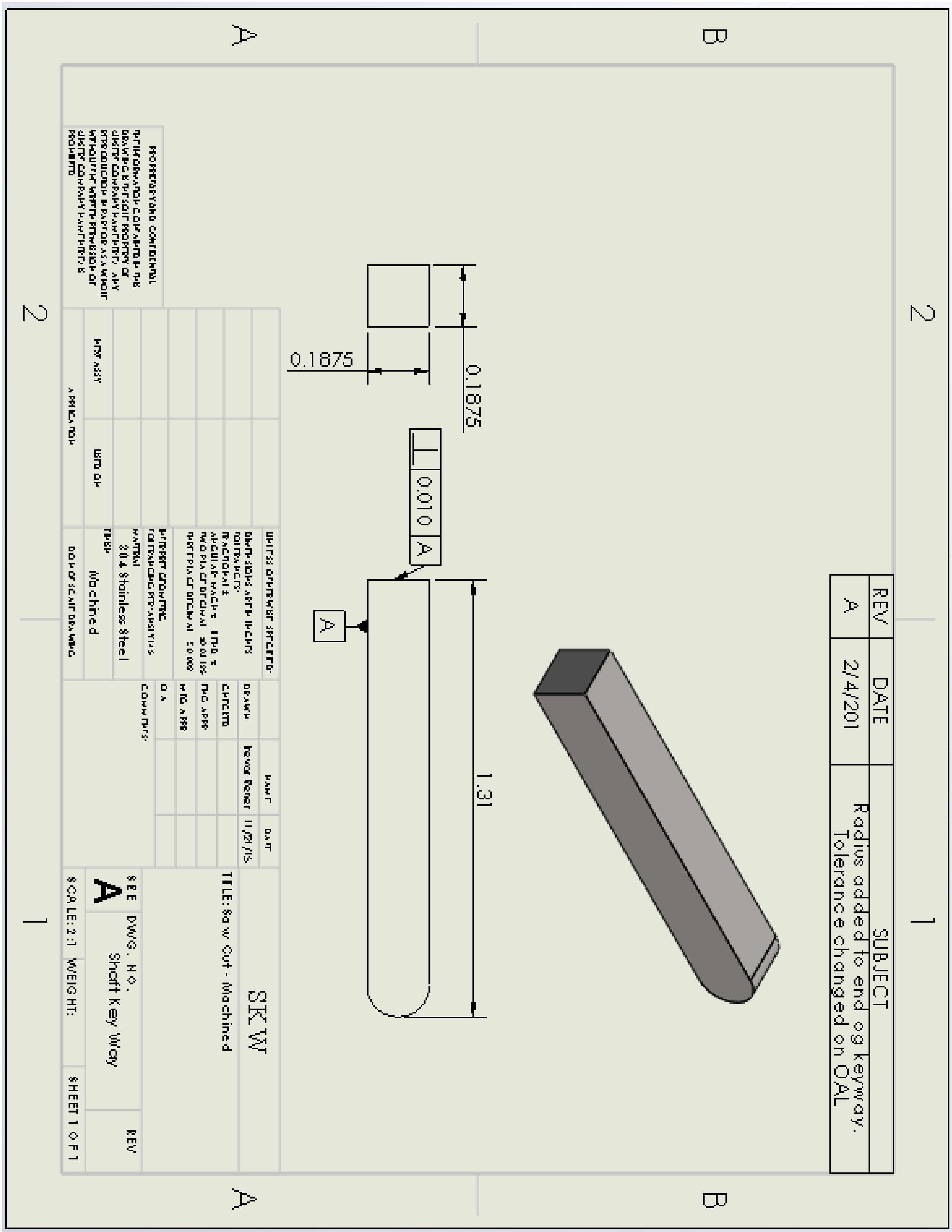
B-12: Motor Side Assembly



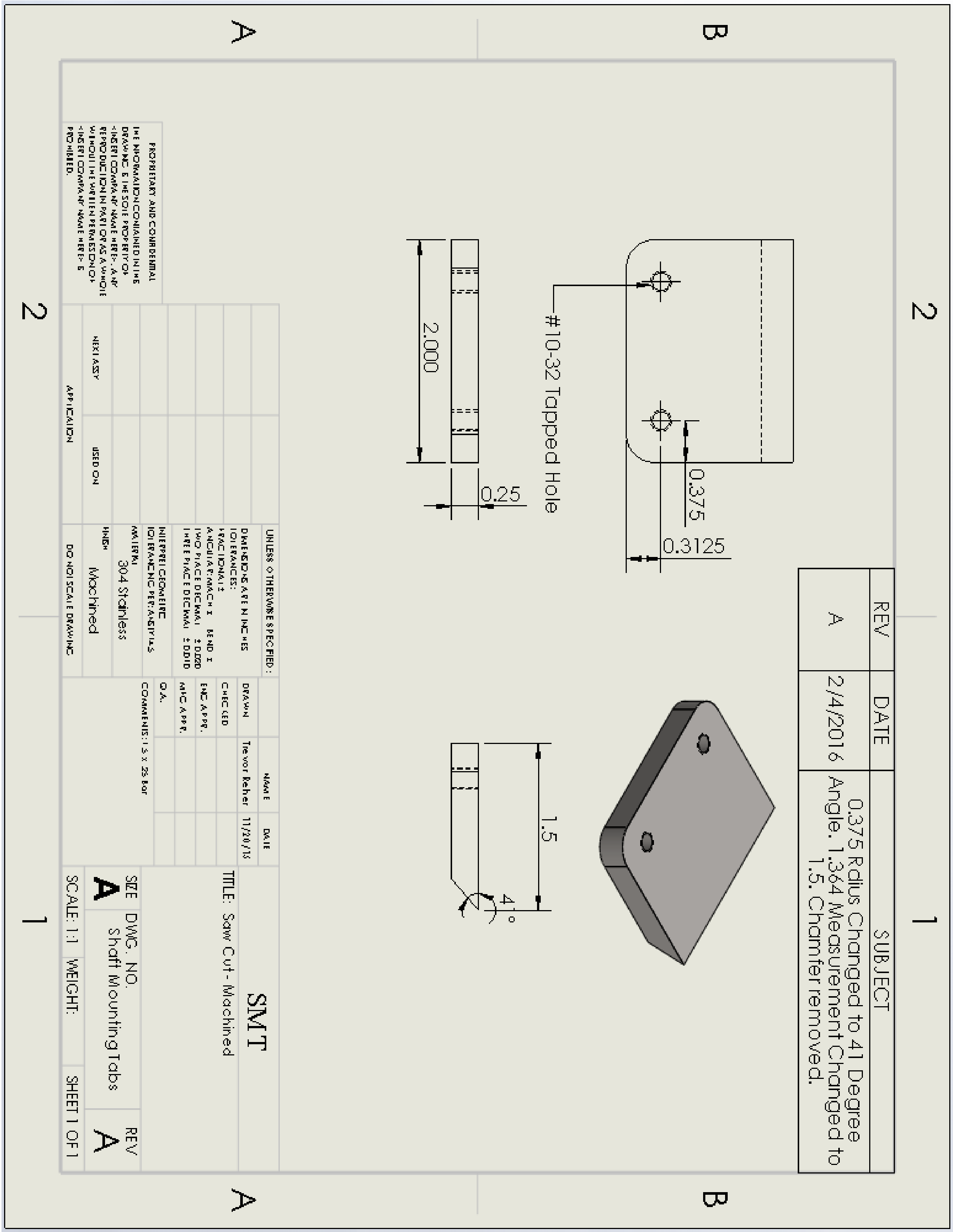
B-13: Spinning Board



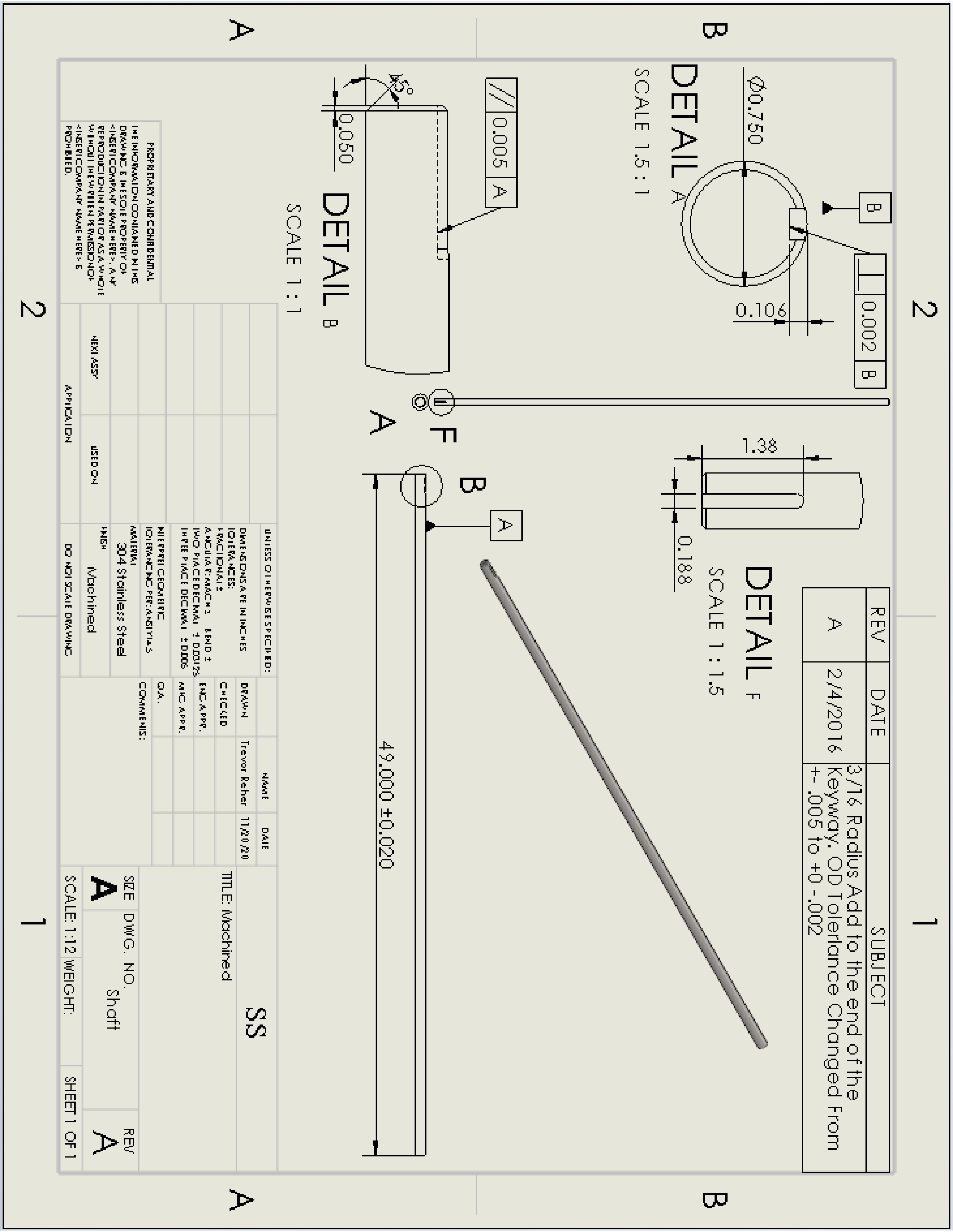
B-14: Motor Key Way



B-15: Shaft Key Way

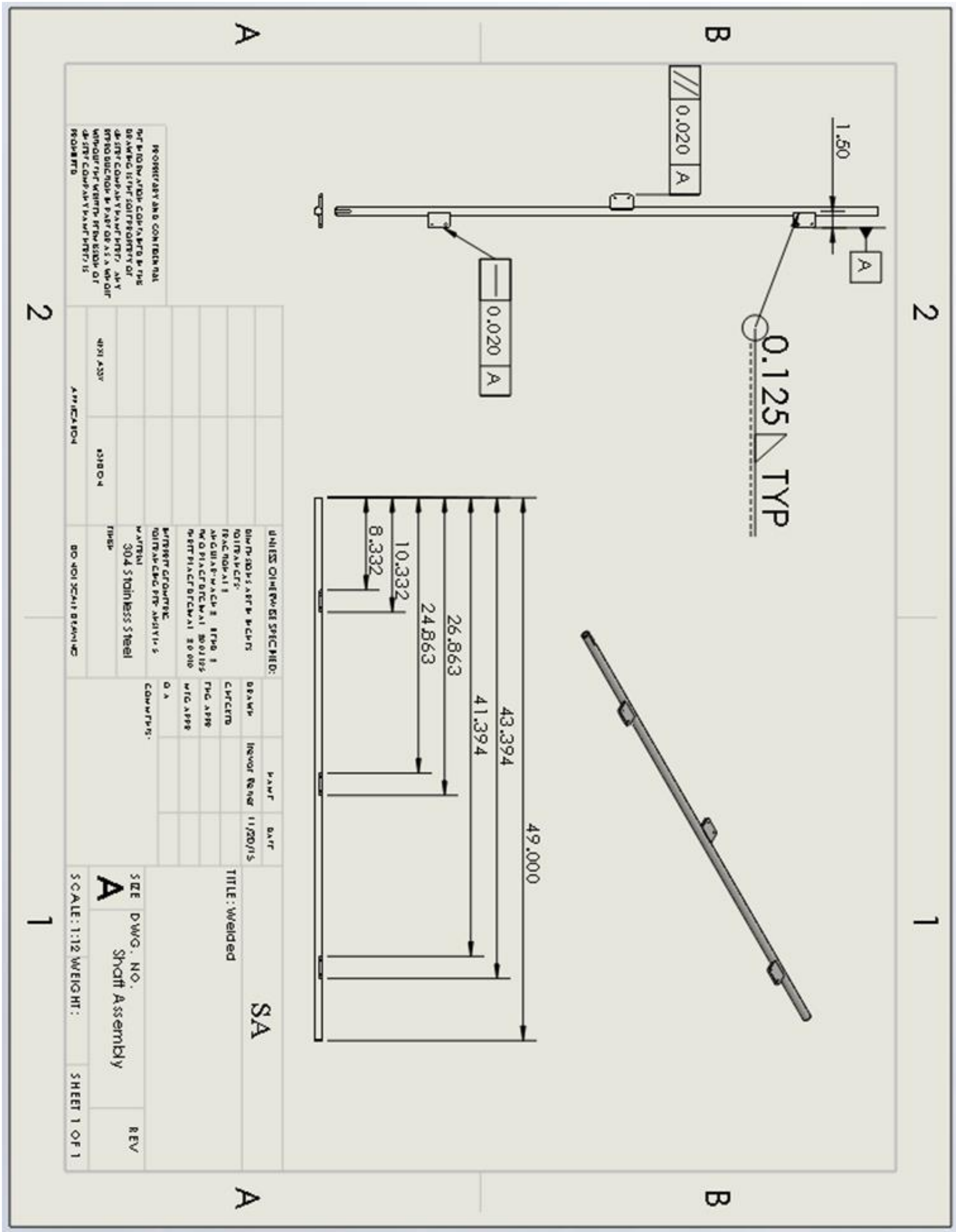


B-16: Shaft Mounting Tab

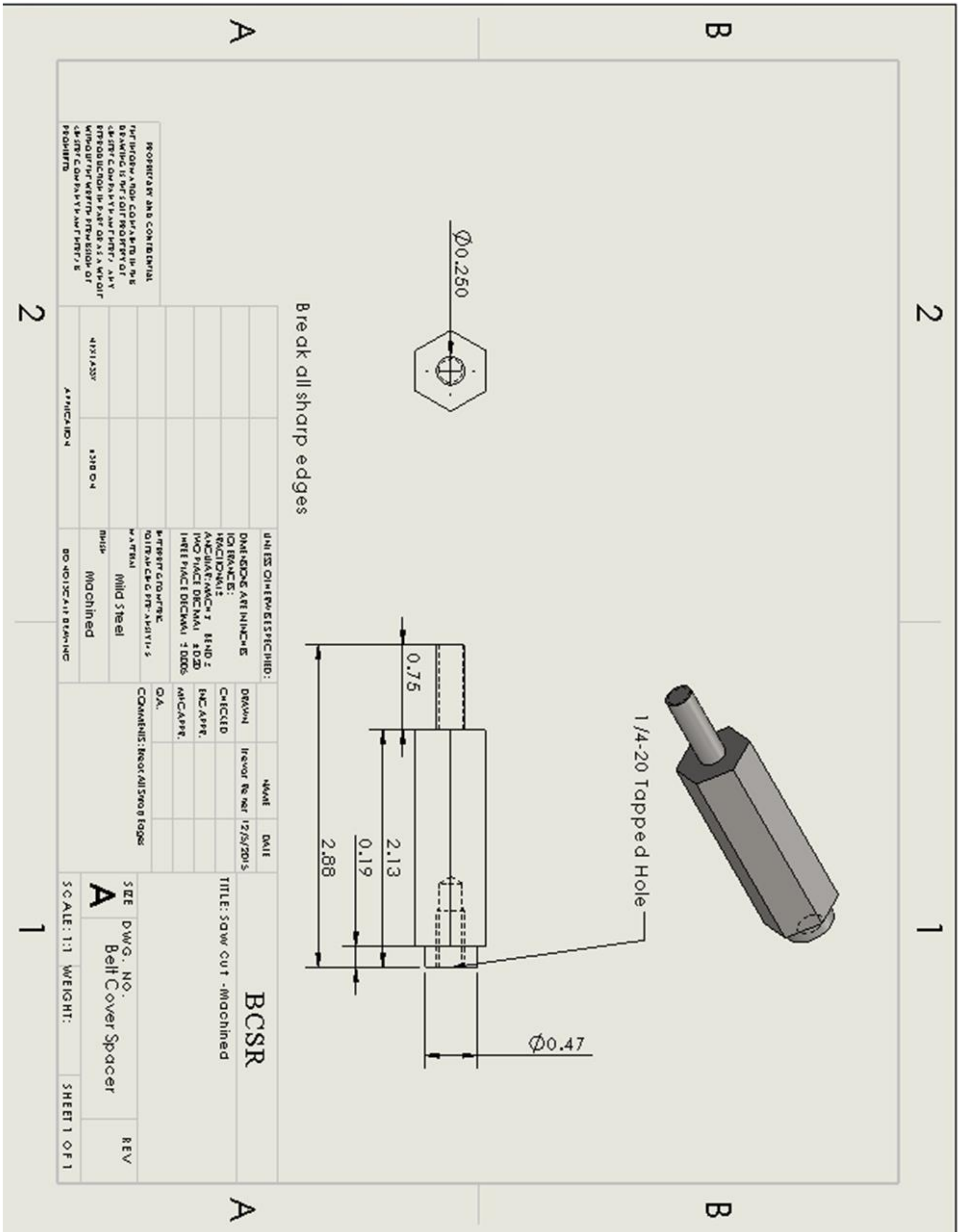


DETAIL A
SCALE 1.5 : 1
Ø0.750
0.106
0.002 B
DETAIL B
SCALE 1 : 1
0.005 A
45°
0.050
DETAIL F
SCALE 1 : 1.5
1.38
0.188
49.000 ±0.020
REV
DATE
SUBJECT
A
2/4/2016
3/16 Radius Add to the end of the Keyway. OD Tolerlance Changed From +-.005 to +0 -.002
304 Stainless Steel
Machined
Trevor Reher
TITLE: Machined
SS
SIZE
A
DWG. NO.
Shaft
REV
A
SCALE: 1:12
WEIGHT:
SHEET 1 OF 1

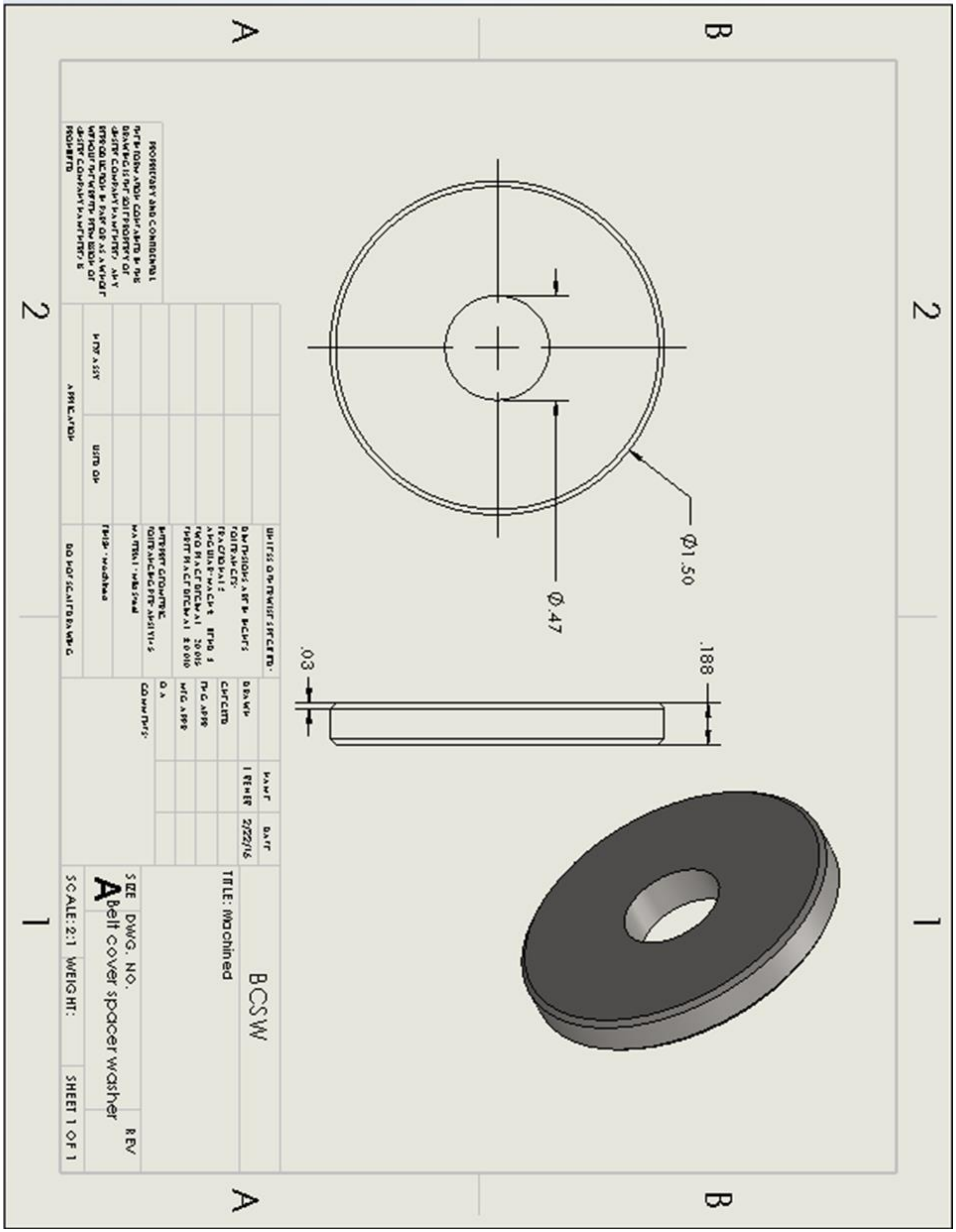
B-17: Shaft



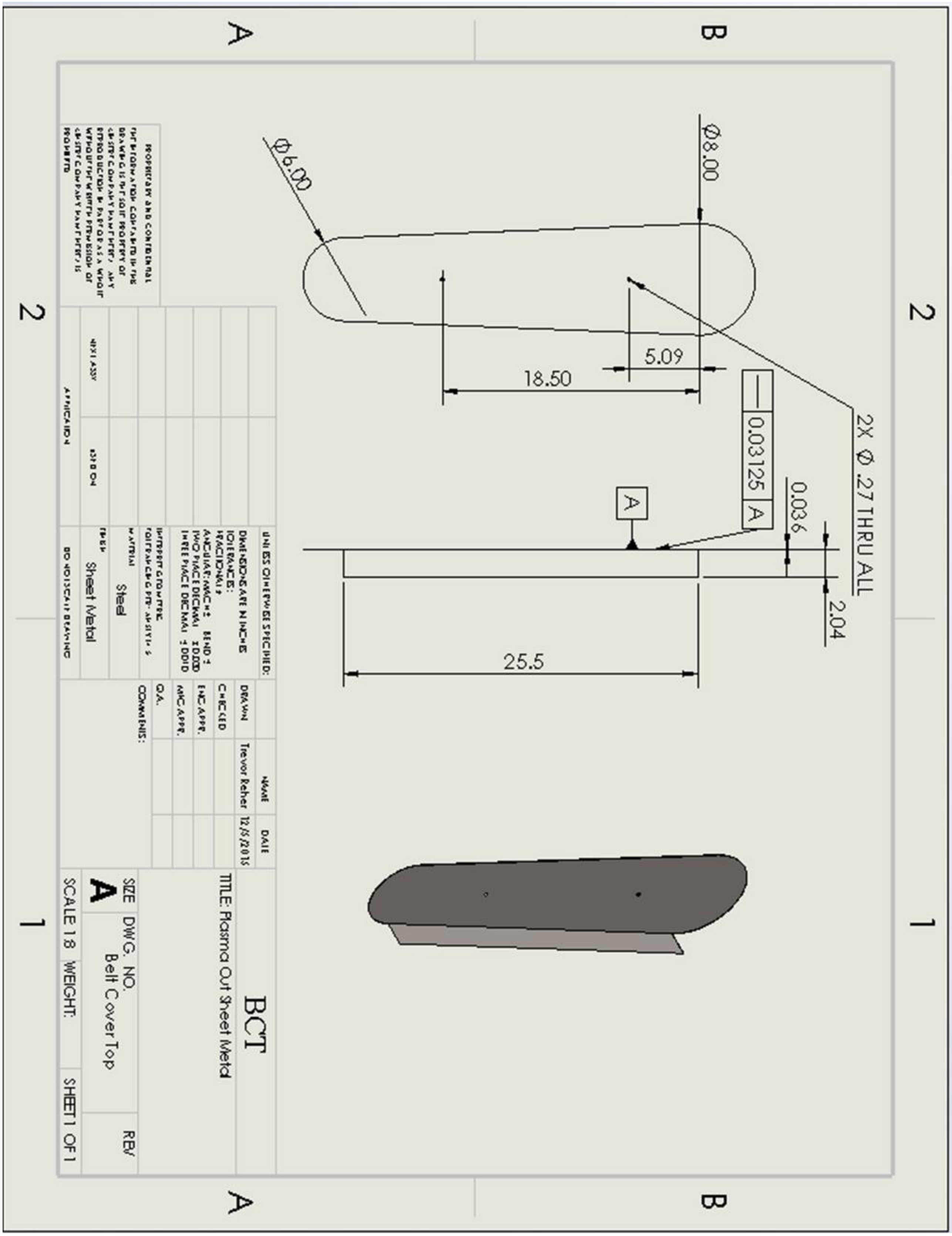
B-18: Shaft Assembly



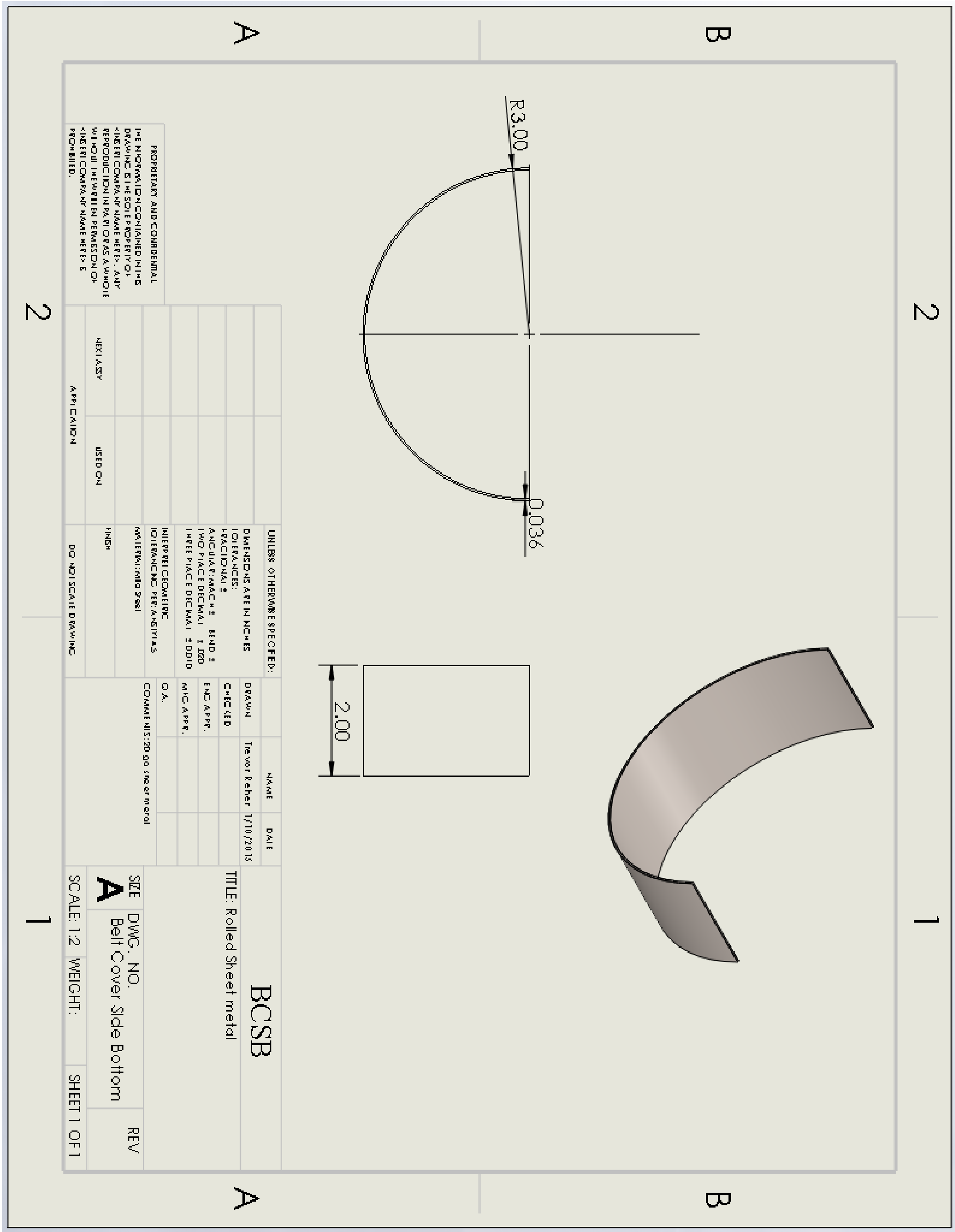
B-19: Belt Cover Spacer



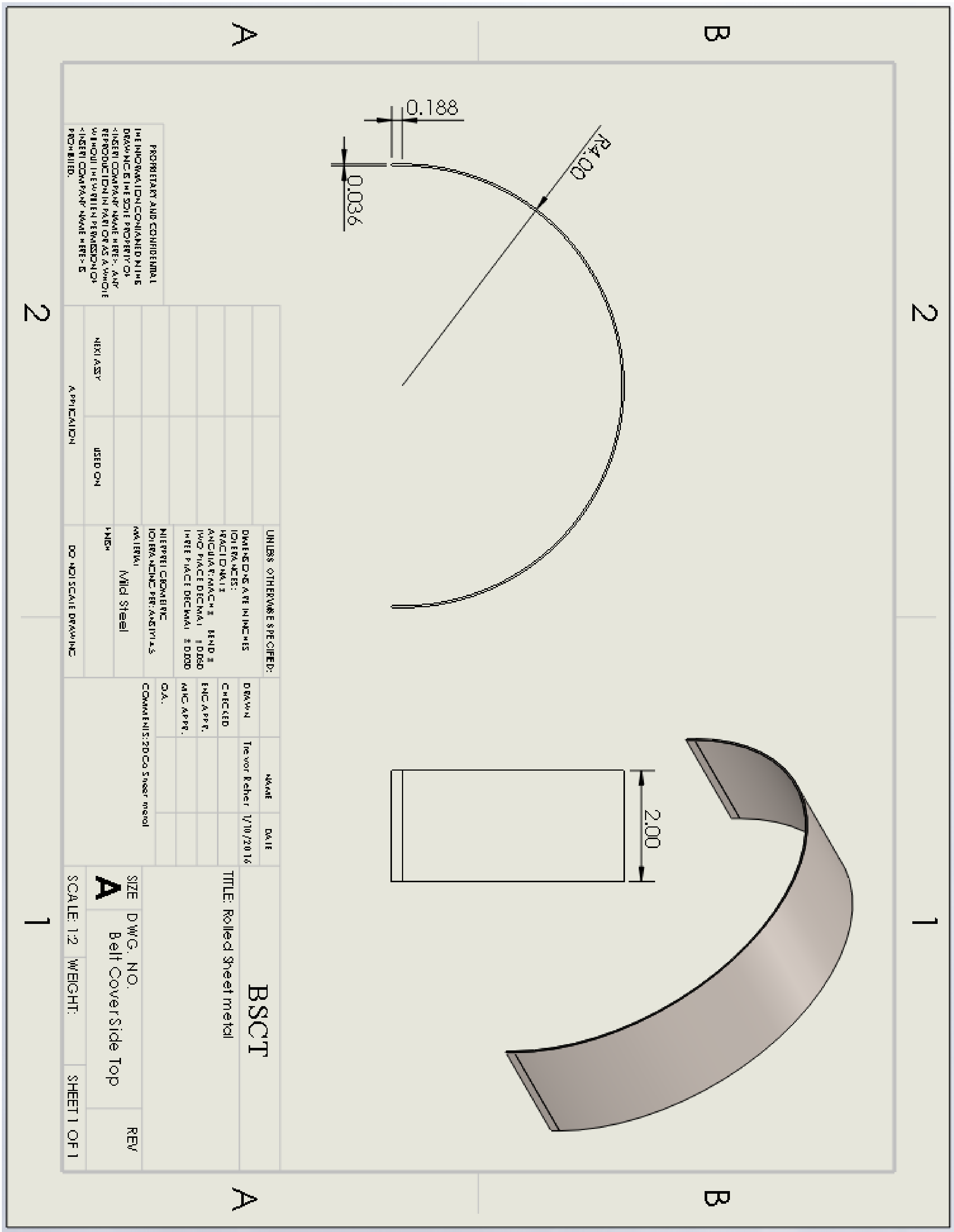
B-20: Belt Cover Spacer



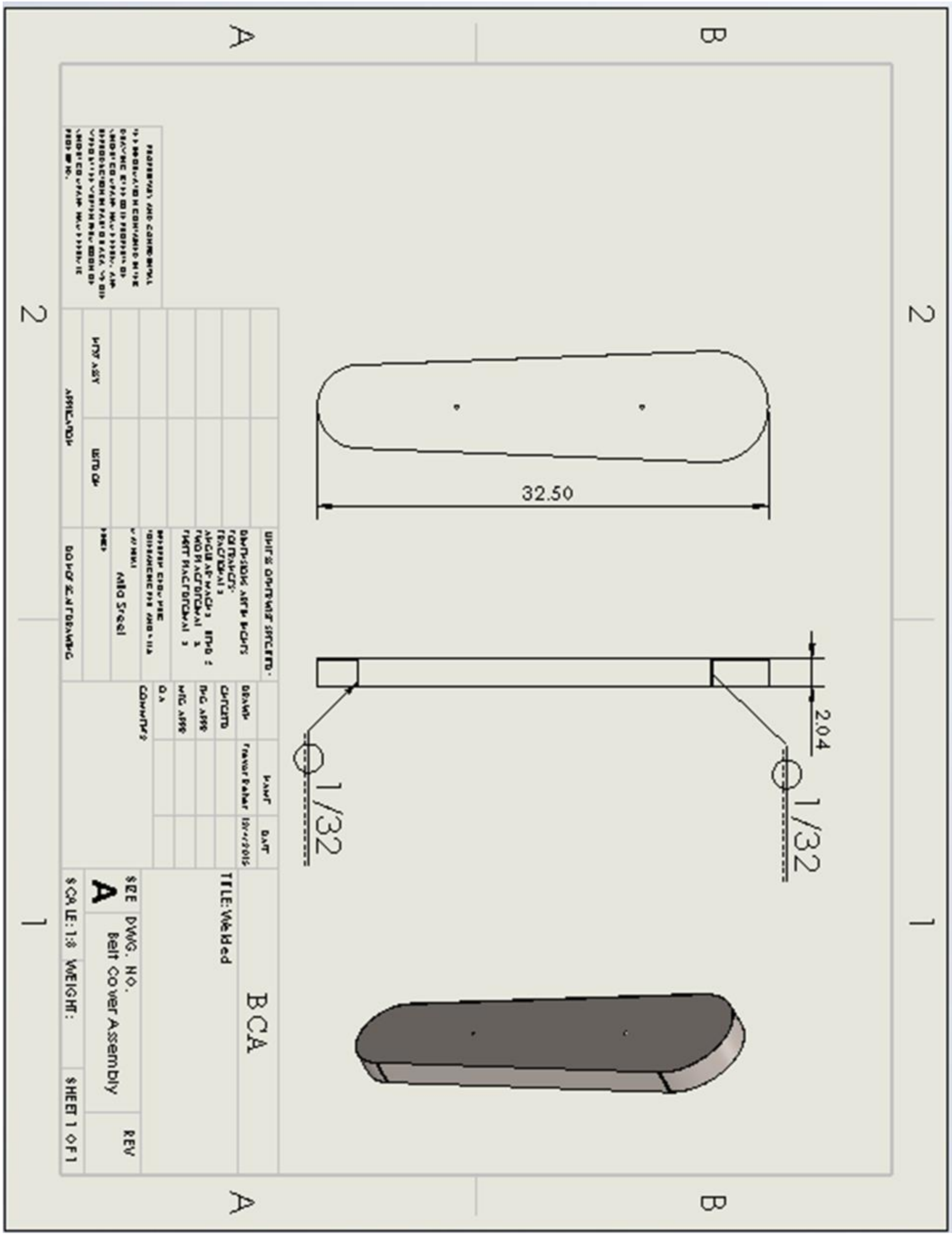
B-21: Belt Cover Top



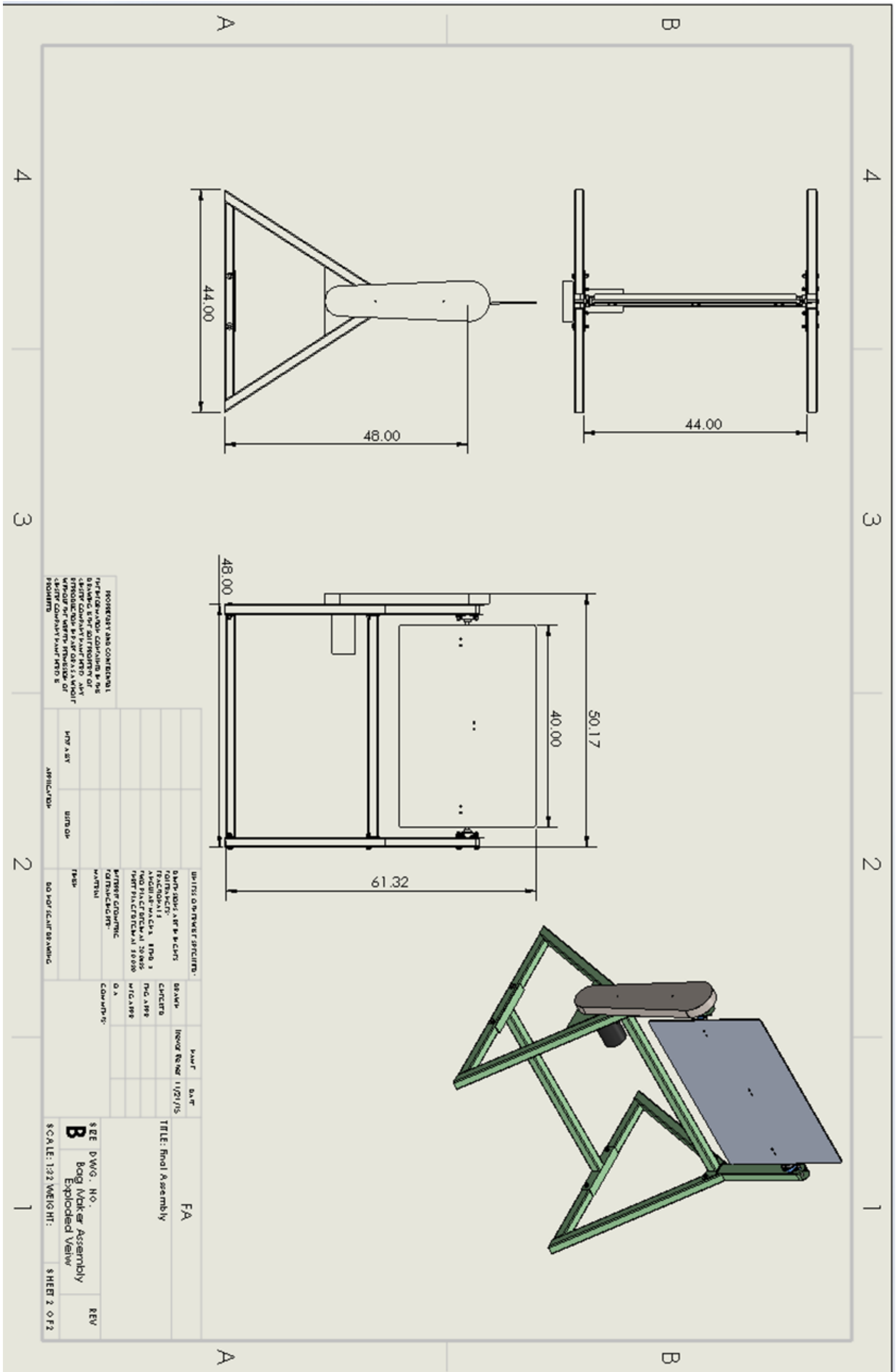
B-22: Belt Cover Side Bottom



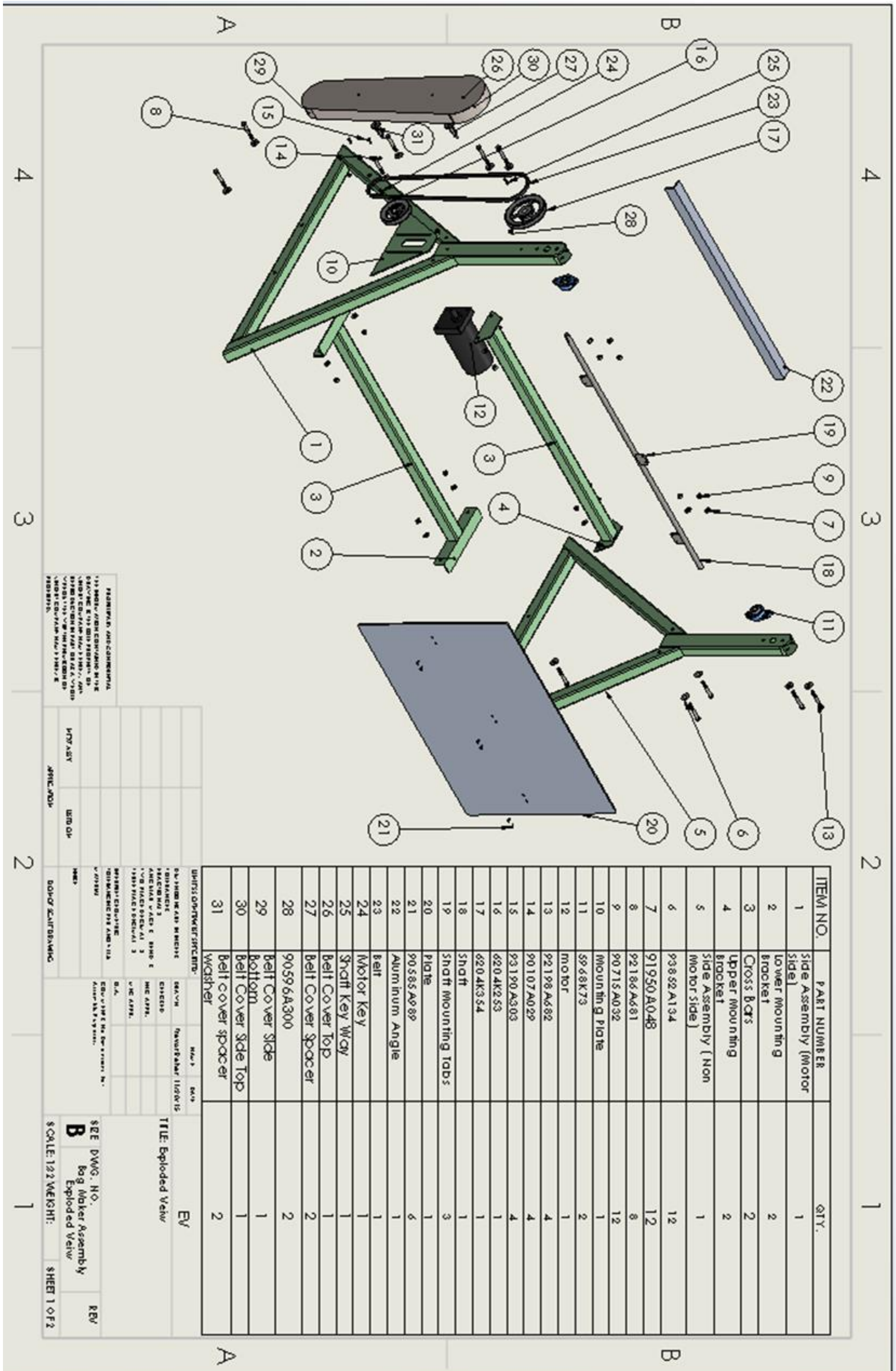
B-23: Belt Cover Side Top



B-24: Belt Cover Assembly



B-25: Shellfish Bag Maker Assembly



B-26: Shellfish Bag Maker Exploded View

Appendix C – Parts List

Parts List					
Part Number	**Part Name**	**Source**	**Quantity Needed**	**Quantity Per Pack**	**Number Packs Needed**
17148	Ace RSTP Zinc Prime	Ace Hardware	3	1	3
17087	Ace RSTP SPRY HTGRN150Z	Ace Hardware	6	1	6
3201225	Grounding Plug 15A BLK	Ace Hardware	1	1	1
345022	Blank Cover 1 Gang Grey	Ace Hardware	1	1	1
3424819	Outlet Box 1G 3/4" 3 Hole	Ace Hardware	1	1	1
30261	Wire SJOW-A 14/2 Bulk	Ace Hardware	1	1	20
30262	Wire SJOOW 14-3 SRV Cord	Ace Hardware	1	1	10
49401145	Capacitor; metal can type; 45 MFD / 250V	Bodine Electric	1	1	1
5681	42R6-FX Series Parallel Shaft AC Gear motor Model 5681	Bodine Electric	1	1	1
77040	1/4-28 x 5/8" 316 Stainless Steel Hex Cap Screw	Fastenal	4	1	4
78013	1/4" 316 Stainless Steel Small OD Flat Washer	Fastenal	4	1	4
71020	7/16" x 1.250" OD Grade 18-8 Stainless Steel Washer	Fastenal	12	1	12
120715	3/16" x 3/16" x 12" Grade 18-8 Stainless Steel Undersized Keystock	Fastenal	1	1	1
6GPA1	General Purpose Foot Switch, Black	Grainger	1	1	1
N/A	1.5 x .25 Stainless Steel Bar	Haskin Steel	1 ft.	6 ft.	1
N/A	2 x 2 x 3/16 Aluminum Angle	Haskin Steel	4 ft.	25 ft.	1
N/A	Aluminum Plate 28x40"	Haskin Steel	1	1	1
N/A	2x2x0.120 Box Steel	Haskin Steel	40 ft.	40 ft.	1
N/A	2x3x0.120 Rectangular Steel	Haskin Steel	4 ft.	4 ft.	1
N/A	2x2x3/16 Steel Angle Iron	Haskin Steel	3 ft.	1	1
N/A	3/4" X 60" Stainless Strain Shaft	Haskin Steel	5 ft.	6 ft.	1
N/A	24 "x 48" x 3/16" Steel Plate	Haskin Steel	-	-	1
520340	Rockwell 4-1/2-IN 5 AMP	Lowes	1	1	1
6204K25	4.0" Sheave	McMaster-Car	1	1	1
6204K35	5.7" Sheave	McMaster-Car	1	1	1
6186K158	61" A-Section V Belt	McMaster-Car	1	1	1
5968K73	Cast Iron Flange-Mounted Steel Ball Bearing	McMaster-Car	2	1	2
92198A682	7/16-14 x 3.25" Stainless Steel Bolts	McMaster-Car	4	5	1
90715A032	7/16-14 Stainless Steel Locknut	McMaster-Car	12	10	2
92186A681	7/16-14 x 3.00" Stainless Steel Bolt	McMaster-Car	8	1	8
91950A048	Type 316 Stainless Steel SAE Flat Washer	McMaster-Car	12	25	1
90596A300	Round Base Wels Nut	McMaster-Car	2	100	1
90585A989	Type 316 Stainless Steel Flat-Head Socket Cap Screw	McMaster-Car	6	10	1

C-1: Parts List

Appendix D – Budget

Bill Of Materials

Part Number	Part Name	Source	Quantity Needed	Quantity Per Pack	Number Packs Needed	Price Per Pack	Total Price	Actual Cost
17148	Ace RSTP Zinc Prime	Ace Hardware	3	1	3	$4.99	$ 14.97	$ 16.17
17087	Ace RSTP SPRY HTGRN150Z	Ace Hardware	6	1	6	$ 4.99	$ 29.94	$ 32.34
3201225	Grounding Plug 15A BLK	Ace Hardware	1	1	1	$ 4.99	$ 4.99	$ 4.99
345022	Blank Cover 1 Gang Grey	Ace Hardware	1	1	1	$ 1.99	$ 1.99	$ 1.99
3424819	Outlet Box 1G 3/4" 3 Hole	Ace Hardware	1	1	1	$ 6.99	$ 6.99	$ 6.99
30261	Wire SJOW-A 14/2 Bulk	Ace Hardware	1	1	20	$ 0.69	$ 13.80	$ 13.80
30262	Wire SJOOW 14-3 SRV Cord	Ace Hardware	1	1	10	$ 0.89	$ 8.90	$ 8.90
49401145	Capacitor; metal can type; 45 MFD / 250V	Bodine Electric	1	1	1	$ 19.57	$ 19.57	$ 20.14
5681	42R6-FX Series Parallel Shaft AC Gear motor Model 5681	Bodine Electric	1	1	1	$ 449.08	$ 449.08	$ 462.10
77040	1/4-28 x 5/8" 316 Stainless Steel Hex Cap Screw	Fastenal	4	1	4	$ 0.58	$ 2.32	$ 2.31
78013	1/4" 316 Stainless Steel Small OD Flat Washer	Fastenal	4	1	4	$ 0.10	$ 0.40	$ 0.39
71020	7/16" x 1.250" OD Grade 18-8 Stainless Steel Washer	Fastenal	12	1	12	$ 0.30	$ 3.60	$ 3.95
120715	3/16" x 3/16" x 12" Grade 18-8 Stainless Steel Undersized Keystock	Fastenal	1	1	1	$ 4.58	$ 4.58	$ 4.58
6GPA1	General Purpose Foot Switch, Black	Grainger	1	1	1	$ 34.55	$ 34.55	$ 34.55
N/A	1.5 x .25 Stainless Steel Bar	Haskin Steel	1 ft.	6 ft.	1	$ 16.69	$ 16.69	$ 16.69
N/A	2 x 2 x 3/16 Aluminum Angle	Haskin Steel	4 ft.	25 ft.	1	$ 35.51	$ 35.51	$ 13.66
N/A	Aluminum Plate 28x40"	Haskin Steel	1	1	1	$ 93.57	$ 93.57	$ 93.57
N/A	2x2x0.120 Box Steel	Haskin Steel	40 ft.	40 ft.	1	$ 77.88	$ 77.88	$ 70.32
N/A	2x3x0.120 Rectangular Steel	Haskin Steel	4 ft.	4 ft.	1	$ 29.25	$ 29.25	$ 28.04
N/A	2x2x3/16 Steel Angle Iron	Haskin Steel	3 ft.	1	1	$ 23.07	$ 23.07	$ 22.48
N/A	3/4" X 60" Stainless Strain Shaft	Haskin Steel	5 ft.	6 ft.	1	$ 51.01	$ 51.01	$ 21.27
N/A	24 "x 48" x 3/16" Steel Plate	Haskin Steel	-	-	1	$ 59.55	$ 59.55	$ 55.72
520340	Rockwell 4-1/2-IN 5 AMP	Lowes	1	1	1	$ 99.00	$ 99.00	$ 107.12
6204K25	4.0" Sheave	McMaster-Car	1	1	1	$ 26.80	$ 26.80	$ 28.38
6204K35	5.7" Sheave	McMaster-Car	1	1	1	$ 34.05	$ 34.05	$ 36.06
6186K158	61" A-Section V Belt	McMaster-Car	1	1	1	$12.35	$ 12.35	$ 12.68
5968K73	Cast Iron Flange-Mounted Steel Ball Bearing	McMaster-Car	2	1	2	$ 40.57	$ 81.14	$ 81.14
92198A682	7/16-14 x 3.25" Stainless Steel Bolts	McMaster-Car	4	5	1	$ 6.87	$ 6.87	$ 6.53
90715A032	7/16-14 Stainless Steel Locknut	McMaster-Car	12	10	2	$ 5.91	$ 11.82	$ 11.42
92186A681	7/16-14 x 3.00" Stainless Steel Bolt	McMaster-Car	8	1	8	$ 1.86	$ 14.88	$ 14.00
91950A048	Type 316 Stainless Steel SAE Flat Washer	McMaster-Car	12	25	1	$ 12.67	$ 12.67	$ 12.67
90596A300	Round Base Wels Nut	McMaster-Car	2	100	1	$ 7.63	$ 7.63	$ 7.63
90585A989	Type 316 Stainless Steel Flat-Head Socket Cap Screw	McMaster-Car	6	10	1	$ 3.35	$ 3.35	$ 3.35
					McMcaster Tax + Shipping	-	-	$ 17.39
					Fastenal Tax + Shipping	-	-	$ 10.79
					Grainger Tax + Shipping	-	-	$ 14.09
					Bodine-Electric + Shipping	-	-	$ 22.21
					Haskin Steel + Shipping	-	-	0
					TOTAL COST		$1,292.77	$1,320.41

D-1: Bill of Material

Appendix E – Schedule

PROJECT TITLE: Shellfish Bag Maker

Engineering Technician: Trevor Reher

TASK: ID	Description	Duration Est. (hrs.)	Actual (hrs.)	October	November	December	January	February	March	April	May	June
1	**Proposal**											
1a	Outline	1.00	1.00									
1b	Intro	2.00	3.00									
1c	Methods	3.00	3.00									
1d	Analysis	10.00	13.00									
1e	Discussion	1.00	2.00									
1f	Parts and Budget	5.00	2.00									
1g	Drawings	1.00	2.00									
1h	Schedule	1.00	2.00									
1i	Summary & Appx	1.00	2.00									
	subtotal:	25.00	30.00									
2	**Analyses**											
2a	Motor Sizing	3.00	4.00									
2b	Pulley/Belt Design	2.00	2.00									
2c	Belt Speed	0.50	0.50									
2d	Key Dimension	0.50	0.50									
2e	Tipping Force	1.00	1.00									
2f	Bolt Shear Stess	1.00	1.50									
2g	Weld Sizing	2.00	2.00									
2h	Material Specs	2.00	2.00									
2i	SolidWorks Design	50.00										
2j	Tolerance	2.00	3.00									
	subtotal:	64.00	16.50									
3	**Documentation**											
3a	Side Bottoms (SB) dwg	2.00	2.00									
3b	Side Legs (SL) dwg	2.00	2.00									
3c	Side Tops (ST) dwg	1.00	2.00									
3d	Lower Mounting Bracket (LMB) dwg	2.00	2.00									
3e	Lower Cross Bar (LCB) dwg	2.00	2.00									
3f	Upper Mounting Bracket (UMB) dwg	2.00	2.00									
3g	Upper Cross Bar (UCB) dwg	1.00	2.00									
3h	Motor Mounting Plate (MP) dwg	2.00	2.00									
3i	Steel Shaft (SS) dwg	3.00	3.00									
3j	Shaft Mounting Tabs (SMT) dwg	3.00	3.00									
3k	Spinning Board (SB)	1.50	2.00									
3l	Belt Cover Spacer	0.50	0.50									
3m	Belt Cover Top	1.00	1.00									
3n	Belt Cover Sides	1.00	1.00									
3o	Assembly dwg	3.00	1.50									
3p	Exposide View dwg	2.00	2.00									
3q	Update Website	1.00	3.00									
	subtotal:	30.00	33.00									
4	**Proposal Mods**											
4a	Project Schedule	1.00	2.00									
4b	Project Part Inv.	1.00	10.00									
4c	Crit Des Review	1.00	2.00									
	subtotal:	3.00	14.00									
5	**Part Construction**											
5a	Order Material/Parts	1.00	2.50									
5b	Side Bottoms (SB)	3.00	1.00									
5c	Side Legs (SL)	4.00	2.50									
5d	Side Tops (ST)	3.00	3.00									
5e	Side Sub Assembly	5.00	4.00									
5f	Lower Cross Bar (LCB)	1.00	0.50									
5g	Upper Mounting Bracket (UMB)	2.00	0.50									
5h	Upper Cross Bar (UCB)	1.00	0.50									
5i	Motor Keyway (MK)	0.25	0.50									
5j	Shaft Keyway	0.25	0.50									
5k	Motor Mounting Plate (MP)	1.50	1.25									
5l	Steel Shaft (SS)	3.00	7									
5m	Lower Mounting Bracket (LMB)	2.00	1.5									
5n	Shaft Sub-Assembly	4.00	4									
5o	Shaft Mounting Tabs (SMT)	3.00	4.5									
5p	Belt Cover Top (BCT)	3.00	4									
5q	Belt Cover Sides (BCS)	3.00	3									
5r	Cross Member Sub-assembly	2.00	2									
5s	Spinning Board (SB)	2.00	3									
5t	Belt Cover Spacer (BCS)	1.00	5									
5u	Wire Sytem	3.00	4									
5v	Prep for paint	5.00	13									
5w	Final Assembly	3.000	5									
	subtotal:	56.000	72.75									

6a	Reassembe Machine	2.00	2
6b	Fix cuting tool	5.00	20
6c	Make test sheets	1.00	1
6d	List Parameters	1.00	1
6e	Design Test & Scope	3.00	1
6f	Obtain resources	1.00	1
6g	Make test sheets	1.00	1
6h	Plan analyses	3.00	1.5
6i	Instrument Device	1.00	0
6h	Perform Evaluation (Test Machine)	2.00	3.00
6j	Take Testing Pics/video	1.00	1.00
6k	Testing Document	5.00	4.00
6l	Update Website	3.00	5.50
	subtotal:	29.00	42.00
7	495 Deliverables		
7a	Get Report Guide	1.00	1.00
7b	Make Rep Outline	1.00	1.00
7c	Write Report	1.00	1.00
7d	Make Slide Outline	1.00	
7e	Create Presentation	2.00	4.00
7f	Make Flash Deliv. List	1.00	1.00
7e	Write 495 Flash Drive parts	1.00	1.00
7f	Update Website	1.00	1.00
7g	Project Flash Drive	1.00	1.00
	subtotal:	1.00	1.00
		11.00	12.00
	Total Est. Hours=		
Note:	**Deliverables:***	1.00	2.00
	Draft Proposal	1.00	2.00
	Analyses Mod	1.00	2.00
	Documents Mods	1.00	2.00
	Final Proposal	1.00	2.00
	Part Constructions	1.00	2.00

E-1: Gantt chart

Appendix F –Testing Document

Testing Method

Introduction

The shellfish bag maker has a one calculated parameters that need be measured in order to determine how much faster it is compared to the current machine being used. The machine is calculated to put 0.99 bags on the machine per second, however the machine never had a calculated cutting time. The reasoning for not having a calculated cutting time is because there wasn't a way to design the cutting operation until the machine was finished being build. The cutting operation is being perform by a Rockwell 4.5" circular saw. The method of making the cutting tool work is going to involve making prototypes to determine the best design for the cutting tool. After having a finished cutting tool the machine will be tested to determine how much faster the new machine is from the current machine.

Without the cutting operation being factored in for the time savings. The spooling operation is calculated to be 1.14 times faster than the current machine. Because the cutting time is unknown the true time saving factor will have to be calculated after testing the machine.

The testing for the machine will began on Friday April 15, 2016 after the finish prototype for the cutting tool in complete. The gantt chart in the appendix shows the testing schedule.

Method/Approach

Resources

For the testing of the Shellfish Bag Maker a few resources are needed; a spool of the raw clam/oyster bag material, spot watch, video camera, another person and access to 110V power. Before the testing can began the overhead crane in the in Central Washington University Hogue Hall Fluke lab needs to be moved into place. For this part of the test Matthew Burvee is needed to move the crane to the proper height above the ground. See the procedure checklist in the appendix.

Data capture

Since the test on the Shellfish Bag Maker is related to a saving in time, the tool needed to capture the data is just a stopwatch. The second person assisting with the testing will record the spool and cut time and help count the number of bags from each test.

Test procedure overview

The testing for the Shellfish Bag Maker is going to be using the machine to cut the raw material to a specified length. For this test the machine will be set up just like it would be in the customer's headquarters location. By setting the machine up to replicate the condition it will be in for the remained of its life, its will help locate potential issues that are needed to be fix before delivery to the customer.

To measure the calculated values of (bags/second) and (bags cut/second), the tool needed is a stop watch, someone to run the stopwatch and a clipboard to record the data. The testing needs to done in dry environment where there is access to 110v power and a place to hang a shackle 6ft. above the ground. To perform the tests a spool of the raw material is needed before testing can begin. The test will take about 30 minutes to step up and about 1-2 hours to perform. See appendix for the testing schedule.

Operational limitations

There are a few limits to the Shellfish Bag Maker, the first the machine can only handle up to 80 bags at a time due to its size. The machine also spins at a fixed RPM of based of a pulley drive train.

Precision and accuracy discussion

Since the testing for the machine for a time saving factor. The accuracy will be determined by how fast the person running the stop watch can hit the button to start and stop the time. This will be reflected in the bags spooled per second. The cutting time is most likely going to result in a low accuracy and precision because it varies by how well the operator can cut the material and has a learning curve associated using the cutting tool. Because there is not enough material to do more than six test an average will have to be taken of both the cutting and spooling time.

Data storage & Presents

The data collected from testing the Shellfish Bag Maker will be documented on a test sheet that can be found in the appendix. The test sheet information will then be put into Excel and compared to the bench-mark of the current machine being used at the shellfish farm. The data from the bench-mark and testing data will be presented in a table that can be seen in the deliverables results section.

Test Procedure

The following procedure is to perform the test for machine's output and cutting time. Before testing can begin raw clam/oyster material must be on hand. For safety reason anyone watching the test should be watching safety glasses because an electric circular saw will be used to cut the material. Since the machine has a spinning apparatus associated with its operation it is advised that anyone be at least five feet away from the machine while it is spooling material onto itself. To replicate this test the test should be performed in Central Washington University Hogue Hall Fluke lab.

1. Using the image below set the machine up as following. Make sure the machine is in a dry environment with access to 110v power. The crane in the fluke lab is used to guide the material to the machine, because of that Matt Burvee is needed to assist in bring the hook to the proper height of 6ft. above the ground. The operator will stand 3 feet in front of the spool and guide the material on using his/her hand. The machine is run by pushing on the foot pedal and holding it. The video below the image shows a demonstration of the machine being used.

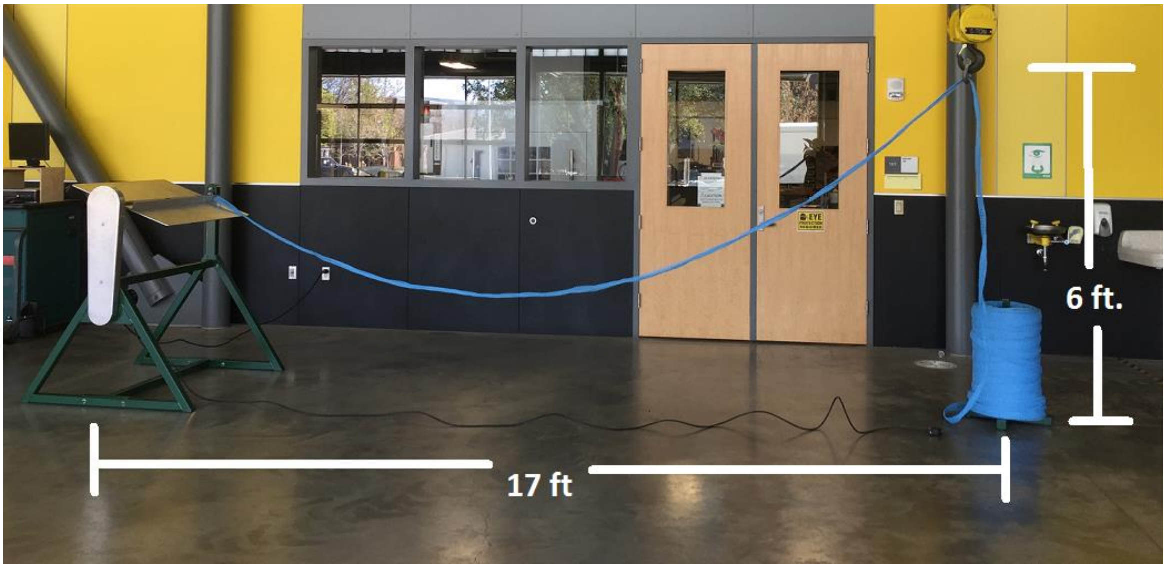


Figure 3: Machine Setup Distances

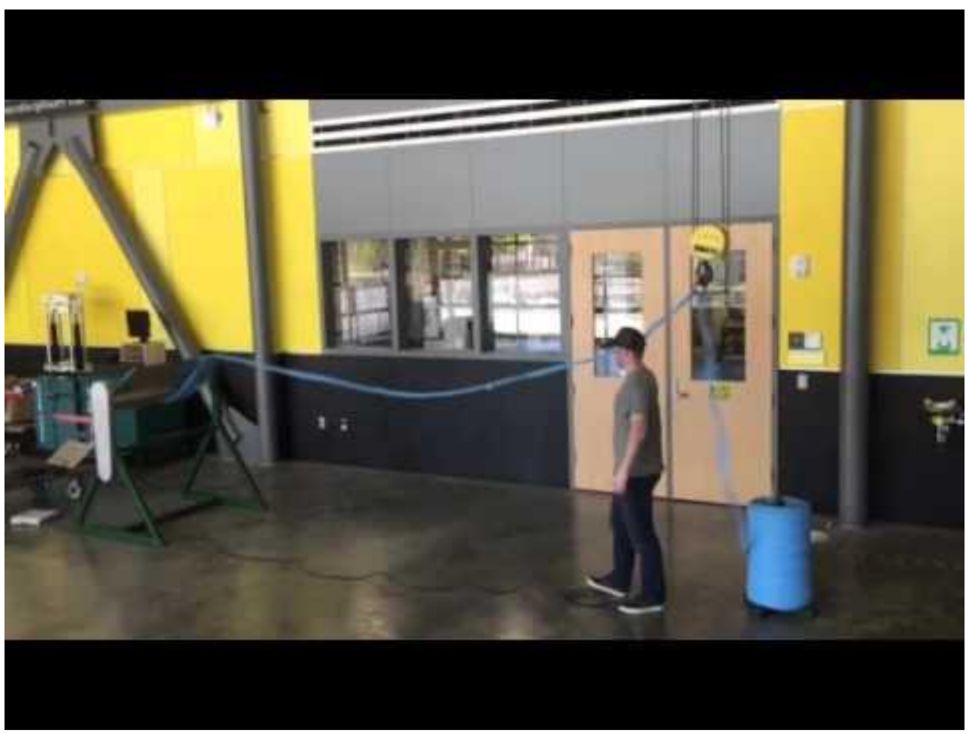


Figure 4: Example of Operation

2. Run the machine for 50-60 seconds and record the amount of time it was putting the material on to the machine.
3. Reset the stop watch.
4. Now grab the Rockwell cutting tool hold the aluminum about 45 degree away from yourself. Set the cutting tool guide in the aluminum angle and pull the trigger of the tool and cut the material. The video below shows of to cut the material. Don't cut material yet.

5. Now cut the material and measure the time is takes to cut all material that has been spooled onto the machine. Start the stop watch the instant the blade starts to cut the material. Record the cutting time.
6. After cutting all the bags count the number of bags the machine produced.
7. Take the number of bags cut and divide that by the time it took to get all the material onto the machine. This measurement will give the (bags/second).
8. Repeat step 7 for the cutting time. Number of bags cut divided by the time it took to cut the bags.
9. Repeat steps 2-7 at least 5 times to get a good average.
10. Compare the bench mark data to the new data collected.

Testing Discussion

The testing of the spooling operation of the machine worked great from the first test and no adjustments had to be made. The machine rotated faster than calculated because it wasn't fully loaded but the slight increase in speed wasn't a safety concern so it was left alone. The testing for the cutting operation was a 3 week battle of trying to make a cutting guide work and cut the material fast enough to meet the requiment. There were three prototypes that were made. The first was made from ¼ thick aluminum and can be seen in figure 4. The reason that it didn't work was because the material would get caught in the bladed since there was nothing to stop it from getting caught it the blade. That moves us to the next prototype which was made from steel for ease of welding and a faster turn around on making the prototype. The steel prototype seen in figure 3 has a closed front and added piece of UHMW to elimate the material from being caught in the blade. This design worked better but wasn't good enough. The main reason the steel deisgn didn't work was being the angle at the front of the guide caused the material to get wedged between the aluminum guide rail and the UHMW. To fix this the thrid prototype was constructed out of 1/8 thick steel and had a UHMQ guide on opposite side from the first two prototypes. This design worked the best because, by placing the guide on the oppsited side and then holding the aluminum plate at a 45 degree angle while cutting gravity would pulled the material down and out of the way. In addition the there was no front angle machined into the guide but just a side releif angle to devent the material away from the saw. The thrid prototype proved to be the best design and was what was given to the customer.

Figure 6: Aluminum Bracket

Figure 5: Steel Bracket

Figure 7: Final Prototype

Deliverables

Calculated Values & Parameter Values

The design requirements specified that the machine be at least 1.10 times faster than the current machine and it would be able to cut 6 bags per seconds. The calculated values for the Shellfish Bag Maker was 0.99 Bags/sec making the machine 1.14 faster. The cutting time was not a calculated value because it was based off how well the circular saw could cut the material. The testing of the machine would provide the actually cutting value.

Results

Shellfish Bag Maker Testing New Machine						
Test Number	**Spool Time (Sec)**	**Cut Time (Sec)**	**Number of Bag Cut**	**Bags Spooled Per Second**	**Bags Cut Per Second**	**Running RPM**
1	64	N/A	67	1.05	N/A	62.8
2	36	8.69	38	1.06	4.37	63.3
3	57	11.65	60	1.05	5.15	63.2
4	65	10.5	69	1.06	6.57	63.7
5	59.5	5	63	1.06	12.60	63.5

Benchmark From Current Machine						
Test Number	**Spool Time (Sec)**	**Cut Time (Sec)**	**Number of Bag Cut**	**Bags Spooled Per Second**	**Bags Cut Per Second**	**Running RPM**
1	70	105.8	60	0.86	0.57	51.43
2	70.4	99.9	58	0.82	0.58	49.43
3	60.4	N/A	56	0.93	N/A	55.63
4	59.66	103.1	57	0.96	0.55	57.32
5	64.96	157.79	55	0.85	0.35	50.80
6	75.05	195.93	64	0.85	0.33	51.17

Figure 8: Testing Data and Bench mark data

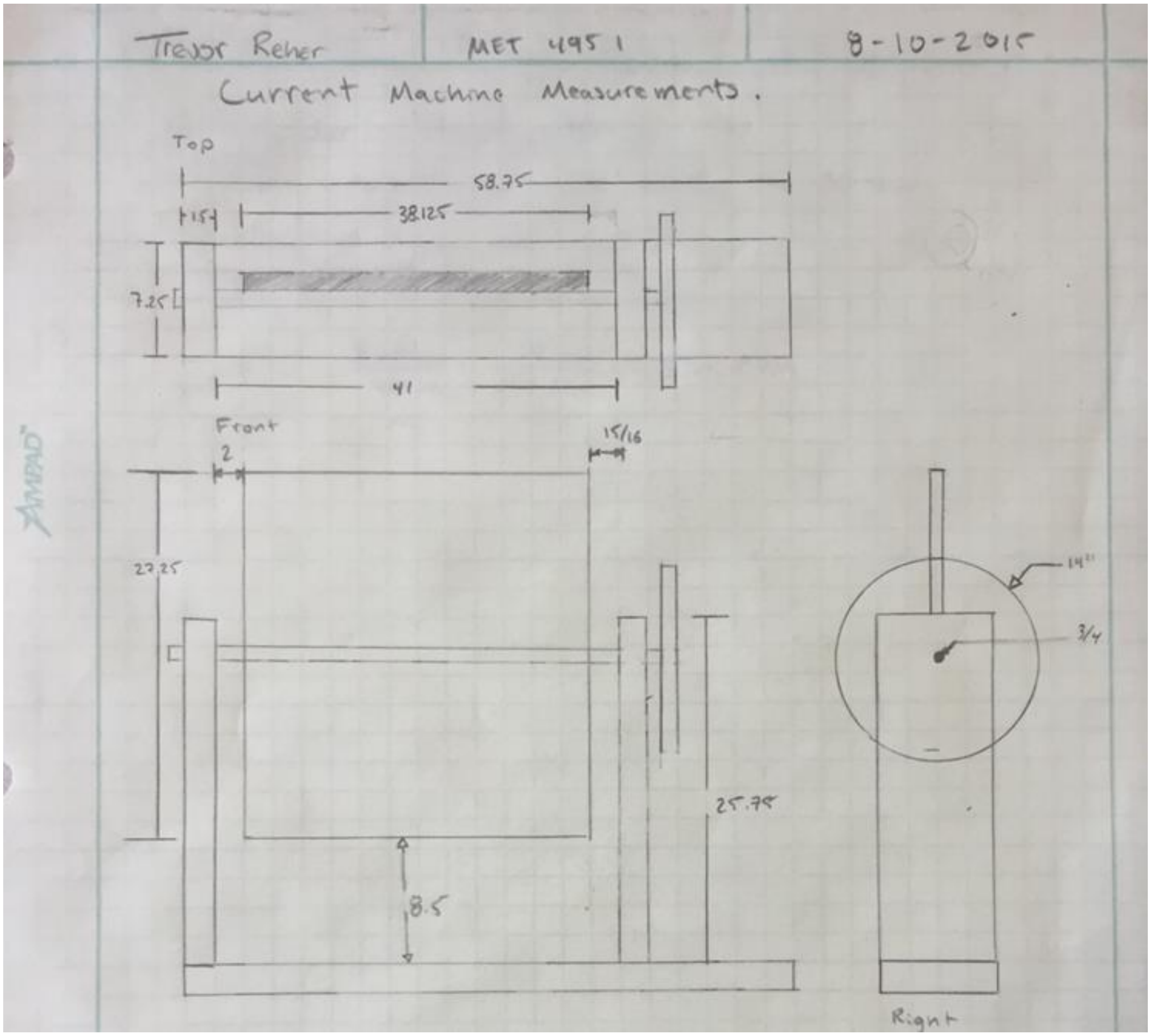
Benchmark Comparison								
Current Machine			**New Machine**			**60 Bag Comparison**	
Average Spool Time	0.87		**Average Spool Time**	1.06		**Current machine Time for 60 Bags**	194.0
Average Cut Time	0.48		**Average Cut Time**	7.17		**New Machine Time for 60 Bags**	65.2
Average RPM	52.6		**Average RPM**	63.2		**Time Factor Improvement**	2.97

Figure 9: Bench-mark comparison of the old and new machine the units for spool time and cut time are in (bags/second)

Conclusion

After testing the Shellfish Bag it showed a greater improvement that expected. The machine was calculated to put 0.99 bag on the machine per second but after testing the machine actually put 1.06 bags per second. The increase from 0.99 to 1.07 is due to the fact that the motor wasn't fully loaded causing it to rotate faster than the name plate RPM. The calculated output RPM was calculated to be 59 RPM and with the motor not fully loaded it was 63 RPM. The increase of 4 RPM just meant the material went on the machine faster. This wasn’t an issue it just helped improve the time factor of the machine.

With the material going on faster the next part was testing the cutting process. The cutting process on the old machine was 0.48 bags per second. The new machine had an average cutting time of 7.17 bags per second. This met the requirement of being able to cut 60 bags within 10 seconds. With the cutting time having such a large improvement it was necessary to compare the old and new machine to see the time saving it offered. By taking the average spool and cut time from figure 7, it was possible to do a 60 bag comparison. The comparison measure the amount of time it took to make 60 bags between the two machines. From the data of the current machine would take 194 second while the new machine would take 65 seconds. The cut down in time meant that the new machine was 2.97 times faster than the old machine.



F-1: Original Machine Used to Cut Bags

Appendix G – Evaluation Sheet

Senior Project Test Sheet

Name: Trevor Reher

Date: 4/15/2016

Shellfish Bag Maker Testing Data					
Test Number	Spool Time (Sec)	Cut Time (Sec)	Number of Bag Cut	Bags Spooled Per Second	Bags Cut Per Second
1	64	N/A	67	1.05	N/A
2	36	8.67	38	1.06	4.37
3	57	11.65	60	1.06	5.15
4	65	10.5	69	1.06	6.57
5	59.5	5.0	63	1.06	12.60
6					
7					
8					
9					
10					
Average Cut Time (Bags/Sec)	= 7.17				
Average spool Time (Bags/Sec)	= 1.06				

Number of bags cut equals the number of bags spooled.

Spool Time = # Bags cut/Spool time

Cut Timing = # Bags cut/ Cut time

G-1: evaluation sheet

Senior Project Check list

Name: Trevor Reher

Date:

Testing Check list		
Item	**Quantity**	**Check Off**
Machine	1	✓
Spool of raw material	1	✓
Stop Watch	1	✓
Smart phone/ video camera	1	✓
Extra person	1	✓
Crane in place	N/A	✓
Safety Glasses	2	✓
110V power	2	✓

G-2: Procedure Check List