Notchmatic

The Cooper Machine Co.

February 4, 2015

Contents

Preface

This report was written to document the design of the Cooper Machine Co. Notchmatic tube notching machine as of the end of Fall 2014. The project was completed by five mechanical engineering students for Cooper Union's Design Elements course. We owe many thanks to Estuardo Rodas, George Sidebotham, and Stan Wei for making this project possible.

Introduction

This report contains the designs that led to the final tube notching machine. An overview of the purpose, usage, and requirements for the machine are given. The Notchmatic and its components are described in detail. Design calculations are given. A full bill of materials and cost report are provide. Part and assembly drawings are given as well. All datasheets for off-the-shelf parts are given. For usage, installation, maintenance, and safety information, please wait until the end of the spring semester.

All of the files (CAD, reports, etc.) related to the machine can be downloaded from our git repository.

Figure 1: A welded notched tube.

Chapter 1

Tube notching basics

Tube Notching is a useful machining process in applications ranging from HVAC to metal framing. In these applications, it is common for low-gauge hollow tubing to be notched prior to welding or fastening. Notching is a process involving the removal of a section or end of a metal or plastic tube such that they can be coped with one another.

Notches vary greatly depending on their application. The following figures are examples of welded round tubes:

Figure 1.1: Hand rail for stairs

Figure 1.2: Welded frame for an all terrain rock buggy.

Typically, tube notching is completed using a common holesaw cutter and careful positioning of the tube itself. This involves time consuming measurements, careful fixturing, custom jigs, and multiple drill bits and cutters.A single project or workpiece can involve multiple notch sizes in a variety of notch configurations. In these situations, set up time and tool cost can compound to wasted time and money. Replacing typical notching methods with a single tube notching machine cuts down setup time and provides a variety of different notch configurations.

Using a tube notcher, a single machinist can cut notches of any radius in its operating range using a single drill bit, due to its eccentric spindle mechanism. The machine also has a 4 degrees of freedom. A single workpiece can easily be positioned at any angle and any position from the cutting edge in the x, y, and z directions.

Chapter 2

Machine Description

The Cooper Union for the Advancement of Science and Art has never, in its history, owned its own Tube Notcher. For this reason, the Cooper Union Machine Co sought to design and build one for the institution. This machine will not just meet the same capabilities of Tube Notchers currently on the market but will surpass them in its design capabilities and will do so at a fraction of the cost.

2.1 Overview

Cooper Union Machine Co.'s Tube Notcher is a variable speed, 4 degree of freedom, variable radius notching machine for hollow tubing. Designed for The Cooper Union's student machine shop, the machine has a small footprint, can be operated by an amateur machinist, and is low cost. To meet its design requirements, the machine was broken into 4 main subsystems; the structure, the driveline, the fixturing mechanism, and the electrical system.

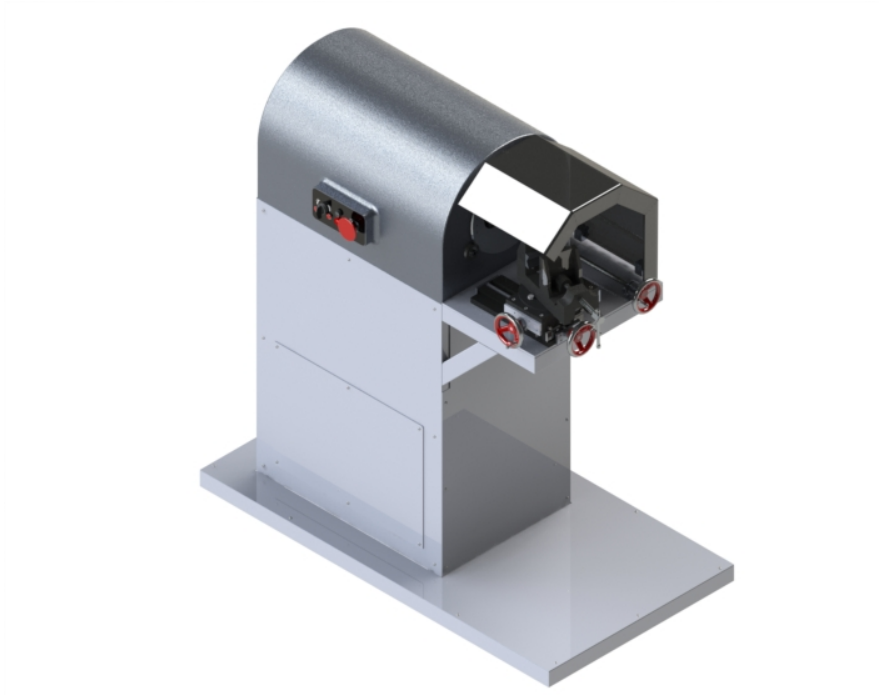


Figure 2.1: Full SolidWorks rendering of Cooper Machine Co's Tube Notcher

2.2 Description of subsystems

As mentioned in the previous section, the four subsystems of the tube notcher are the structure, the driveline, the fixturing mechanism, and the electrical system. The structure is composed of 3 parts; the frame, the shell, and the headstock. Its purpose is to support the weight of the machine itself, to withstand all forces generated while the machine is in use, and to facilitate the placement of the other subsystems for a user-friendly experience. The driveline is the largest of the 4 subsytems. It consists of the variator, eccentric, and spindle. Its purpose is to change the speed of the machine for use with different materials, allow for cuts of variable radius, and to house the end mill and collet during use. The fixturing mechanism is used to hold the workpiece in place and accommodate a variety of workpiece configurations relative to the cutting edge. Additionally, the fixturing mechanism must withstand the direct cutting forces during machining. Finally, the electrical system considers the electrical components of the system including the motors, switches, and controls for the machine. It also implements many of the safety mechanisms of the design itself.

2.2.1 Structural

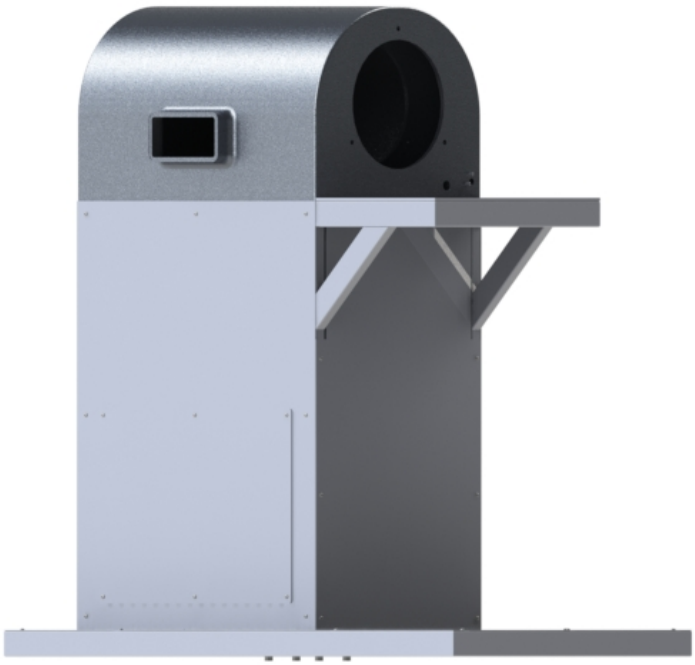


Figure 2.2: SolidWorks rendering of the frame and shell design

The Notchmatic's structure provides the strength of the machine and is the central body to which the other three subsystems are mounted to. The most critical part of the structure is the need to withstand the various static and dynamic loads that it experiences. This not only allows the Notchmatic to function properly while maintaining the precision of the cut but also keeps the user of the Notchmatic safe from potential failure due to excessive or unexpected loading conditions. The frame portion of the machine is designed to handle these loads. The shell is expected to experience some vibrations, at most, during machine operation. The main purpose of these components is to house all of the driveline parts, keep parts clear from metal shavings and other debris, keep the user away from dangerous components, and allow access to critical items for maintenance. Maintenance is critical to ensure a long life-span and consistent accuracy of the machine. The variator motor needs to be regularly lubricated, electronics must be regularly accessed, belts have to be checked for wear, and OSHA requirements need to be satisfied.

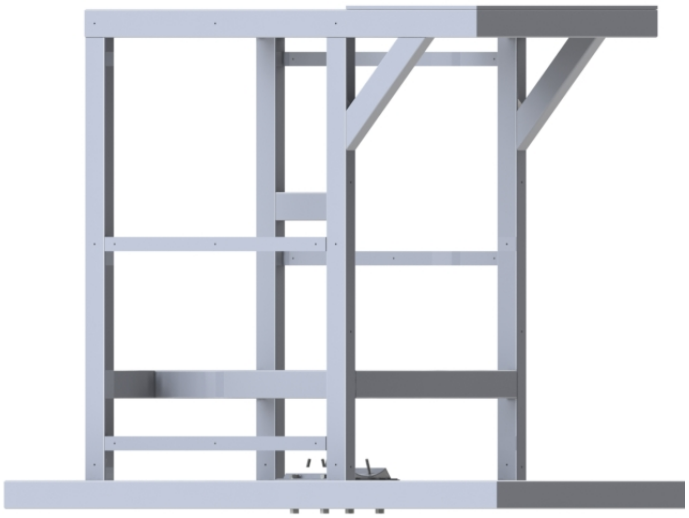


Figure 2.3: SolidWorks rendering of the Frame

The frame is largely constructed of hollow steel rectangular tubing and a single steel sheets spanning the length of the machine, as shown above. The frame of the machine provides the majority of the support and has mounting holes for the variator motor, variator pulley, spindle motor, and control box. A custom motor mount was created for the main spindle motor using a 0.25in steel plate. This was tested for natural frequency, and is not in the range affected by operation speed of machine; thus avoiding harmonic vibrations. Further damping prevents fastening from coming undone and makes overall installation more secure. For these dampers, rubber sheet was chosen over sandwich dampers to decrease cost and size. The mount has 6 mounting holes and sits at the base of the design. A rendering of the motor mount is shown below.

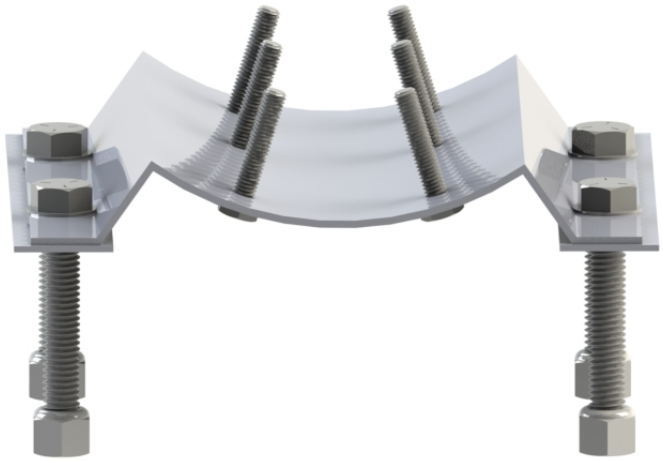


Figure 2.4: SolidWorks rendering of the Motor Mount

The final component of the frame is the steel bed. The bed is made from a single 0.25in steel plate. At

the cutting end, it includes a latticed rib pattern. This greatly increases bed strength and, for that reason, is a common technique used in industry. This bears the heaviest loads during machine operation. On the other end, a diagonal cross support beam supports the bed. The bed will be constructed separately and then fit into the overall frame; allowing for easier installation of the fixturing mechanism and headstock. The figure below shows the underside of the steel bed to show the support members that add strength to the structure. The right end is where the cutting for the machine takes place. As described earlier, this part of the frame experiences the highest loads. Another reason to have an overdesigned bed is to reduce the deflection of the bed itself. Reducing the deflection increases the precision of the machine and can allow workpieces with higher tolerences to be machined.

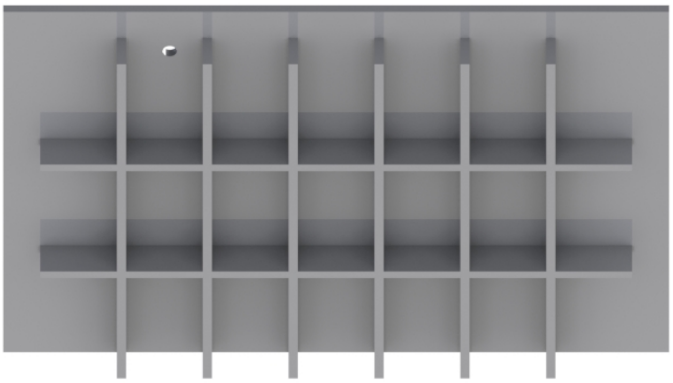


Figure 2.5: SolidWorks rendering of the Bed

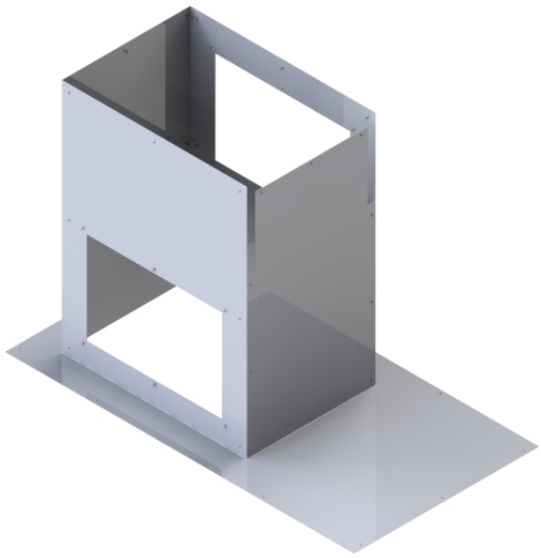


Figure 2.6: SolidWorks rendering of the Shell

The shell of the Notchmatic, seen above, is the next biggest section of the structure of the machine. Initially, the shell was made from 18 gage aluminum sheets, but has since been replaced with 18 gage steel sheets. This material change reduces the surface damage of the machine resulting in a longer machine life. The shell is made of 5 separate steel sheets to simplify the fabrication of the machine. Welding copious amounts of thin steel sheets together would have been difficult, and aluminum would not have been plausible. The benefits of using the steel sheets for cost, strength, a machinability made the switch from to aluminum to steel a clear and obvious decision. The steel sheets are attached to the frame (one on each side of the machine and one at the base). The base plate completes the machine's aesthetics instead of leaving exposed frame.

There is a hole in the middle of the base sheet frame, and no two sheets should be in contact in order to avoid possible vibrations issues. Additionally, the base frame prevents the machine from tipping over. The three side faces, excluding the side plate under bed, may be manufactured as a continuous sheet of steel. The minimum radius that can be bent from 18 gage sheet steel is smaller than .12 (the corner radius of the frame members), thus allowing the shell to be fastened securely to the frame. This is dependent on the machine shop's ability to bend three feet of 18 gage steel. Currently, the 5 sheet set up are fastened to the frame using bolts, as shown below. It's important to note that these bolts are offset from the corners to avoid tapping into welds. Also, internal-tooth locking washers are being used in lieu of split lock washers. While both would mitigate vibration-caused loosening on fasteners, the second provides a more finished look. Wheels will later be included to give mobility to an otherwise very heavy machine. They will be supported by welded-in. Bushings provide extra strength at these points.

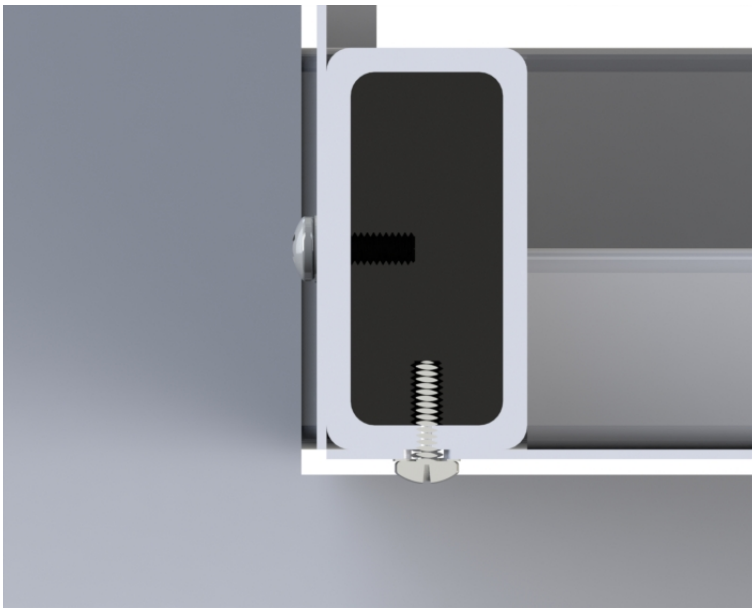


Figure 2.7: SolidWorks rendering of the Shell Fasteners

The headstock of the Notchmatic has the same pupose as the shell in addition to supporting the carrier plate support bearings and control panel. The Headstock will be cast from approximately 57 lbs of 6061 aluminum. The flat faces on the inside of the casting support the carrier plate while the remaining portion protects the driveline from debris. The headstock also has holes to facilitate other components. On the front there is a mounting boss for the control panel and on the side of the cutting edge there is a hole for the eccentric drive handwheel shaft and for the safety shield shaft. Finally, there are holes in the base of the headstock so that it mounts to the steel bed of the frame. The figure below is the headstock casting alone used in the Notchmatic's design.

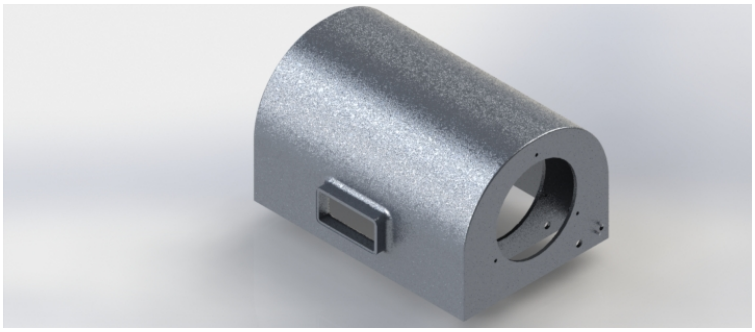


Figure 2.8: SolidWorks rendering of the Headstock Design

Detailed drawings of the fasteners used, machined parts, and assemblies can be found in Chapter 4.

2.2.2 Driveline

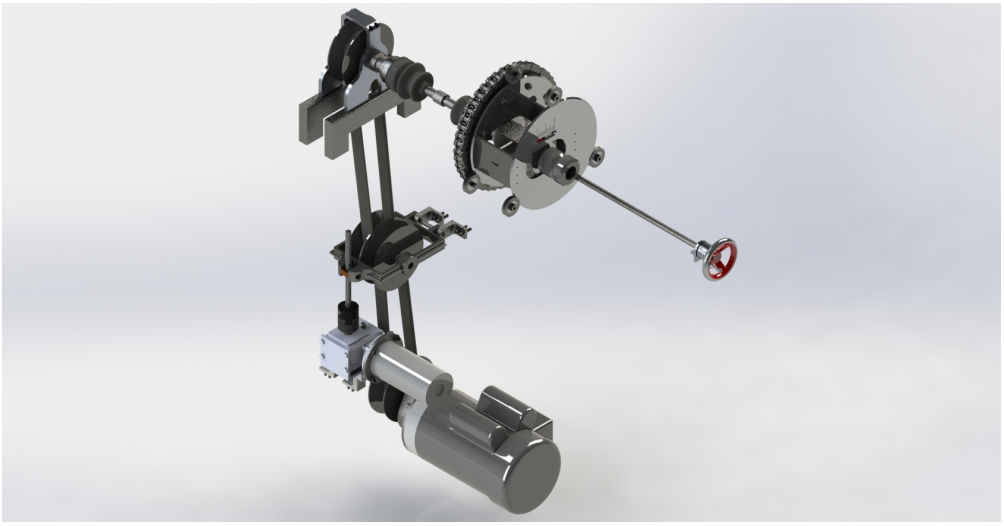


Figure 2.9: SolidWorks rendering of the Driveline

The Notchmatics driveline subsystem transmits power from the electric motor to the end mill. The subsystem is further broken into three discrete parts: the spindle gearbox, the variator assembly, and the headstock driveshaft. The electric motor chosen to run the Notchmatic is a 1.5hp 110/220 VAC split phase squirrel cage motor. Due to the build constraints, this motor operates at approximately 1725 RPM. While this upper RPM bound is good for steels, and cast irons, for metals like aluminum, brass, and copper, much higher spindle speeds are recommended. Initial conservative calculations suggested that the Notchmatic would need at most 2/3hp for the heaviest possible cut the machine would be able to perform. Therefore the decision was made to step up gear up the motors output speed 2.5:1. To accomplish this, a pair of helical gears rated for 2hp was selected from Boston Gears extensive gear catalogs. Helical gears were chosen for their smoother running capabilities as well as their smaller form factor.

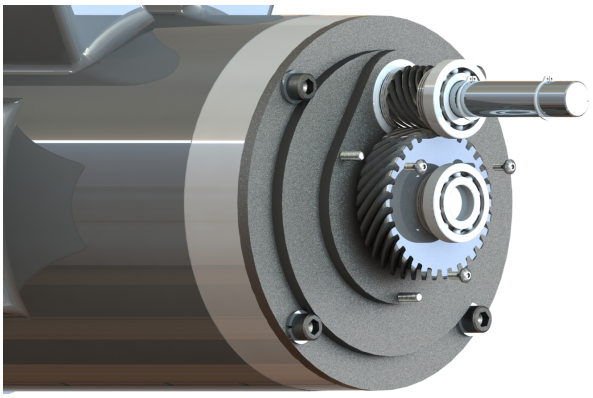


Figure 2.10: SolidWorks rendering of the Gearbox Internal Assembly

One of the inherent downsides to helical gears however was their need for thrust compensating bearings. While this complicated the gearbox assembly, the relative cost savings and smaller form factor were deemed more important. The output shaft of the spindle gearbox runs to the bottom-end variable speed pulley. While this pulley has the same 16 slope as the variator pulleys, the bottom-end variable speed pulley has a fixed thickness. This ensures that the belt rides at one level of the pulley.

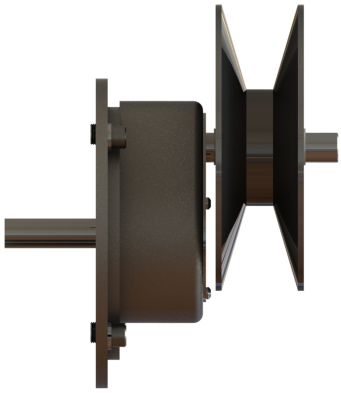


Figure 2.11: SolidWorks rendering of the Gearbox and Pulley Assembly

The lower variable speed belt that runs from the bottom-end variable speed pulley to the variator assembly. This assembly serves to continuously modulate the spindle speed of the Notchmatic over a range from 100 rpm to 4300 rpm. This wide speed range is obtained achieved by the linking of the angular position of the variator frame with the position of the pulley core. Based on the position of the frame, belt tension from either the upper or lower belt will continuously adjust the location of the core. The core location has a direct relationship with the effective pulley radii of the upper and lower pulleys.

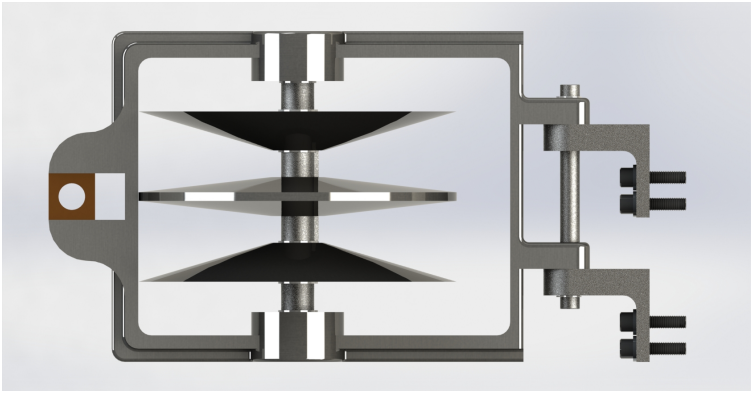


Figure 2.12: SolidWorks rendering of the variator frame countershaft without belts

In order to maintain dynamic stability within this system, the variator frame is adjusted by way of a DC servomotor, a 10:1 reducing gearbox, and a 1/5 pitch multistart precision ACME feed screw. Although the components within this portion of the variator subassembly were selected primarily due to the availability of the parts, the 10:1 gearbox not only allows for finer grained control of the variator position, but also increases the effective holding torque of the feedscrew.

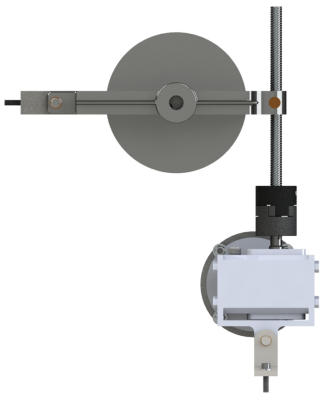


Figure 2.13: SolidWorks rendering of the DC motor, gearbox, and feedscrew

On the opposite side of the variators countershaft is the upper variable speed belt which runs to the top-end variable speed pulley. This pulley is identical to the bottom end pulley except for the bore diameter. On this top pulley, the bore diameter is 3/8 larger than on the bottom pulley. This top pulley is keyed to the rear headstock driveshaft. The rear headstock driveshaft serves as the fixed reference point for the entire headstock driveshaft assembly. At the termination of the rear driveshaft is a press-fit CV-joint housing. This press fit, rated to three times the full-load stall torque transmits the rotational power to the mid-shaft. The mid-shaft terminates in a second CV-joint which is keyed to the spindle nose. The decision to use a key rather than a press fit was motivated the requirement that the spindle bearings be lubricated after every 50 hours of service.

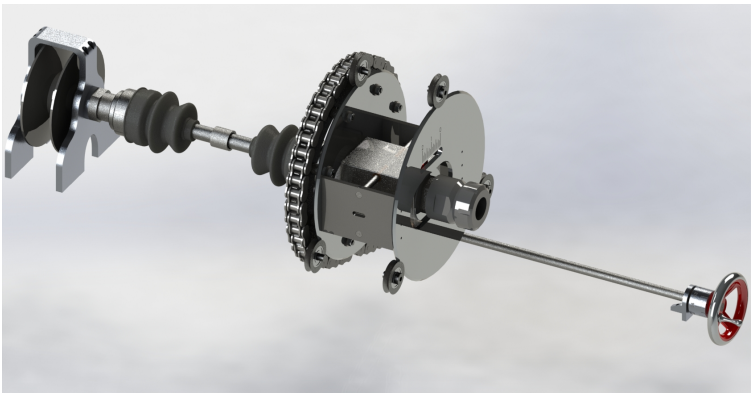


Figure 2.14: SolidWorks rendering of the overall headstock driveshaft assemblies

The spindle nose eccentric mechanism is where the Notchmatic differs from the others on the market. The spindle bearings are embedded within a bearing block which slides along a pair of precision ground 1045 steel rods. The position of this bearing block is driven by a 1/2-10 ACME threaded rod which enters from the side of the eccentric mechanism. In order to increase the effective stiffness of the system, a pair of precision ground carrier plates form the guide ways along which the bearing block travels. The whole eccentric mechanism is driven by No. 60H ANSI roller chain. This roller chain variant is capable of withstanding upwards of 2000 lbf in normal operation. The 1:5 drive sprocket ratio ensures that the operator will not have to exert much force in order to notch thick-walled tubing.

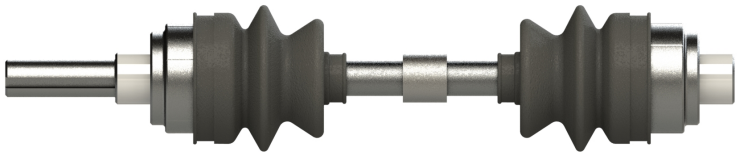


Figure 2.15: SolidWorks rendering of the Eccentric Assembly

Tool holding for the Notchmatic is achieved through the use of an ER-40 collet holder. This allows greater flexibility of the selected tool. The recommended cutting tool for the Notchmatic is a 1 nitride coated roughing end mill. This style of tool pairs well with the Notchmatics wide speed range.

2.2.3 Fixturing

Figure 2.16: SolidWorks rendering of the Full Fixturing Mechanism

The fixturing mechanism for the Notchmatic assembly allows the workpiece to be positioned using three translational and one rotational degree of freedom. This allows the user to position the tube for centered notches, offset notches, angled notches, and even plunge cuts. Plunge cuts, however, require the user to purchase and use a separate end mills than the one currently used in the design. The full fixturing mechanism, shown above, is made from three main components; the dovetail slides, the rotational plate, and the vice. In the design of these components, it is critical that all loading conditions were considered. Thus, the material and fixturing decisions were made contingent upon the force analysis and calculations.

The dovetail slides, shown below, make up a large portion of the fixturing mechanism. The slides allow the workpiece to be moved horizontally along the machine table. The bottom "x" direction dovetail slide is mounted to the steel bed in the structure of the Notchmatic. This bottom dove tail slide uses a lead screw to move the top dovetail slide and consequently the rest of the fixturing apparatus. The dovetails slides will be machined from cast iron bars and will be fitted with cutom made lead screws. To operate the dovetail slides and position the workpiece, handwheels rotate the leadscrews resulting in translational movement. The image below shows a top view of the dovetail slide and its placement on the structure of the machine.

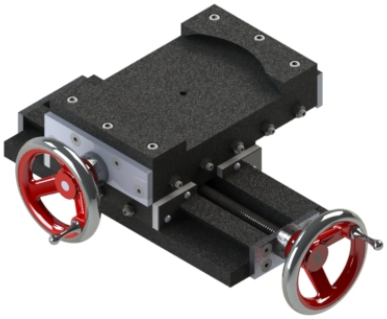


Figure 2.17: SolidWorks rendering of the Slide

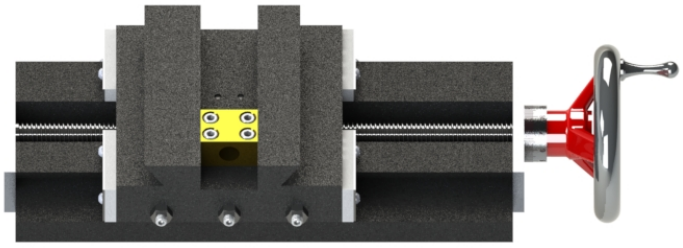


Figure 2.18: SolidWorks rendering of the Slide

On top of the slides is the rotational plate. The rotational plate provides the rotational degree of freedom so that angled cuts can be made into the workpiece. The rotation requires two plates; a pressure plate and a swivel plate. Both plates will be machined in house from raw materials. The block is rotated by lifting a cam handle and manually rotating the plate before locking the piece. To clamp, two screws are tightened which allows the plate to clamp to the swivel blocks mounted on the top of the dovetail stage. Like the slides, the rotating mechanism is made from steel and will require regular lubrication to function properly. The top swivel plate holds the vice which houses the workpiece. The vice is a standard machining vice that uses a lead screw to secure the piece. Since the workpiece on the Notchmatic is likely to be rounded, a vice jaw extension attachment will be custom made and attached to the original jaw. The vise jaw extensions will be made from welded plates and will be screwed onto the original jaws. They are sized to comfortably hold the smallest to largest tube diameters; 1in to 3.5in, respectively. This jaw can be moved towards or away from the bed of the launcher giving the final vertical degree of freedom. A thumb screw is used to set the jaw in place. The tube fits snugly in the jaw because it includes a v-block. The rotational block, vice, and jaw components are shown in the figure below.

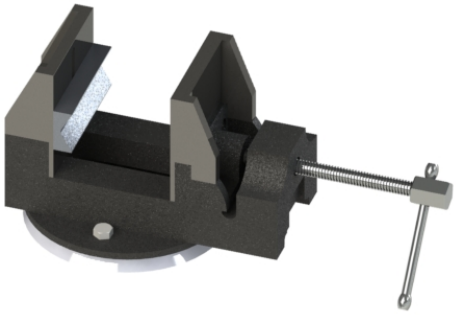


Figure 2.19: SolidWorks rendering of the Rotating Plates, Vice, and Jaw of the Fixturing Mechanism

2.2.4 Electrical

The electrical system is broken into two main sections; the circuit design and the electrical components. The circuit design includes all of the wired connections and safety of the electrical system in addition to their placement on the overall design of the tube notcher. The switches were selected according to these needs and were considered in parallel to the circuit design.

Circuit Design

The circuitry of the tube notcher is broken into the AC and DC power lines. The AC power line controls the spindle AC motor which drives the cutting tool. The DC power line, on the other hand, controls the variator motor driving the continuous variable transmission. The majority of the safety features are included in the DC Line. The circuit begins from the wall outlet which provides 120VAC single phase. After the outlet, the first component is an anti automatic restart protection plug. For safety reasons, this is a critical component in the circuit for the tube notcher. After the protection plug, there is a 20A circuit breaker. From here, the power line is split between AC line and the DC line, as described earlier. A schematic of the wall components is shown below.

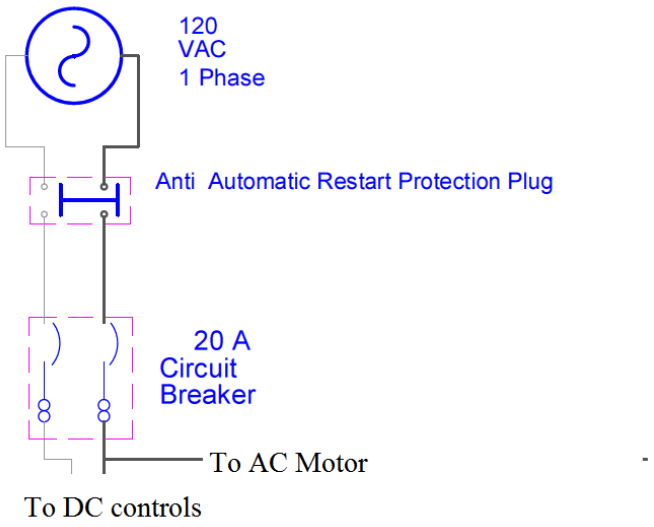


Figure 2.20: Schematic of the wall outlet connections and components

The AC line is the simpler of the two lines and is composed of only 2 components. First, there is a drum switch that controls the rotational direction, including netural, of the spindle. The spindle is driven by an AC motor. The entire AC line is shown in the figure below. The additional on/off control of the motor, however, is controlled by relays which are included in the DC line.

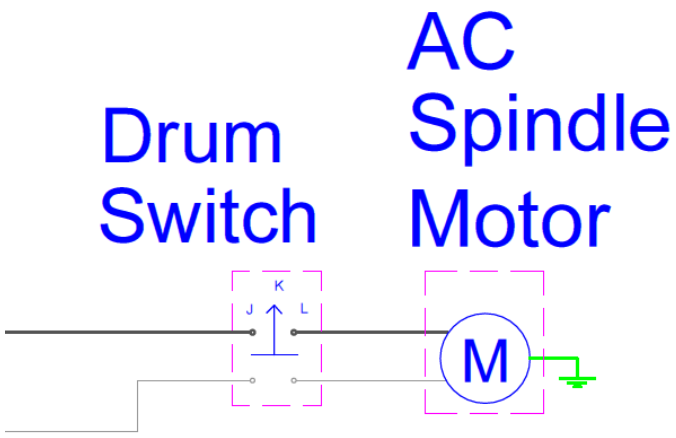


Figure 2.21: Schematic of the AC line

The DC line includes the majority of the circuitry for the tube notcher. Because the power originally starts from the wall, the first step in the DC line is to convert the voltage from 120VAC to 12VDC. This is done in two stages. First, a transformer steps down the voltage from 120 VAC to 12 VAC. Then, a full wave rectifier converts the 12VAC into 12VDC. To protect the rest of the circuit, a 20A fuse is connected at the output of the positive DC terminal of the full wave rectifier. Capacitors are connected from the DC positive to DC negative in order to smooth out the DC output from the rectifier. This will provide power and ground the DC controls. This segment of the DC circuit is shown in the following figure.

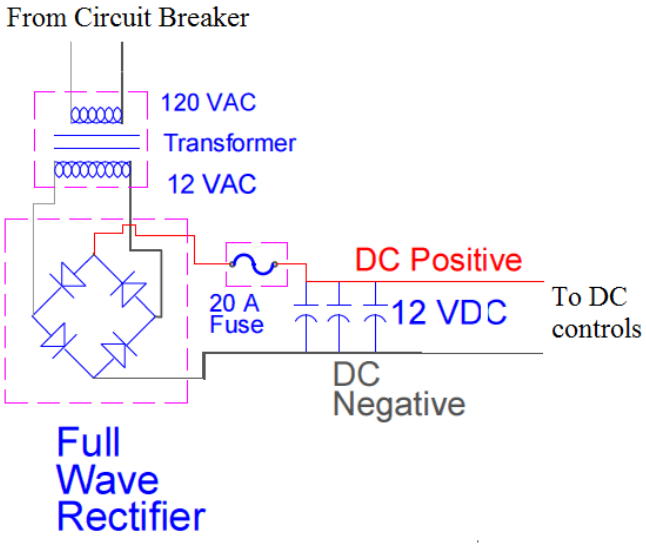


Figure 2.22: Schematic of the AC to DC conversion

The remainder of the DC line includes the switches and relays that allow the tube notcher to function. Also included are the safety features which will be elaborated on in the following section. In total, there are 7 switches and 6 relays.

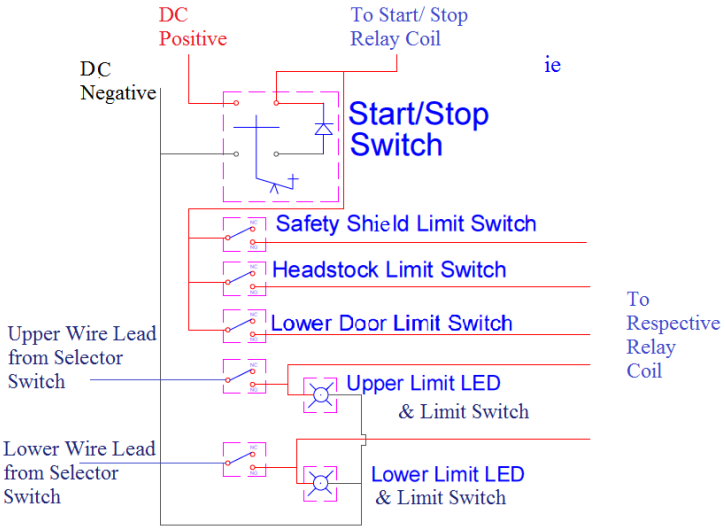


Figure 2.23: Schematic of the Start/Stop and Limit Switches

The figure above depicts 6 of the switches used in the tube notchers design; the start/stop, safety shield, headstock, lower door, and variator limit switches. DC positive and negative lines are connected to the terminals of the start/ stop switch. Once the start/ stop switch is turned "on", all the limit switches have a source of power, except the upper and lower limit switch which are powered by the selector switch. The start/ stop is connected to a relay coil which will turn on the AC and DC motors of the tube notcher. It is very important that the DC motor only runs when the AC motor is also running. If DC motor runs when the AC motor is off, the belts of the variator pulley will experience slack, become loose and belt will slip off the pulley.

There are various limit switches on the tube notcher that mainly control corresponding relays to turn the AC and DC motors "off" or "on". All the limit switches are Ormon Z-15GW2-B, which has a long lever arm with a wheel at the end. The limit switches are connected to a relay coil which will turn "on/off" the AC and DC motors of the tube notcher. When the limit switch contacts are close, the relay coils are magnetize. All of the limit switches are placed in series with one another.

The safety shield limit switch contact is closed when the safety shield is covering the cutting tool and pushing the lever arm of the limit switch. Similiarly, the headstock door and lower door limit switches contacts are closed when the door closes and pushes the lever arm of the limit switch. The last two limit switches are for the variator pulleys. It is critical that the variator pulleys do not over-travel beyond the upper and lower limits. Therefore, there are limit switches for the upper and lower limits of the variator pulley. When the pulley contacts the lever arm, the limit switch contact is close, providing power the relay coil to turn the DC motor off.

The final switch is the 3-position center-return selector switch; depicted below. The 3 position selector switch is used for controlling the vertical position of the variator pulley by driving a DC motor that is attached to a feed screw that vertically positions the variator pulley. The selector switch has 3 positions: "increase"(left position), "stop" (center position), and "decrease" (right position). At the center position, all the contacts of selector switch are open which doesnt provide power to the DC motor, hence this is the stop position. When the knob is at the increase position (left position), the upper two contacts are closed and the bottom two contacts are opened, as seen below. The top wire lead is positive and the lower lead is negative

which causes the DC motor to spin in a direction that moves the variator pulley upwards. In the decrease position (right position), the upper two contacts are opened and the bottom two contacts are closed which changes the polarity of the DC motor. Opposite of the increase position, the polarity of the DC motor wire lead is reverse: the top wire lead is negative and the lower lead is positive which causes the DC motor to spin a direction that moves the variator pulley downwards. When the top wire lead is positive ("increase" position) , power is provide for the upper limit switch. With power, when variator pulley over-travels, the upper limit switch is able to magnetize the relay coil to turn the DC motor off. This is equivalent to a "AND" logic; when "increase" position is selected AND upper limit switch is pushed, then the DC motor can turn off. The red "increase" LED indicator turns to indict over-traveling. When the user selects the "decrease" position, the DC motor regains power.

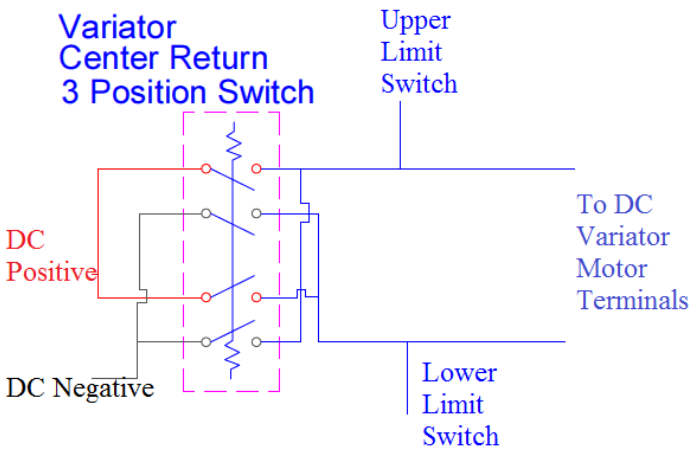


Figure 2.24: Schematic of the 3-position center-return selector switch

Relays are used for controlling on/off for both AC and DC motors of the tube notcher. There is an emergency button that opens the contacts for both motors when the button is press. The relay are DPDT which means double pole double throw. Below is a schematic of a DPDT start/stop relay. Double poles means there are two separate contacts that are triggered by magnetized coil. Double throw means for each contact, there is a normally closed terminal (NC) and a normally opened terminal (NO) that shared a common terminal (left side of the contacts). When the coil is not magnetized, the contact is unmoved causing the common terminal and normally closed terminal to be connected. When the coil is magnetized by a limit switch or start/stop button providing current into the coil, the contact is shifted causing the common terminal and normally opened terminal to be connected. There is a flyback diode connected in parallel with the coil to prevent high current spikes when the contact that provides current to the coil is closed.

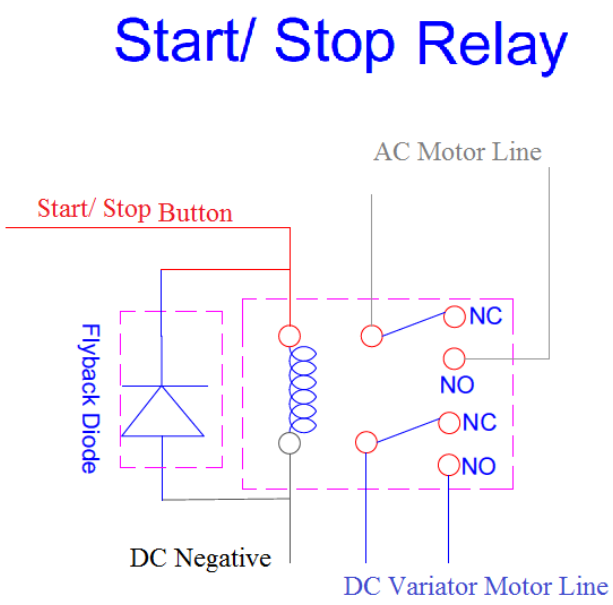


Figure 2.25: Schematic of the Start/Stop Switch Relay

The relay contacts and emergency button are connected in series. This is equivalent to an OR logic which means the motors will turn off when any of the limit switches, emergency button or start/stop button is triggered. This a safety feature of the tube notcher. The normally opened terminals of the start/stop relay, safely shield relay, headstock relay and lower door relay are connected in series for each motor connection and their contacts will closed when their respective limit switch or start/stop button provides current. For the DC motor, in addition to those relays, the normally closed terminals of the upper variator relay and lower variator relay are also connected in series. Their contacts will open when their respective limit switch is closed by the variator pulley pushing the lever arm. In this relay connection, the case, as mentioned before, when the AC motor is off and the DC motor is on cannot happen.

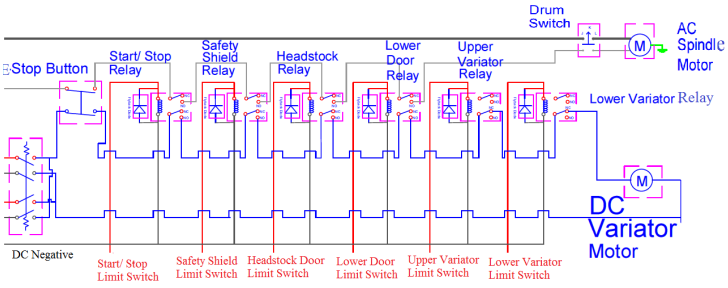


Figure 2.26: Schematic of the Relays

Electrical Components

The control aspects of the tube notcher are kept under low voltage DC. Keeping a lower voltage is safer for the user and cost efficient. To simplify maintence and part replacement only one type of relay and limit switch is used in the design. The relay and socket come inpairs. The particular relay used in Notchmatic's design has a good reputation in industry for being reliable and robust. Although, the power rating for this relay is beyond what the tube notcher is expected to experience, these relays are not as expensive as other relays of similar performance. These relays are also popular in industry; making replacement for these relays

less difficult. This relay is DPDT which means it provides normally opened and closed connections while other relays provide only normally opened or normally closed for the same cost. Additionally, socket mounts provides modularity, meaning relays can be swap and if a relay fails, the socket will not need to be replace. The screw terminals provide easier wire connections.

Like the relays, the limit switches on the Notchmatic have a good reputation in industry. They have a long lever arm that is more rigid than other limit switches. The mechanical life is expected to be over 5 million cycles and the electrical life is expected to be over 1 million cycles. The switches have holes for mounting and are easily wired using screw terminals.

As described earlier, an anti-restart plug is included into the design. According to OSHA safety standards, small motor machines must have an anti restart device to prevent the machine from restarting when there is a power interruption. This anti restart plug is easily attached to the tube notcher before connected to the outlet.

Figure 2.27: Solidworks rendering of of the Control Box

The majority of the electrical system's components are placed in three locations, the control box, the control panel, and the safety shield. The control box is located at the bottom of the Notchmatic, as shown in the figure above. It contains the relays and other circuit components that are included in the design. The majority of the switches, however, are located on the control panel. The control panel as seen below, is mounted to the headstock and has the majority of the switches that operate the machine. The switches that are not on the control panel are the limit switches. These are located on the safety shield, see below, and on the variator pully ends. Access to all the switches were made easy so that even an amateur macinist could operate the Notchmatic with ease.

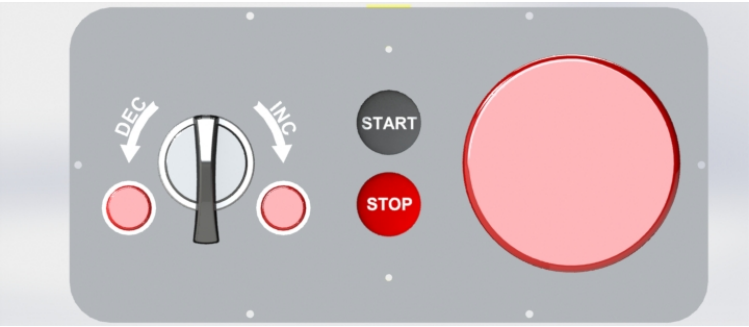


Figure 2.28: SolidWorks rendering of the Control Panel

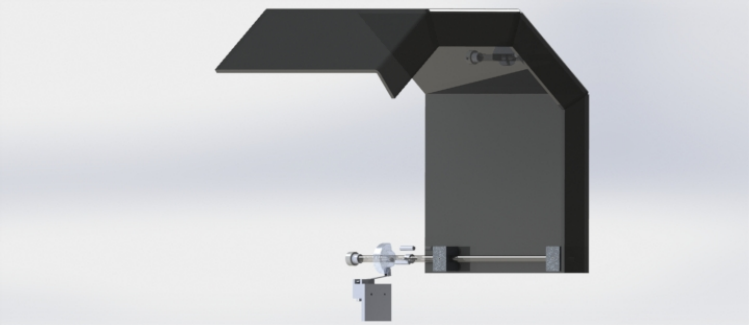


Figure 2.29: SolidWorks rendering of the Safety Shield

Chapter 3

Calculations

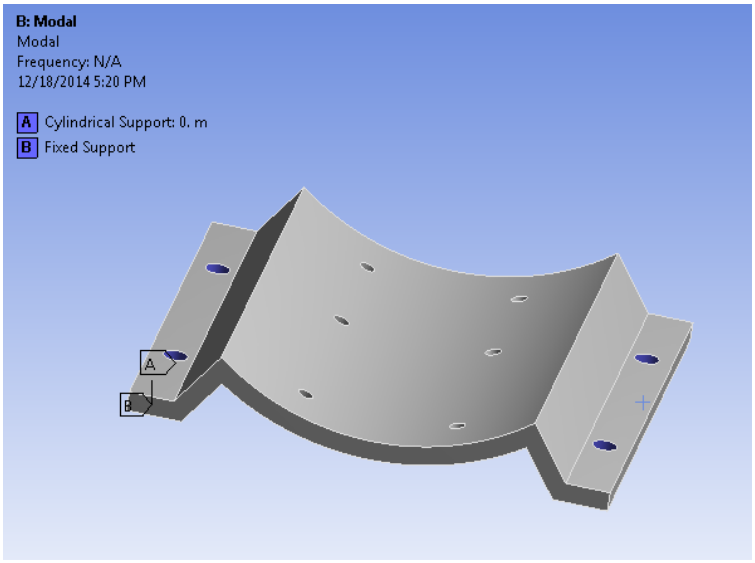
3.1 Structural

The steel sheets that make up the shell of the Notchmatic require a minimum length of thread engagement in order to fit securely. To calculate this length, the equation below is used. In the equation, At is Thread Tensile Stress Area, Knmax is Maximum Minor Diameter Internal Thread, Esmin is Minimum Pitch Diameter External Thread, and n is the Threads per Inch.

$$L_e = \frac{2 \times A_t}{K_n max \ \pi \left(\frac{1}{2} + 0.57735 \ n \left(E_s \ min - K_n \ max \right) \right)}$$

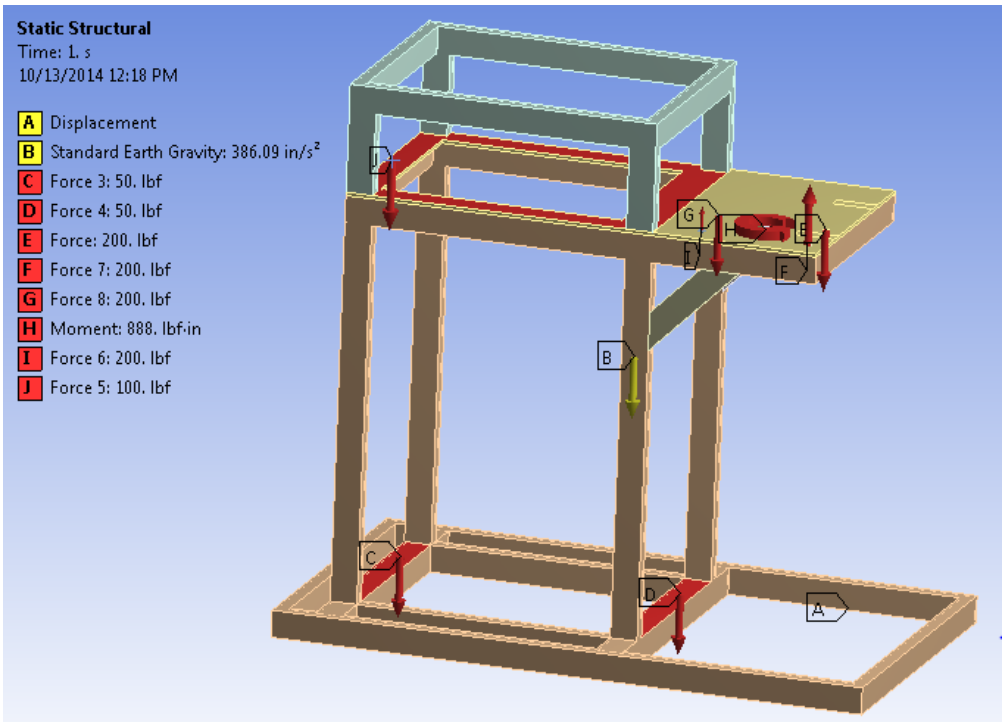
Fastener thread engagement length for a 8-32 bolt is 0.140 inches. The head stock frame thickness is 0.12 inches. Although, the head stock frame thickness is 0.02 inches less than the require fastener thread engagement length, the head stock frame does not experience any significant load during cutting operations.

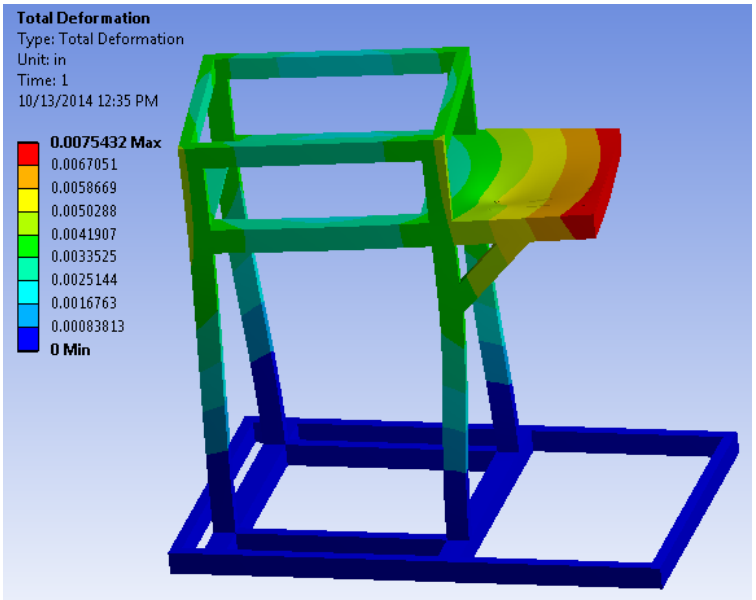
The following is a calculation of the effects of vibration on the Motor Mount of the AC Spindle Drive Motor. ANSYS Mechanical was used and the frequency at the first 6 modes were found. The rpm of the driveline motor is 1750, and the natural frequency of the motor mount is over 2000.

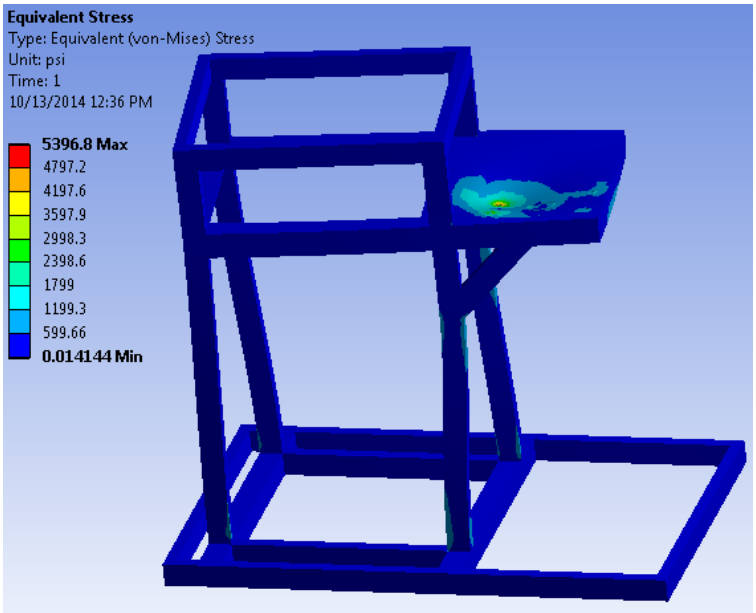


An ANSYS FEA Analysis was conducted earlier in the design in the frame. Since that esign iteration, the base structure of the frame has not changed dramatically. For that reason, it was concluded that the frame's current design, sufficiently bears the forces that the machine will experience during operation. Below is the results of the earlier simulation.

In total 8 loads, labeled C to J, were applied to the frame. Loads C and D represent the weight of the spindle motor and transformer. Load E represents the weight of an individual leaning on the machine while it is in use. Loads F,G,H, and I represent forces that are generated when a piece is being machined. Lastly, Load J represents the weight of the aluminum headstock and the driveline assembly.







This current test demonstrated a displacement of 6.93e-5 meters at the hanging beds edges (much less than the goal 1/32 inches maximum deflection of the bed) and a maximum stress of only 9.4e6 Pa. However, the model must be retested with corrected values from cutting force calculations. This current test demonstrated a displacement of 6.93e-5 meters at the hanging beds edges (much less than the goal 1/32 inches maximum deflection of the bed) and a maximum stress of only 9.4e6 Pa.

Chapter 4

Bill of Materials

4.1 Overview

As mentioned previously, Cooper Union Machine Co's Tube Notcher was designed to be cheaper than tube notchers currently on the market. To do so the machine was compared to Baleigh Industrial's Tube Notcher; the TN-800. Baileigh Industrial's design, shown below, can be purchased for $7,995.00.

Figure 4.1: Baileigh Industrial's TN-800 Tube and Pipe Notcher

After designing the machine as seen in Chapter 2, Cooper Union Machine Co's Tube Notcher costs $3423.44 to manufacture. The cost of the Notchmatic considers two situations. The first is the full cost of the machine assuming that new materials are purchased and the entire material is built from scratch. The second is the final cost of the machine and only considers the cost of the machine to the Department of Mechanical Engineering at The Cooper Union. This removes any hardware which will be graciously provided by the Cooper Union's Machine Shop as well as all materials that were donated to the project or recycled from The Cooper Union. In reality, many of the parts were acquired from The Cooper Union. The full cost for the Notchmatic amounts to $3000.00. After reductions, however, the final cost of the tube notcher is only $2149.51 total. Compared to Baileigh Industrial's machine, Cooper Union Machine Co can build an equivalent system for 33% of the cost.

The following section lists the components and associated costs of each subsystem of the Tube Notcher.

ME336:	Tube Notcher
Cost Report:	Summary
Team:	David Chen
	Kevin John
	Jackie Song
	Kunsoo Yuk
	Jon Zorko

Quantity	System	Description	Raw Materials	New Parts	Hardware	Subsystem	Total
92	Driveline	Variator, Eccentric, Spindle	$182.28	$842.26	$117.81	$1,024.54	$2,198.00
24	Fixturing	Vices, Slides	$276.96	$123.17	$73.19	$400.13	
37	Electrical	Motor, Wiring, Safety, Switches	$40.79	$305.76	$0.00	$346.55	
35	Structural	Headstock, Frame, Shell	$426.78	$0.00	$34.86	$426.78	

Type	Cost	Comparison
Baleigh Industrial	$7,995.00	$5,797.00
New Machine	$3,534.97	$1,336.97
Our Machine + Hardware	$2,423.86	$225.86
Our Machine	$2,198.00	$0.00

Key	Color
Purchased	
Raw Material	
Hardware	

Figure 4.2: Overall Cost for CMC's Notchmatic

4.1.1 Structural

Quantity	Part Number	Vender	Description	Price	Extension
2		Discount Steel	ASTM A1008 Cold Rolled Sheet, 18 ga (.048in), 4'x8'	63.36	$126.72
1		McMaster	Ultra-Strength Neoprene Sheet (1/16"), 6" x 6"	$5.49	$5.49
1	6210	Bolt Depot	Hex 6x1x30mm	$7.16	$7.16
1	322	Bolt Depot	Hex 1/4"-20 x 5/8in (Zinc-plated Grade5)	$4.05	$4.05
1	1552	Bolt Depot	Philips pan 8-32 x 1/2	$1.90	$1.90
1	363	Bolt Depot	Hex 3/8-16 x 2-1/2in (50 Pack)	$9.64	$9.64
1	91113A031	McMaster	Lock Washer 3/8" Screw Size, 0.384" ID, 0.692" OD	$5.38	$5.38
1	91113A009	McMaster	Lock Washer #8 Screw Size, 0.384" ID, 0.692" OD	$2.59	$2.59
1	97135A230	McMaster	Steel (Grade 8) nylon insert(3/8"-16)	$4.14	$4.14
3		Speedy Metals	1"x2"x.120"Wall, 18" length, Steel	$6.65	$19.95
0		Speedy Metals	1"x2"x.120"Wall, 24" length, Steel	$8.74	$0.00
4		Speedy Metals	1"x2"x.120"Wall, 36" length, Steel	$12.99	$51.96
6		Speedy Metals	1"x2"x.120"Wall, 48" length, Steel	$17.15	$102.90
2		Speedy Metals	2"x2"x.120"Wall, 18" length, Steel	$7.19	$14.38
2		Speedy Metals	2"x2"x.120"Wall, 18" length, Steel	$7.19	$14.38
3		Speedy Metals	.25"x1" Flat, 48" length, Steel	$10.08	$30.24
3		Speedy Metals	.25"x1" Flat, 48" length, Steel	$6.26	$18.78
2		Speedy Metals	12"x24"x1/4" A-36 Steel Plate	$20.99	$41.98
65		Alibaba	Aluminum 6061 Scrap Ingot (1lb)	$0.70	$45.50
				Raw Materials	$472.28
				New Parts	$0.00
				Hardware	$34.86
				Total	$507.14

Figure 4.3: Full Cost Report for the Structural System

The structure of the Notchmatic, in total, costs $461.64. Because the frame was designed around the loads generated by this particular machine, it was custom made. Therefore, the structure is made from only raw materials and hardware for fastening. The majority of the cost for this system comes from the raw materials which includes the steel beams for the frame, the steel sheets for the shell, and the aluminum material needed to cast the headstock. Since the maufacturing of the Notchmatic is done in-house, there is no associated manufacturing cost for the machine. Additionally, raw materials can be ordered from bulk metal suppliers as seen in the cost report above. Suppliers such as McMaster, Bolt Depot, and Speedy Metals. The steel bed and shell material choice reduced the cost of the machine. By reinforcing the bed rather than simply using a thicker bed, the cost was reduced without jeopardizing the structural strength of the machine. Secondly, the shell cost was reduced by switching from aluminum to steel. After removing the fasteners , which will be provided by The Cooper Union Machine Shop, the final cost for the structural system reduces to $426.78. This saves a total of $50.00 from the overall cost of the machine. Another key cost reduction is the headstock casting material. The aluminum used to cast the headstock will come from recycled aluminum found in The Cooper Union and are ,therefore, not included in the final cost for the machine. The cost report below shows the final cost of the machine after removing the fasteners and casting material from the full cost report. This is the amount needed to build and assemble the structure for the Notchmatic at The Cooper Union.

Quantity	Part Number	Vender	Description	Price	Extension
2		Discount Steel	ASTM A1008 Cold Rolled Sheet, 18 ga (.048in), 4'x8'	63.36	$126.72
1		McMaster	Ultra-Strength Neoprene Sheet (1/16"), 6" x 6"	$5.49	$5.49
3		Speedy Metals	1"x2"x.120"Wall, 18" length, Steel	$6.65	$19.95
0		Speedy Metals	1"x2"x.120"Wall, 24" length, Steel	$8.74	$0.00
4		Speedy Metals	1"x2"x.120"Wall, 36" length, Steel	$12.99	$51.96
6		Speedy Metals	1"x2"x.120"Wall, 48" length, Steel	$17.15	$102.90
2		Speedy Metals	2"x2"x.120"Wall, 18" length, Steel	$7.19	$14.38
2		Speedy Metals	2"x2"x.120"Wall, 18" length, Steel	$7.19	$14.38
3		Speedy Metals	.25"x1" Flat, 48" length, Steel	$10.08	$30.24
3		Speedy Metals	.25"x1" Flat, 48" length, Steel	$6.26	$18.78
2		Speedy Metals	12"x24"x1/4" A-36 Steel Plate	$20.99	$41.98
				Raw Materials	$426.78
				New Parts	$0.00
				Hardware	$0.00
				Total	$426.78

Figure 4.4: Final Cost Report for the Structural System

4.1.2 Driveline

Quantity	Part Number	Vender	Description	Price	Extension
6	6200 ZJEM (C3)	Motion Industries	Carrier Bearing	$10.69	$64.14
2	18590/18520/Q	Motion Industries	Spindle Nose Bearings	$147.46	$294.92
1	C1.25-ER40-4.0	Maritool	ER40 Collet Holder- Straight Shank	$74.31	$74.31
1	93248110	MSC Direct	ER40 1" Collet	$35.73	$35.73
2		Speedy Metals	1/2" Eccentric Guide Rail	$4.69	$9.38
2	INV-02004181	Taylor Race Engineering	Tripod Housings	$219.00	$438.00
2	615-3	RCV Performance	Tripod Boot	$7.50	$15.00
1	N/A	Ebay	6" diameter Eccentric Handwheel	$39.99	$39.99
1	7265K5	McMaster	No. 60H Roller Chain	$21.10	$21.10
1	7265K524	McMaster	No. 60H Master Link	$2.06	$2.06
1	7265K524	McMaster	Eccentric Drive - Handwheel Sprocket	$16.31	$16.31
3	2938T1	McMaster	Eccentric Drive Sleeve Bearings	$0.49	$1.47
1		Speedy Metals	Eccentric Drive Sprocket Stock	$54.82	$54.82
2	3113K36	McMaster	Dimensionally Certified Sleeve Bearings	$4.53	$9.06
1		Speedy Metals	Spindle Nose Sleeve Stock	$14.00	$14.00
1	2020-1100	RCV Performance	Spindle Driveshaft	$185.00	$185.00
1		Speedy Metals	Spindle Driveshaft	$9.19	$9.19
1	97633A320	McMaster	Retaining C-Clips	$5.60	$5.60
1	6408K13	Mcmaster	Gearbox Coupler	$6.45	$6.45
1		Online Metals	Pulley Spacer	$3.16	$3.16
1		Speedy Metals	2" Hex Stock - Spindle Preload Nut	$10.71	$10.71
1		Speedy Metals	Spindle Block	$29.03	$29.03
2		Speedy Metals	Carrier Plates - 1045 Steel	$22.21	$44.42
1		Speedy Metals	Eccentric End Plates	$10.34	$10.34
1		Speedy Metals	Eccentric ACME Nut Retainer	$3.12	$3.12
1		Online Metals	Driveshaft Pulley Bushings	$3.16	$3.16
2	6384K65	Mcmaster	Countershaft Bearings	$9.59	$19.18
2	1430V215	V-Belt Supply	Variator V-Belt	$16.06	$32.12
1		Online Metals	Driveshaft Pulley Housing	$18.89	$18.89
1		Speedy Metals	Driveshaft Pulley Axle	$10.02	$10.02
1		Speedy Metals	Variator Pulleys	$104.24	$104.24
6	1677K4	Mcmaster	Frame/Feedscrew Pivot Bearings	$1.48	$8.88
1	97633A170	Mcmaster	Retaining C-Clips	$8.74	$8.74
1	93410A924	Mcmaster	ACME Threaded Rod - Eccentric	$16.38	$16.38
1	95270A114	Mcmaster	ACME Flange nut - Eccentric	$6.89	$6.89

Figure 4.5: Full Cost Report for the Driveline

1	99030A304	McMaster	Variator Feed Screw	$33.25	$33.25
1	99030A304	McMaster	Variator Feed Nut	$35.86	$35.86
1	H1230L	Amazon Supply	Spindle Motor Drive Gear	$49.03	$49.03
1	H1212R	Amazon Supply	Spindle Motor Driven Gear	$35.28	$35.28
4	5909K32	Mcmaster	Spindle Gearbox Thrust Bearing	$3.11	$12.44
8	5909K45	Mcmaster	Spindle Gearbox Thrust Washer	$1.10	$8.80
4	3760T4	Mcmaster	Spindle Gearbox Ball Bearing	$18.82	$75.28
1	97633A230	Mcmaster	Retaining C-Clips	$12.45	$12.45
1		Speedy Metals	5/8" Keyed Shaft	$9.39	$9.39
1	91251A446	McMaster	Steel Socket Head Cap Screw 1/4-28-1 1/2	$5.78	$5.78
1	91950A029	McMaster	Steel Flat Washer 1/4	$7.55	$7.55
1	94945A210	McMaster	Steel Nylon Hex Locknut 1/4-28-7/16	$9.23	$9.23
1	91251A146	McMaster	Steel Socket Head Cap Screw 6-32-3/8	$8.29	$8.29
1	91251A439	McMaster	Steel Socket Head Cap Screw 1/4-28-5/8	$6.03	$6.03
1	91251A437	McMaster	Steel Socket Head Cap Screw 1/4-28-1/2	$7.29	$7.29
1	91251A340	McMaster	Steel Socket Head Cap Screw 10-32-3/8	$9.10	$9.10
1	92313A829	McMaster	Steel Cup point Set Screw 10-32-1/2	$3.76	$3.76
1	98437A110	McMaster	1/4 Steel Split Lock Washer	$8.37	$8.37
1	93501A027	McMaster	Steel Spring Lock Washer	$9.14	$9.14
1	93501A007	McMaster	Steel Spring Lock Washer No 6	$7.43	$7.43
1	90715A115	McMaster	Steel Nylon Hex Locknut 10-32-3/8	$5.23	$5.23
1	97416A115	McMaster	Steel Flat Washer No 10	$3.82	$3.82
2	92271A111	Mcmaster	1/8" - 3/16" stepped key stock	$17.65	$35.30
				Raw Materials	$182.28
				New Parts	$1,723.82
				Hardware	$117.81
				Total	$2,023.91

Figure 4.6: Full Cost Report for the Driveline

Within the driveline subsystem there were two primary areas of notable cost savings. One area is the eccentric power transmission system, more specifically the CV joints, tripods, and mid-shaft. By using old Formula SAE spec. components, not only is approximately $500 saved, but also the components are oversized by a factor of four. The other notable area of cost savings is the spindle nose bearings. Traditionally, ABEC -7 machine-grade bearings are used to meet the demands of the high speed, high load conditions of the spindle nose. Bearings of this precision rating often cost around $1300 each. The more economical approach is to use bearings with a lower precision rating. However, simply using bearings with a lower precision rating will negatively impact the overall precision attainable with the machine. To offset this, a preloading torque is placed on these bearings. This preloading torque forces the concentricity of the spindle bearings to increase. This technique made it possible to use a set of ABEC-3 tapered roller bearings which cost $150 each.

Quantity	Part Number	Vender	Description	Price	Extension
6	6200 ZJEM (C3)	Motion Industries	Carrier Bearing	$10.69	$64.14
2	18590/18520/Q	Motion Industries	Spindle Nose Bearings	$147.46	$294.92
1	C1.25-ER40-4.0	Maritool	ER40 Collet Holder- Straight Shank	$74.31	$74.31
1	93248110	MSC Direct	ER40 1" Collet	$35.73	$35.73
2		Speedy Metals	1/2" Eccentric Guide Rail	$4.69	$9.38
1	N/A	Ebay	6" diameter Eccentric Handwheel	$39.99	$39.99
1	7265K5	McMaster	No. 60H Roller Chain	$21.10	$21.10
1	7265K524	McMaster	No. 60H Master Link	$2.06	$2.06
1	7265K524	McMaster	Eccentric Drive - Handwheel Sprocket	$16.31	$16.31
3	2938T1	McMaster	Eccentric Drive Sleeve Bearings	$0.49	$1.47
1		Speedy Metals	Eccentric Drive Sprocket Stock	$54.82	$54.82
2	3113K36	McMaster	Dimensionally Certified Sleeve Bearings	$4.53	$9.06
1		Speedy Metals	Spindle Driveshaft	$9.19	$9.19
1		Online Metals	Pulley Spacer	$3.16	$3.16
2		Speedy Metals	Carrier Plates - 1045 Steel	$22.21	$44.42
1		Speedy Metals	Eccentric End Plates	$10.34	$10.34
1		Speedy Metals	Eccentric ACME Nut Retainer	$3.12	$3.12
1		Online Metals	Driveshaft Pulley Bushings	$3.16	$3.16
2	6384K65	Mcmaster	Countershaft Bearings	$9.59	$19.18
2	1430V215	V-Belt Supply	Variator V-Belt	$16.06	$32.12
1		Online Metals	Driveshaft Pulley Housing	$18.89	$18.89
6	1677K4	Mcmaster	Frame/Feedscrew Pivot Bearings	$1.48	$8.88
1	93410A924	Mcmaster	ACME Threaded Rod - Eccentric	$16.38	$16.38
1	95270A114	Mcmaster	ACME Flange nut - Eccentric	$6.89	$6.89
1	H1230L	Amazon Supply	Spindle Motor Drive Gear	$49.03	$49.03
1	H1212R	Amazon Supply	Spindle Motor Driven Gear	$35.28	$35.28
4	5909K32	Mcmaster	Spindle Gearbox Thrust Bearing	$3.11	$12.44
8	5909K45	Mcmaster	Spindle Gearbox Thrust Washer	$1.10	$8.80
4	3760T4	Mcmaster	Spindle Gearbox Ball Bearing	$18.82	$75.28
1		Speedy Metals	5/8" Keyed Shaft	$9.39	$9.39
2	92271A111	Mcmaster	1/8" - 3/16" stepped key stock	$17.65	$35.30
				Raw Materials	$182.28
				New Parts	$842.26
				Hardware	
				Total	$1,024.54

Figure 4.7: Final Cost Report for the Driveline

4.1.3 Fixturing

Quantity	Part Number	Vendor	Description	Price	Extension
1	6053904	MSC	Lead Screw	$22.29	$22.29
2	95365A115	McMaster	ACME Nuts	$20.67	$41.34
1	61f.625x1.5	Speedy Metals	Bar stock for V-block	$2.36	$2.36
1	61f.375x1.5-18	Speedy Metals	Lead screw end plates	$4.99	$4.99
1	if2.25x5.25-36	Speedy Metals	Cast iron bar for dovetail slides	$210.44	$210.44
2	61r1.25	Speedy Metals	Round stock for dials	$0.70	$1.40
1	ir7	Speedy Metals	Stock for swivel plate	$20.37	$20.37
1	18f.25x7	Speedy Metals	Stock for swivel pressure plate	$15.33	$15.33
1	6sh18-12x12	Speedy Metals	Sheet for way wipers	$8.73	$8.73
1	if.75x1.5-18	Speedy Metals	Cast iron bar for gibs	$13.34	$13.34
1	-	eBay	Palmgren Swivel Vise	$160.00	$160.00
4	6391K172	McMaster	Screw end bearings	$0.83	$3.32
1	5720K11	McMaster	Cam handle	$12.43	$12.43
1	92505A545	McMaster	Gib screws	$5.56	$5.56
1	93181A029	McMaster	Gib screw locking nuts	$5.56	$5.56
1	91253A540	McMaster	Vise & Jaw Attachment mounting screws (top)	$7.74	$7.74
1	91251A346	McMaster	Acme nut mounting screws	$5.89	$5.89
1	91253A539	McMaster	End plate mounting screws	$11.00	$11.00
1	2FKB5	Grainger	Way wiper felt	$0.76	$0.76
1	94567A540	McMaster	Thumb screw	$2.24	$2.24
1	90116A323	McMaster	Vise Jaw Attachment mounting screws (side, stationary)	$6.74	$6.74
1	92005A423	McMaster	Vise Jaw Attachment mounting screws (side, floating)	$10.42	$10.42
1	97395A491	McMaster	Vise locating pin	$13.13	$13.13
1	91309A621	McMaster	Swivel locking screws	$9.64	$9.64
1	91251A537	McMaster	Swivel block mounting screws	$10.09	$10.09
1	91773A148	McMaster	Way wiper screws	$3.92	$3.92
1	98381A310	McMaster	Dial alignment pins	$6.58	$6.58
1	91253A355	McMaster	Bed mount screws	$9.43	$9.43
1	95462A515	McMaster	Bed mount nuts	$8.28	$8.28
				Raw Materials	$276.96
				New Parts	$283.17
				Hardware	$73.19
				Total	$633.32

Figure 4.8: Full Cost Report for the Fixturing Mechanism

The fixturing mechanism of the Notchmatic, in total, costs $633.32. As shown in the full cost report, the fixturing requires raw materials, fasteners, and new parts. Larger parts of the fixturing such as the dovetail stages, lead screws, rotational plates, and vblock are made from raw materials. Costs were reduced by buying larger blocks and machining them down as opposed to buying many smaller blocks. The greatest cost reduction in the design was achieved by removing the vice from the cost report. A vice was graciously donated to The Cooper Union Machine Co. by Professor Estuardo Rodas thereby reducing the cost by $160.00. Since the fixturing mechansim bears the majority of the cutting forces during the machine's operations, the quality and strength of this subsystem could not be jeopordized. Specific fastening equipment is also needed for this same reason. After removing the vice and the fasteners from the cost report, the final cost of the fixturing mechanisms is $400.13. The final budget for the fixturing mechanism is reduced to 63.2% of it's original full cost.

Quantity	Part Number	Vendor	Description	Price	Extension
1	6053904	MSC	Lead Screw	$22.29	$22.29
2	95365A115	McMaster	ACME Nuts	$20.67	$41.34
1	61f.625x1.5	Speedy Metals	Bar stock for V-block	$2.36	$2.36
1	61f.375x1.5-18	Speedy Metals	Lead screw end plates	$4.99	$4.99
1	if2.25x5.25-36	Speedy Metals	Cast iron bar for dovetail slides	$210.44	$210.44
2	61r1.25	Speedy Metals	Round stock for dials	$0.70	$1.40
1	ir7	Speedy Metals	Stock for swivel plate	$20.37	$20.37
1	18f.25x7	Speedy Metals	Stock for swivel pressure plate	$15.33	$15.33
1	6sh18-12x12	Speedy Metals	Sheet for way wipers	$8.73	$8.73
1	if.75x1.5-18	Speedy Metals	Cast iron bar for gibs	$13.34	$13.34
4	6391K172	McMaster	Screw end bearings	$0.83	$3.32
1	5720K11	McMaster	Cam handle	$12.43	$12.43
1	2FKB5	Grainger	Way wiper felt	$0.76	$0.76
1	94567A540	McMaster	Thumb screw	$2.24	$2.24
1	90116A323	McMaster	Vise Jaw Attachment mounting screws (side, stationary)	$6.74	$6.74
1	92005A423	McMaster	Vise Jaw Attachment mounting screws (side, floating)	$10.42	$10.42
1	97395A491	McMaster	Vise locating pin	$13.13	$13.13
1	91773A148	McMaster	Way wiper screws	$3.92	$3.92
1	98381A310	McMaster	Dial alignment pins	$6.58	$6.58
				Raw Materials	$276.96
				New Parts	$123.17
				Hardware	
				Total	$400.13

Figure 4.9: Final Cost Report for the Fixturing Mechanism

4.1.4 Electrical

Quantity	Part Number	Vender	Description	Price	Extension
1	10250H2747	Ebay	Start/stop Switch	$50.00	$50.00
1	RS-1A	Elec. Motor Warehouse	Electric Motor Reversing Drum Switch	$48.99	$48.99
1	Q120U	HomeDepot	Circuit Breaker	$4.56	$4.56
2	FL67WL7R	AlliedElectronics	Indicator Light	$2.50	$5.00
1	JDS-1996	Ebay	Anti-Restart Plugs	$37.00	$37.00
1	ASW33L20	Ebay	3 Position Rotary Switch	$20.99	$20.99
5	Z-15GW2-B	Ebay	Limit Switch	$8.33	$41.65
1	KBPC3510	Ebay	Full Wave Rectifier	$5.95	$5.95
6	KRPA-11AG-12	Ebay	Relay 2p2t	$6.27	$37.62
6	27 e 122	Ebay	Relay Socket	$4.50	$27.00
1		Ebay	ATO/ATC Blade Fuseholder	$3.79	$3.79
1	G2624955	Zoro	Class 2 Transformer, 12VAC, 5 VA, 1 PH	$24.05	$24.05
1	8920K135	McMaster	3/8"x36" low-carbon steel shaft	$4.28	$4.28
1	6389K349	McMaster	Nylon sleeve bearing for 3/8" shaft, pkg 5	$2.94	$2.94
1	61r1.75	Speedy Metals	Cam	$1.23	$1.23
1	61f.125x2	Speedy Metals	Limit switch mount bar	$0.80	$0.80
1	shield	Tap Plastics	Polycarbonate sheet	$36.09	$36.09
1	61f1x1.5	Speedy Metals	Shield mount block	$2.67	$2.67
1	97654A143	McMaster	Shield mount screw	$10.99	$10.99
1	92785A238	McMaster	Shield block/cam set screw	$3.95	$3.95
1	98381A310	McMaster	Shield shaft dowel pin	$0.00	$0.00
1	9414T8	McMaster	Shield shaft collar	$1.05	$1.05
				Raw Materials	$40.79
				New Parts	$329.81
				Hardware	$0.00
				Total	$370.60

Figure 4.10: Full Cost Report for the Electrical System

The electrical system of the Notchmatic, in total, costs $370.60. The larget portion of the budget of the cost for the electronics of the Notchmatic comes from the switches that allow the machine to function. All seven switches were purchased for $161.63. The remaining 56.4% of the electrical system budget is composed of electrical components and raw materials for the safety shield. Raw materials for the control box and control panel will come from left over material from the structural and driveline systems. Most of the switches used are common for industry applications and, therefore, could be purchased from 3rd party websites. Although this is already included in the full cost report, it greatly reduced the cost. Consequently, "new" switches and relays could be purchased at "used" prices from ebay. Not only did this reduce the cost but it also did so without jeopordizing the safety of the user or functionality of the machine. Since there are no fastners included in the electronics system, cost was only reduced when a transformer was provided by Estuardo Rodas. From this reduction the final cost of the electrical system becomes $346.55.

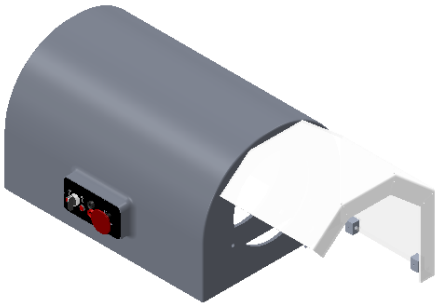
Quantity	Part Number	Vender	Description	Price	Extension
1	10250H2747	Ebay	Start/stop Switch	$50.00	$50.00
1	RS-1A	Elec. Motor Warehouse	Electric Motor Reversing Drum Switch	$48.99	$48.99
1	Q120U	HomeDepot	Circuit Breaker	$4.56	$4.56
2	FL67WL7R	AlliedElectronics	Indicator Light	$2.50	$5.00
1	JDS-1996	Ebay	Anti-Restart Plugs	$37.00	$37.00
1	ASW33L20	Ebay	3 Position Rotary Switch	$20.99	$20.99
5	Z-15GW2-B	Ebay	Limit Switch	$8.33	$41.65
1	KBPC3510	Ebay	Full Wave Rectifier	$5.95	$5.95
6	KRPA-11AG-12	Ebay	Relay 2p2t	$6.27	$37.62
6	27 e 122	Ebay	Relay Socket	$4.50	$27.00
1		Ebay	ATO/ATC Blade Fuseholder	$3.79	$3.79
1	8920K135	McMaster	3/8"x36" low-carbon steel shaft	$4.28	$4.28
1	6389K349	McMaster	Nylon sleeve bearing for 3/8" shaft, pkg 5	$2.94	$2.94
1	61r1.75	Speedy Metals	Cam	$1.23	$1.23
1	61f.125x2	Speedy Metals	Limit switch mount bar	$0.80	$0.80
1	shield	Tap Plastics	Polycarbonate sheet	$36.09	$36.09
1	61f1x1.5	Speedy Metals	Shield mount block	$2.67	$2.67
1	97654A143	McMaster	Shield mount screw	$10.99	$10.99
1	92785A238	McMaster	Shield block/cam set screw	$3.95	$3.95
1	98381A310	McMaster	Shield shaft dowel pin	$0.00	$0.00
1	9414T8	McMaster	Shield shaft collar	$1.05	$1.05
				Raw Materials	$40.79
				New Parts	$305.76
				Hardware	$0.00
				Total	$346.55

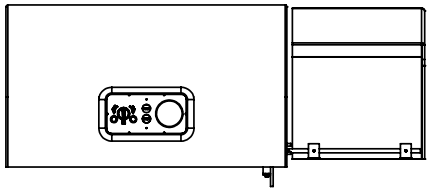
Figure 4.11: Final Cost Report for the Electrical System

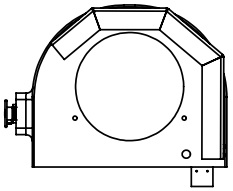
Chapter 5

Drawings

5.1 Structural







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	NEXT ASSY		
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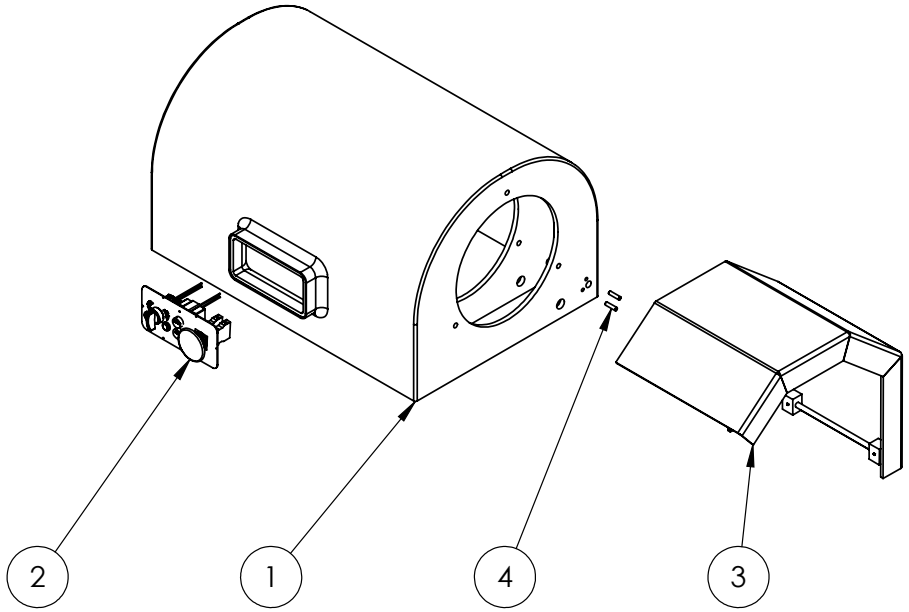
	COMMENTS:		SCALE: 1:16 WEIGHT: | SHEET 1 OF 2

5 4 3 2 1

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	headstock casting	Headstock casting	1
2	user control panel		1
3	safety-shield	Safety Shield	1
4	97395A491	Rotational stop dowel pin	2



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	APPLICATION		
	NEXT ASSY	CMC Notchmatic	
INTERPRET GEOMETRIC TOLERANCING PER:			
MATERIAL	SUBSYSTEM		SIZE A | FILE NAME headstock casting subassembly | REV 1.0
FINISH	COMMENTS:		
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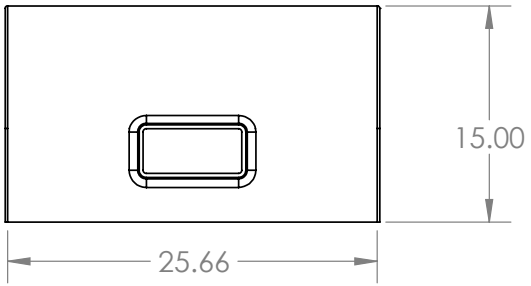
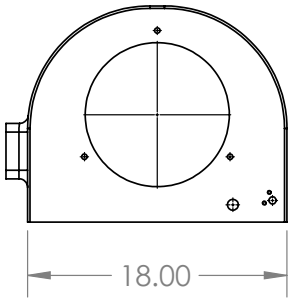
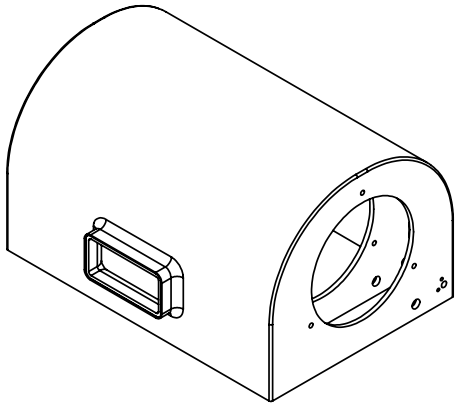
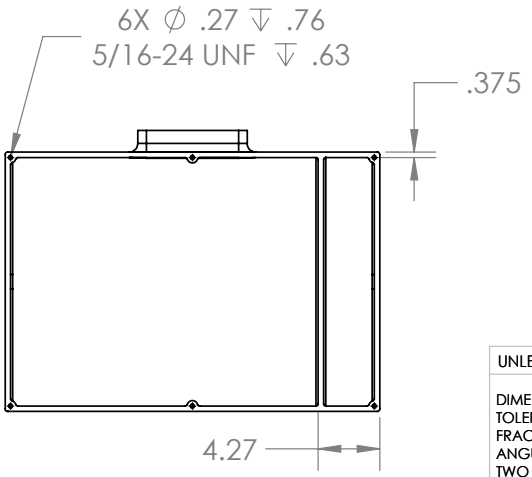
5 4 3 2 1









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MATERIAL 6061-T6 (SS)	SUBSYSTEM	
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Cooper Machine Co.

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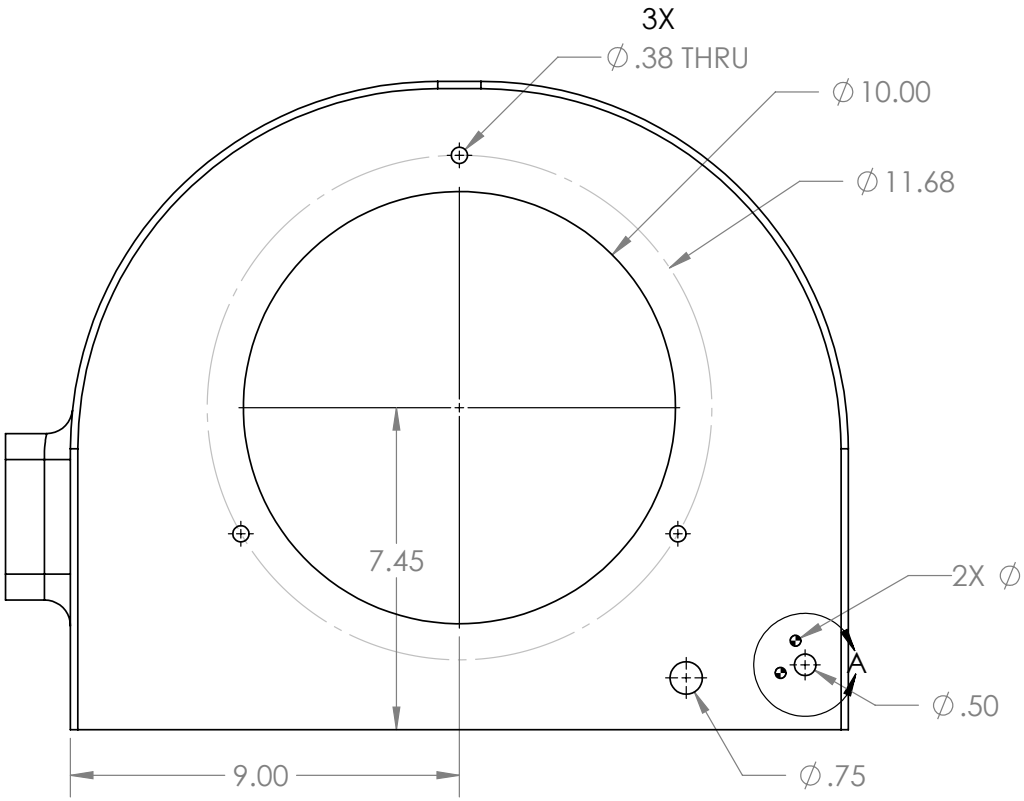

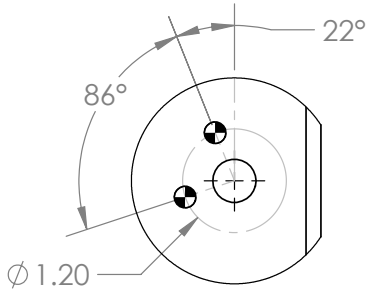

DETAIL A
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	APPLICATION	
INTERPRET GEOMETRIC TOLERANCING PER:	NEXT ASSY	
MATERIAL 6061-T6 (SS)	SUBSYSTEM	
FINISH	COMMENTS:	
DO NOT SCALE DRAWING		

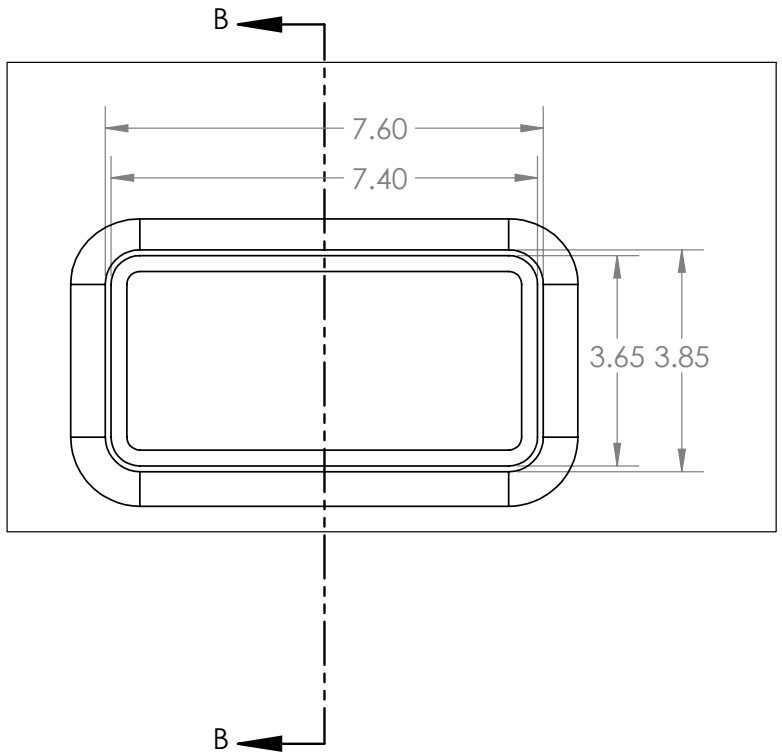
Cooper Machine Co.

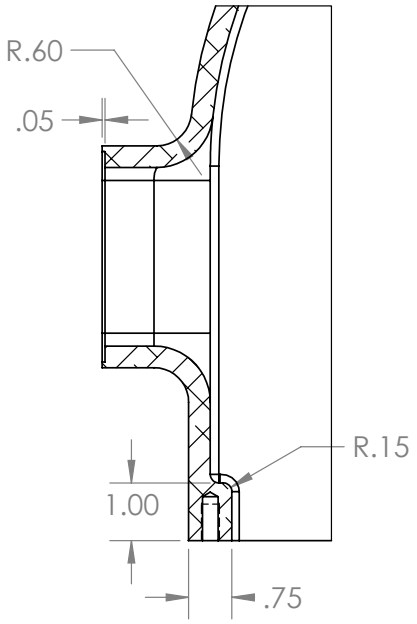
TITLE:
Headstock casting

SIZE	FILE NAME	REV
A	headstock casting	1.0

SCALE: 1:4 | WEIGHT: 57.09 | SHEET 2 OF 3

5 4 3 2 1





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	APPLICATION		
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MATERIAL: 6061-T6 (SS)	SUBSYSTEM		SCALE: 1:3; WEIGHT: 57.09; SHEET 3 OF 3
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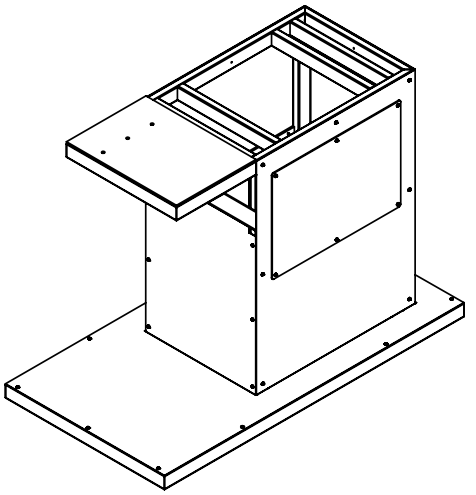
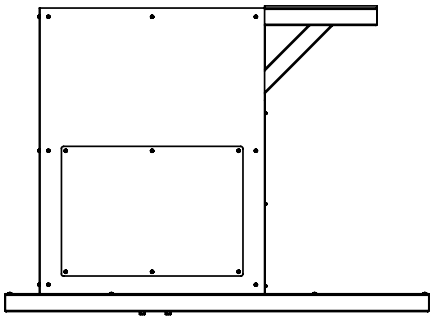
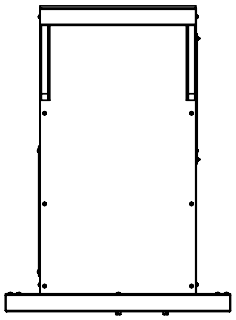
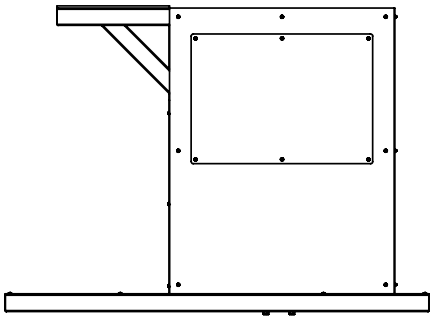
5 4 3 2 1









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	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	Notchmatic
INTERPRET GEOMETRIC TOLERANCING PER:		
MATERIAL	SUBSYSTEM	Structural
FINISH	COMMENTS: Headstock Mounting is Separate	
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Cooper Machine Co.

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Frame and Shell

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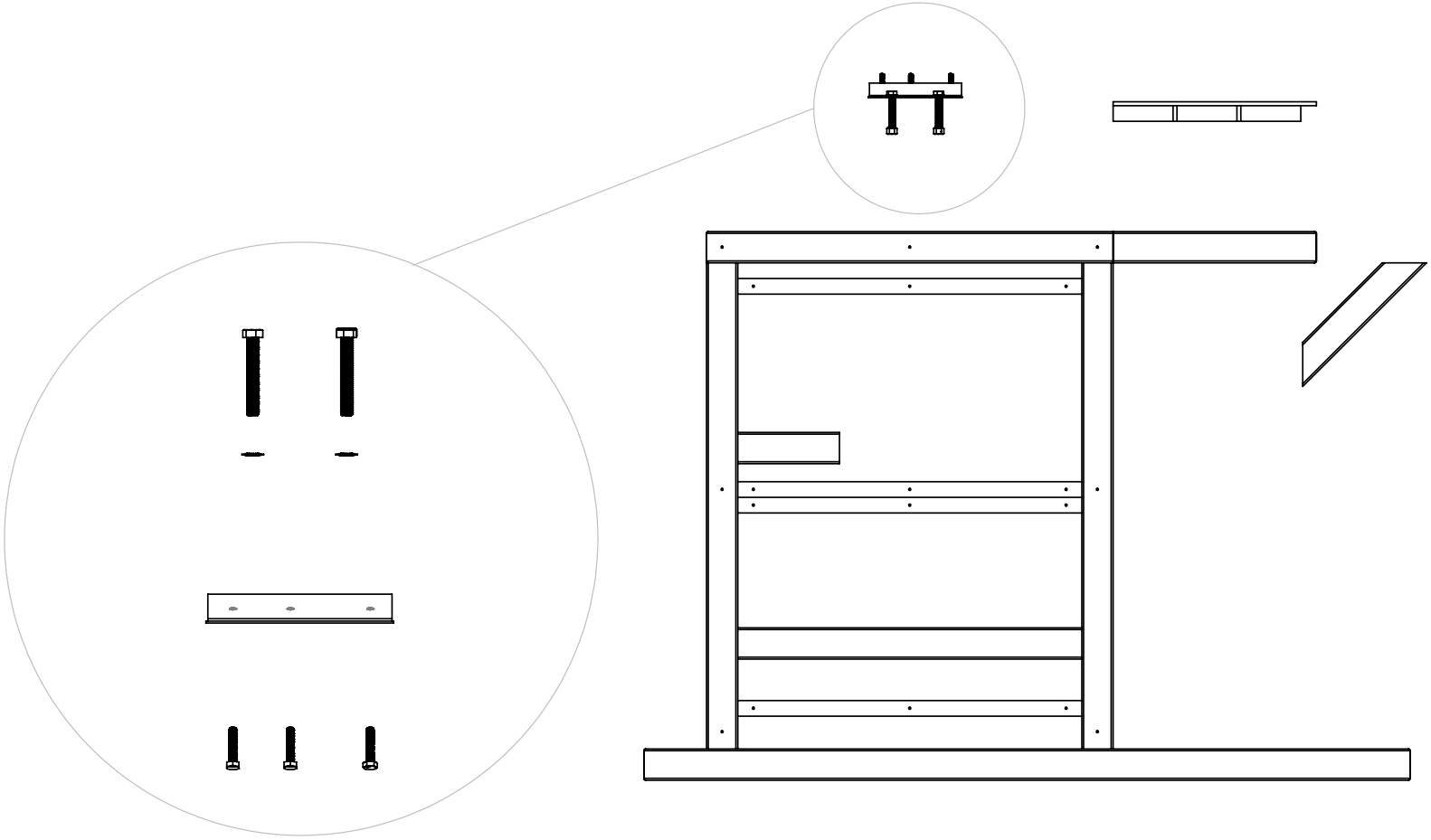

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	APPLICATION		
	NEXT ASSY	Notchmatic	
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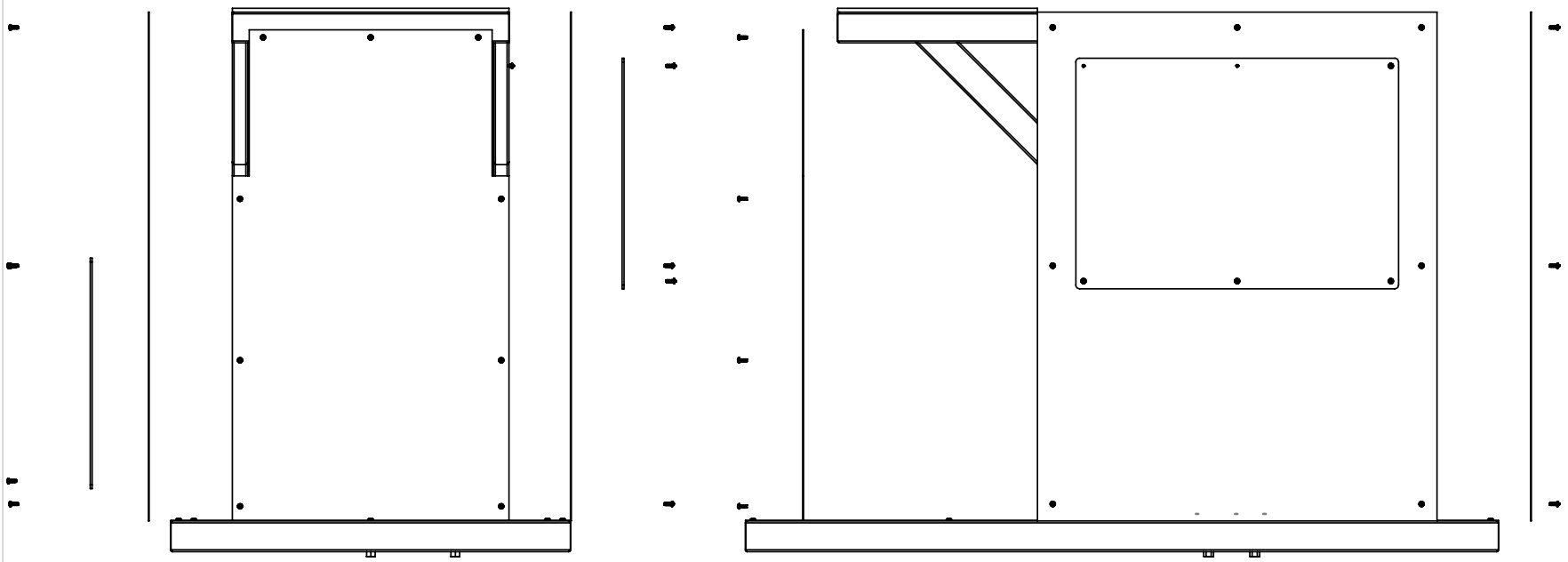

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	APPLICATION	
	NEXT ASSY	Notchmatic
INTERPRET GEOMETRIC TOLERANCING PER:		
MATERIAL	SUBSYSTEM	Structural
FINISH	COMMENTS: Frame and Shell V 2	
DO NOT SCALE DRAWING		

Cooper Machine Co.

TITLE:

Frame and Shell

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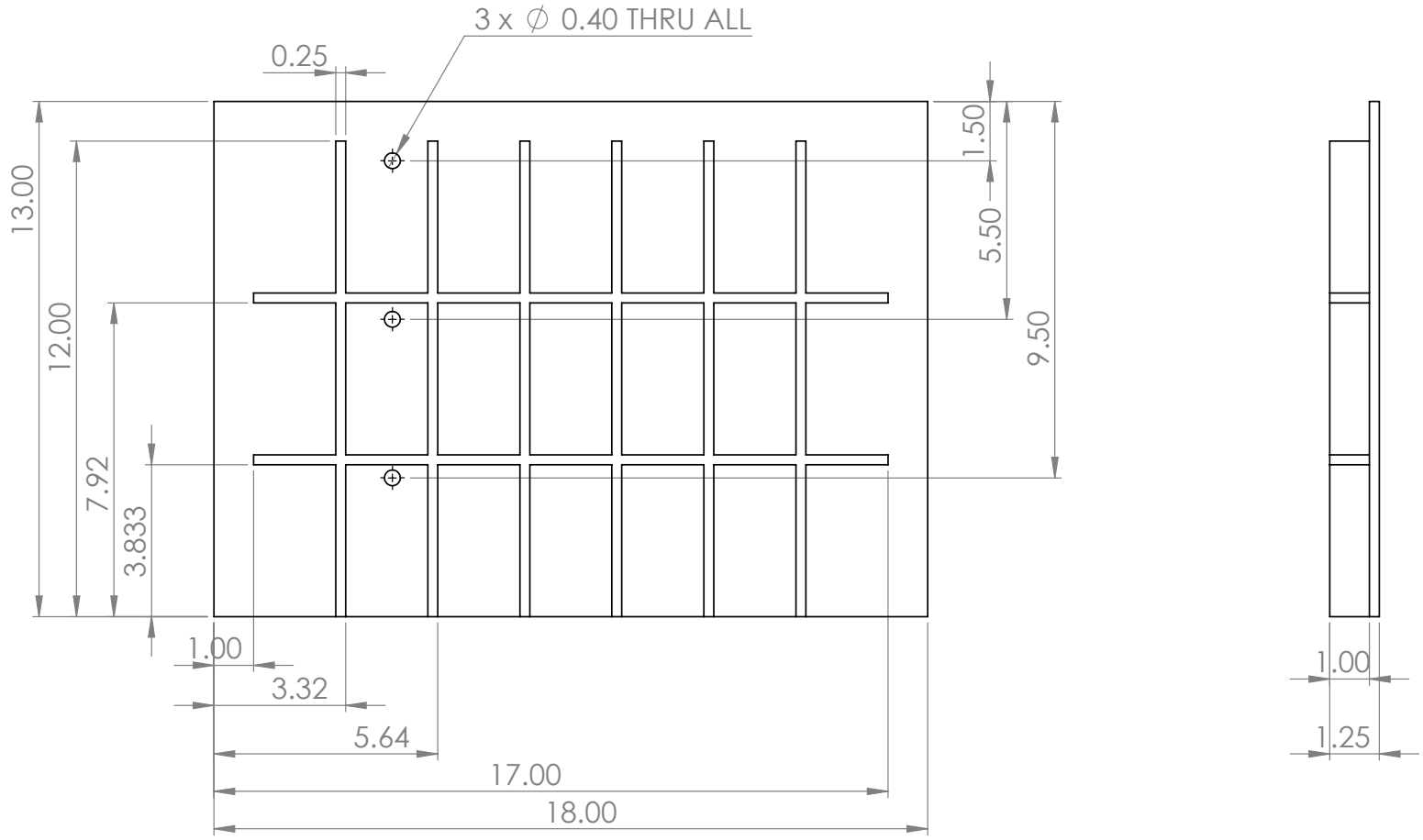
5 4 3 2 1



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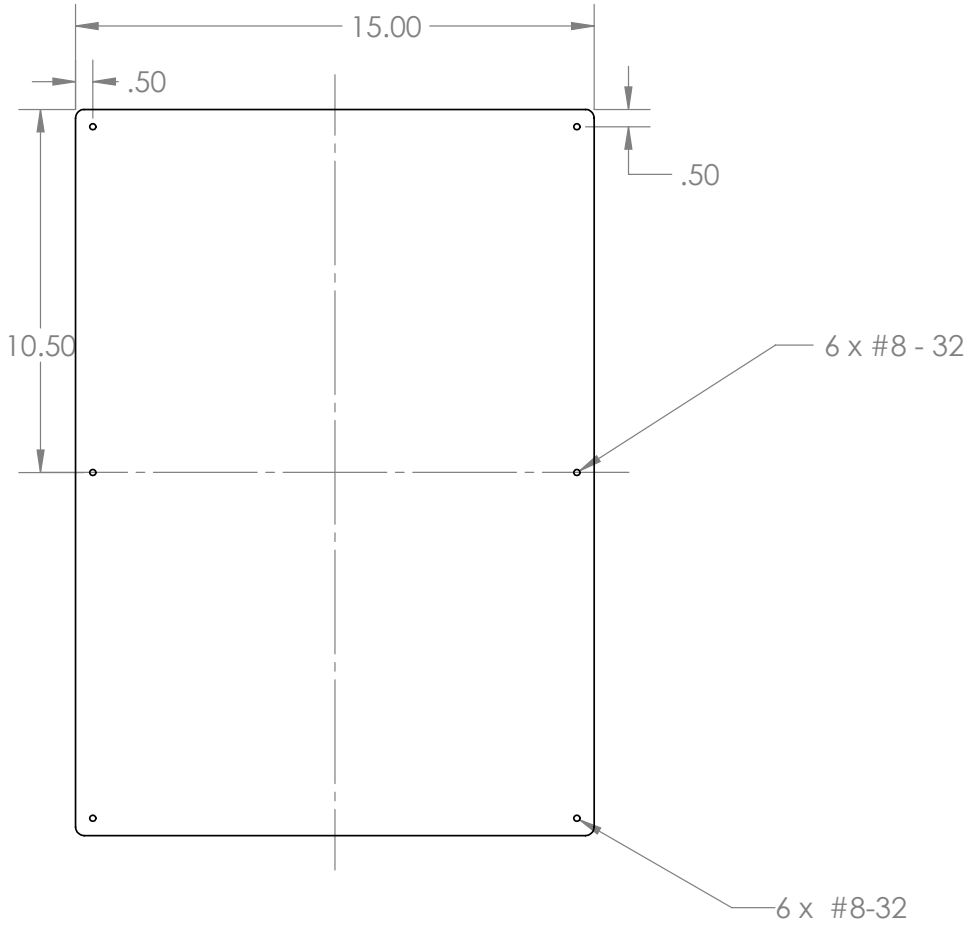
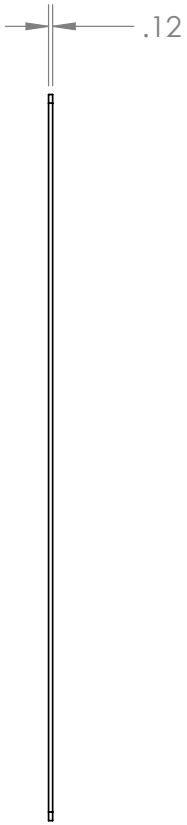
	APPLICATION	
	NEXT ASSY	Frame and Shell
INTERPRET GEOMETRIC TOLERANCING PER:		CMC Notchmatic
MATERIAL ASTM A36 Steel	SUBSYSTEM	
FINISH	COMMENTS: Bed Frame.	
DO NOT SCALE DRAWING		

Cooper Machine Co.		
TITLE: Bed		
SIZE A	FILE NAME Frame Bed	REV 1.0
SCALE: 1:4	WEIGHT: 23.73	SHEET 1 OF 1

5 4 3 2 1





UNLESS OTHERWISE SPECIFIED:	DRAWN BY	K. Yuk
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	Frame and Shell
		CMC Notchmatic
INTERPRET GEOMETRIC TOLERANCING PER:	SUBSYSTEM	Structural
MATERIAL 1023 Carbon Steel Sheet (SS)	COMMENTS: One Each on Front and Back Shells	
FINISH		
DO NOT SCALE DRAWING		

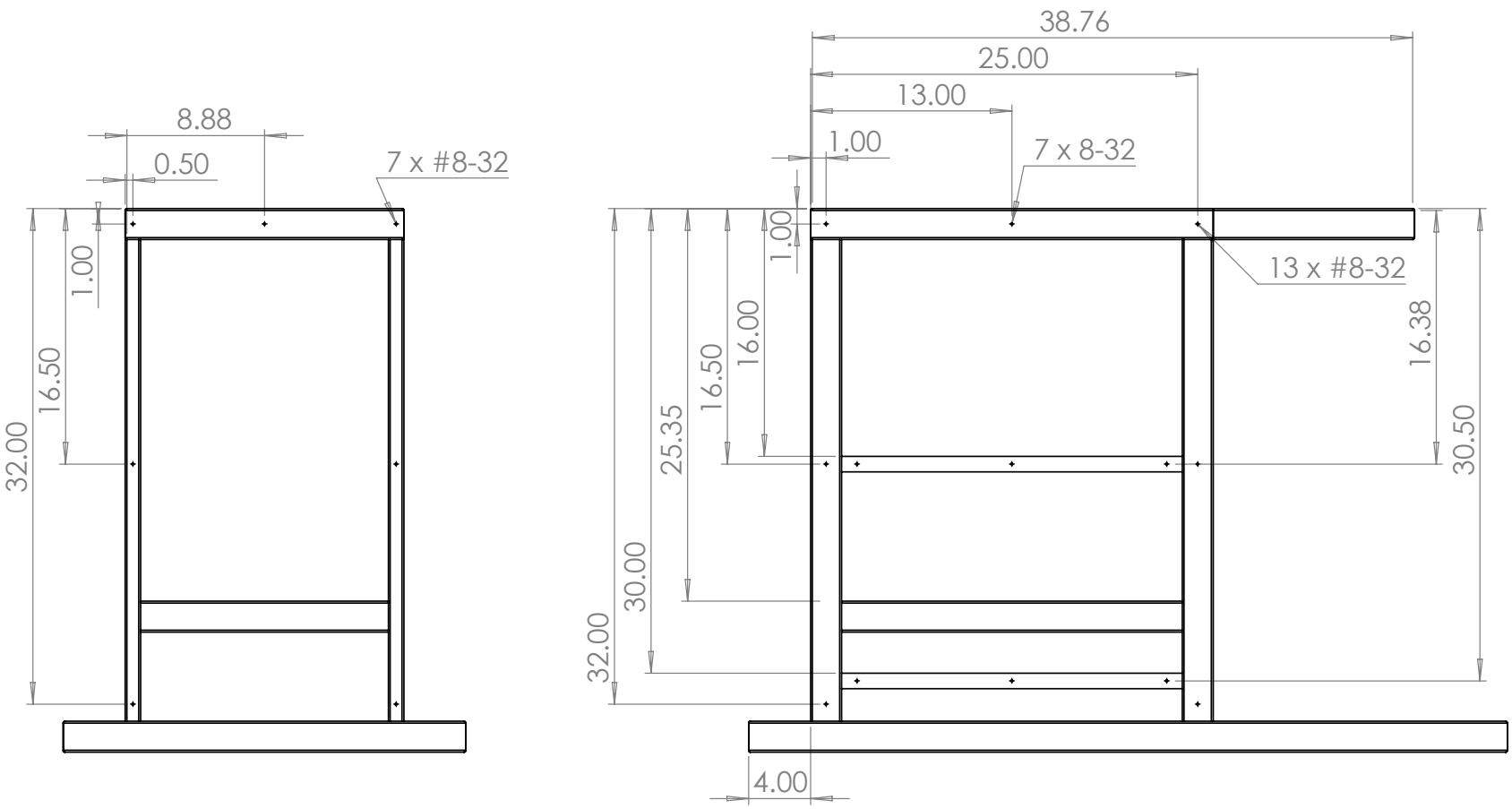
Cooper Machine Co.

TITLE: Frame Door

SIZE	FILE NAME	REV
A	Frame Door	1.0

SCALE: 1:5 | WEIGHT: 10.72 | SHEET 1 OF 1

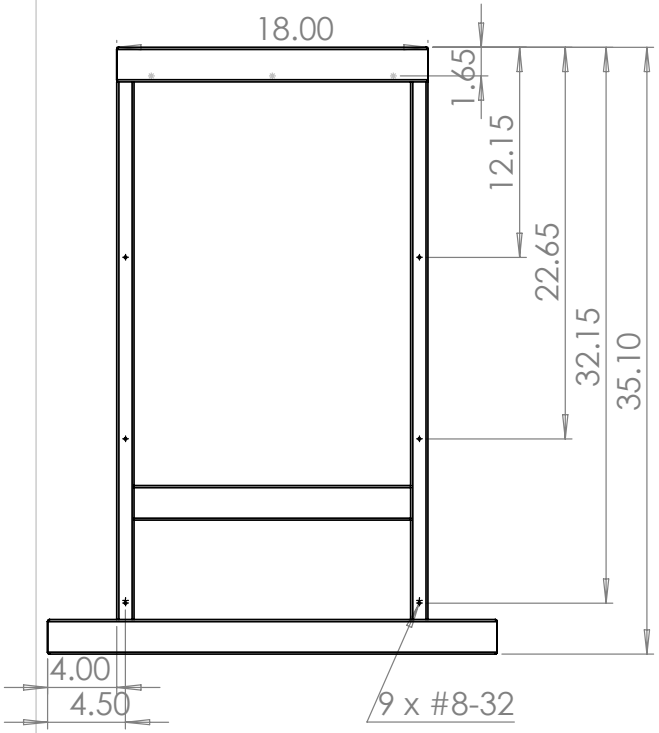
5 4 3 2 1

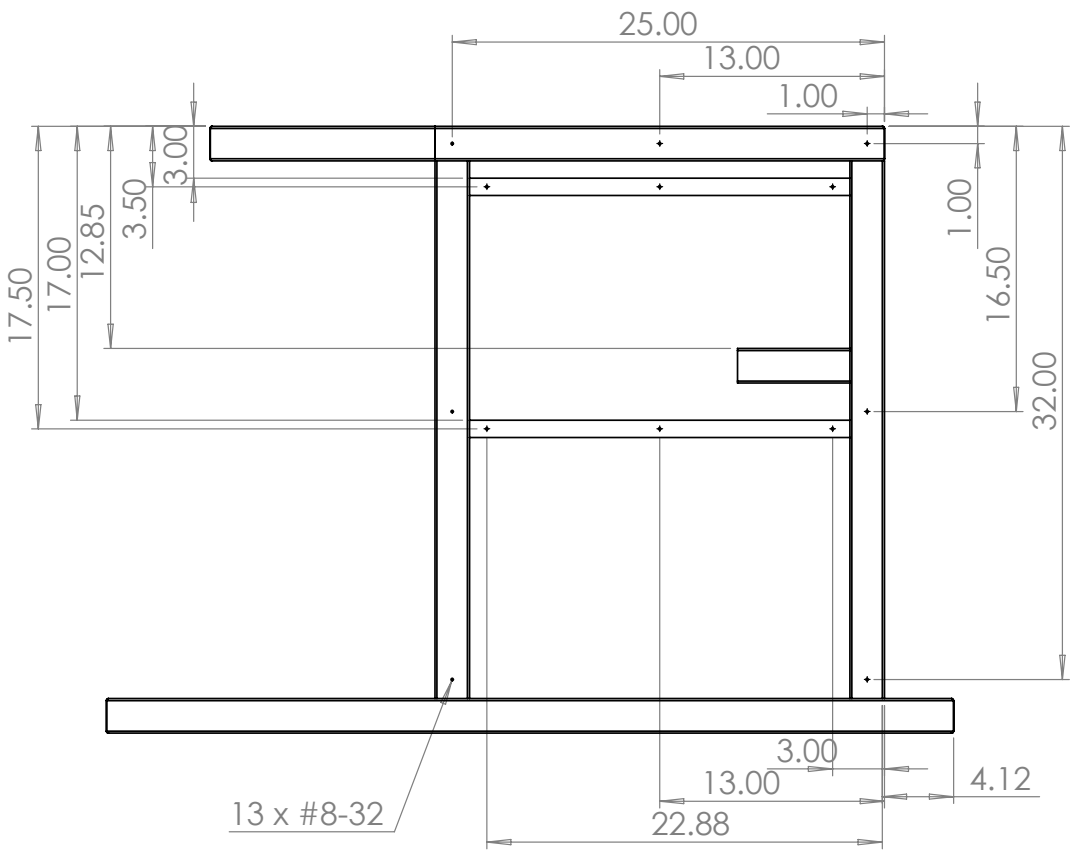


UNLESS OTHERWISE SPECIFIED:	DRAWN BY	J. Song
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	Frame and Shell
INTERPRET GEOMETRIC TOLERANCING PER:		Notchmatic
MATERIAL ASTM A36 Steel	SUBSYSTEM	
FINISH	COMMENTS:	
DO NOT SCALE DRAWING		

Cooper Machine Co.		
TITLE: Frame		
SIZE	FILE NAME	REV
A	Frame Weldments Holes V 1	1.0
SCALE: 1:20	WEIGHT: 121.97	SHEET 1 OF 1

5 4 3 2 1





UNLESS OTHERWISE SPECIFIED:	DRAWN BY	J. Song
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	Frame and Shell
INTERPRET GEOMETRIC TOLERANCING PER:		Notchmatic
MATERIAL ASTM A36 Steel	SUBSYSTEM	
FINISH	COMMENTS:	
DO NOT SCALE DRAWING		

Cooper Machine Co.

TITLE:

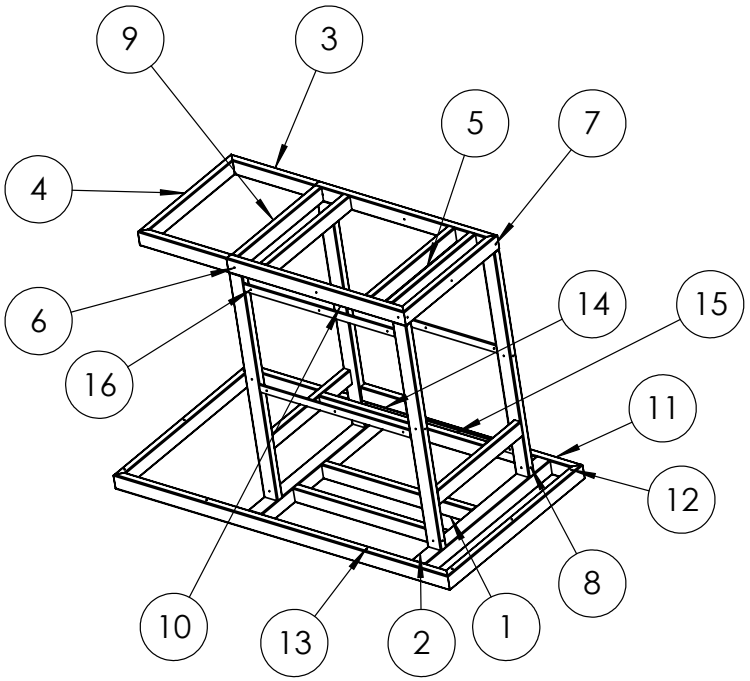
Frame

SIZE	FILE NAME	REV
A	Frame Weldments Holes V 2	1.0

SCALE: 1:20 WEIGHT: 121.97 SHEET 1 OF 1

5 4 3 2 1

ITEM #	Qty.	Profile Dimensions	Length	Angle1	Angle2
1	2	2x1x.12 Rect. Tube	22	0.00	0.00
2	2	2x2x.12 Rect. Tube	24	0.00	0.00
3	2	2x1x.12 Rect. Tube	13	45.00	0.00
4	1	2x1x.12 Rect. Tube	18	45.00	45.00
5	5	2x1x.12 Rect. Tube	16	0.00	0.00
6	2	2x1x.12 Rect. Tube	26	0.00	45.00
7	1	2x1x.12 Rect. Tube	18	45.00	45.00
8	2	2x1x.12 Rect. Tube	31.1	0.00	0.00
9	1	2x1x.12 Rect. Tube	16	0.00	0.00
10	2	2x1x.12 Rect. Tube	31.1	0.00	0.00
11	1	2x1x.12 Rect. Tube	49	45.00	45.00
12	2	2x1x.12 Rect. Tube	26	45.00	45.00
13	1	2x1x.12 Rect. Tube	49	45.00	45.00
14	1	2x1x.12 Rect. Tube	6.5	0.00	0.00
15	1	.25x1 Rect. Extrus.	24	0.00	0.00
16	4	2x1x.12 Rect. Tube	22	0.00	0.00



UNLESS OTHERWISE SPECIFIED:	DRAWN BY	K. Yuk
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	Frame and Shell
INTERPRET GEOMETRIC TOLERANCING PER:		Notchmatic
MATERIAL ASTM A36 Steel	SUBSYSTEM	
FINISH	COMMENTS:	
DO NOT SCALE DRAWING		

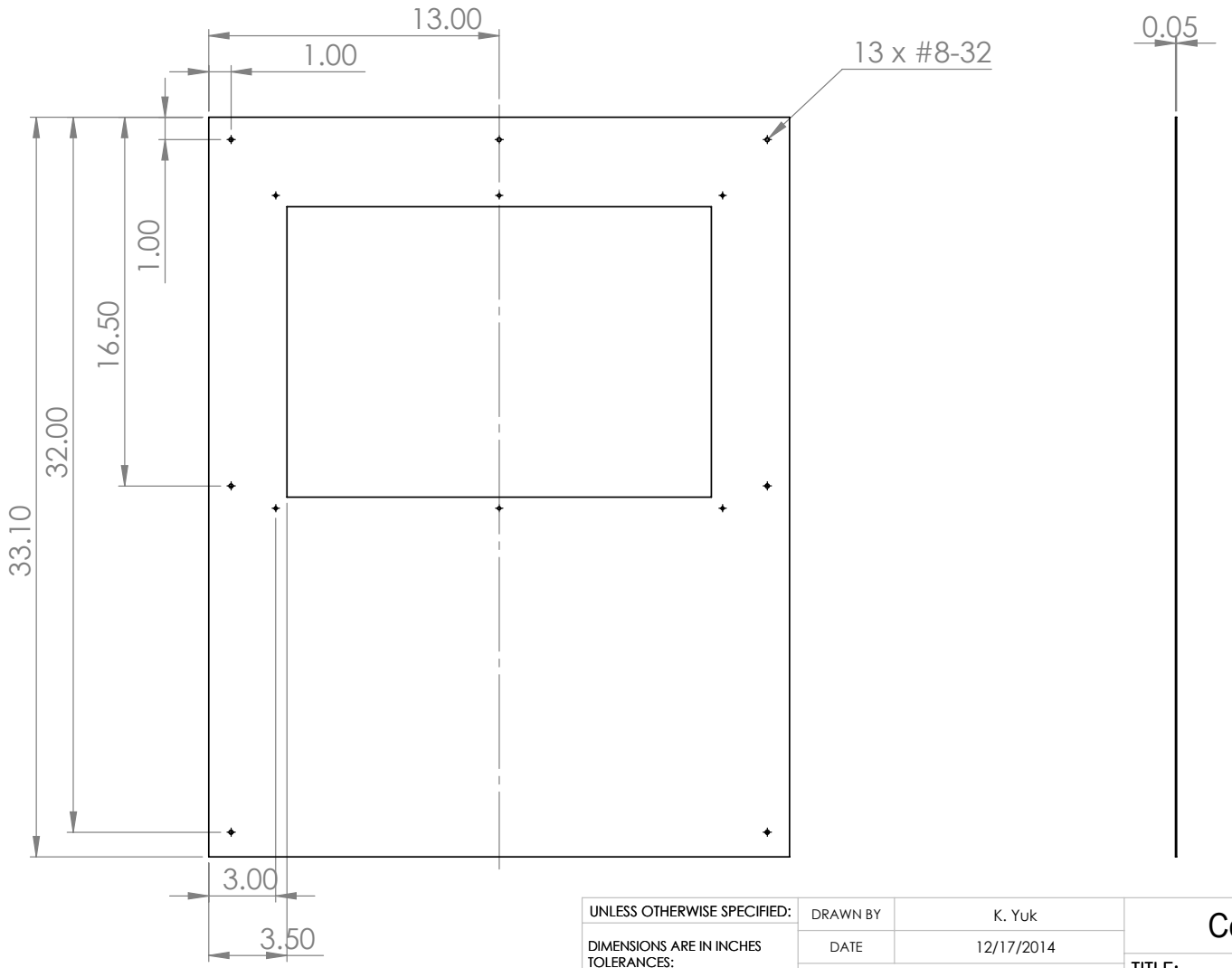
Cooper Machine Co.

TITLE: Frame

SIZE	FILE NAME	REV
A	Frame Weldments List	1.0

SCALE: 1:20 WEIGHT: 121.97 SHEET 1 OF 1

5 4 3 2 1



UNLESS OTHERWISE SPECIFIED:	DRAWN BY	K. Yuk
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	Frame and Shell
INTERPRET GEOMETRIC TOLERANCING PER:		CMC Notchmatic
MATERIAL 1023 Carbon Steel Sheet (SS)	SUBSYSTEM	
FINISH	COMMENTS: Faces away from Controls	
DO NOT SCALE DRAWING		

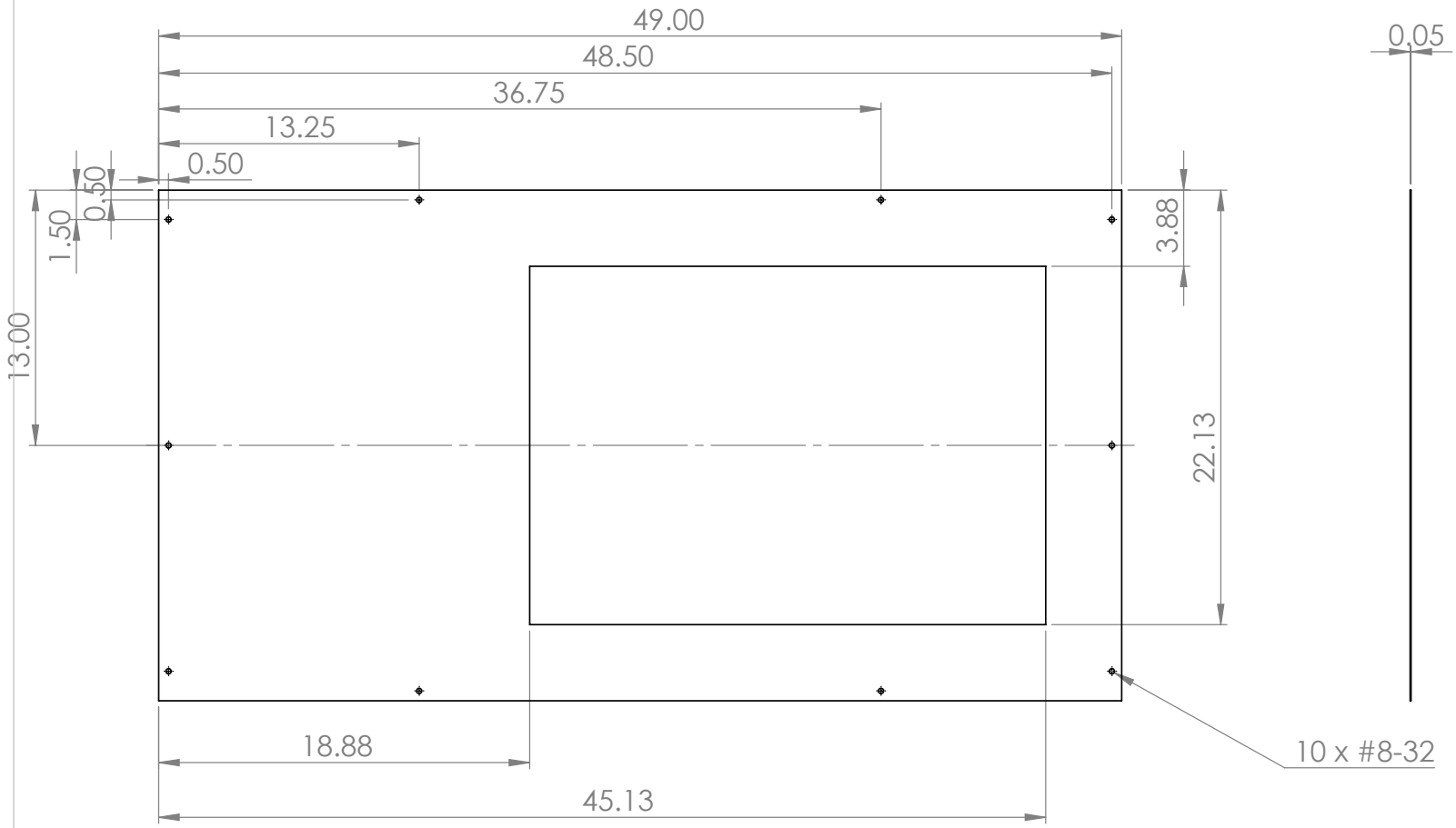
Cooper Machine Co.

TITLE: Shell Back

SIZE	FILE NAME	REV
A	Shell Back	1.0

SCALE: 1:7 | WEIGHT: 8.36 | SHEET 1 OF 1

5 4 3 2 1



UNLESS OTHERWISE SPECIFIED:	DRAWN BY	J. Song
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	Frame and Shell
INTERPRET GEOMETRIC TOLERANCING PER:		CMC Notchmatic
MATERIAL 1023 Carbon Steel Sheet (SS)	SUBSYSTEM	Structural
FINISH	COMMENTS:	
DO NOT SCALE DRAWING		

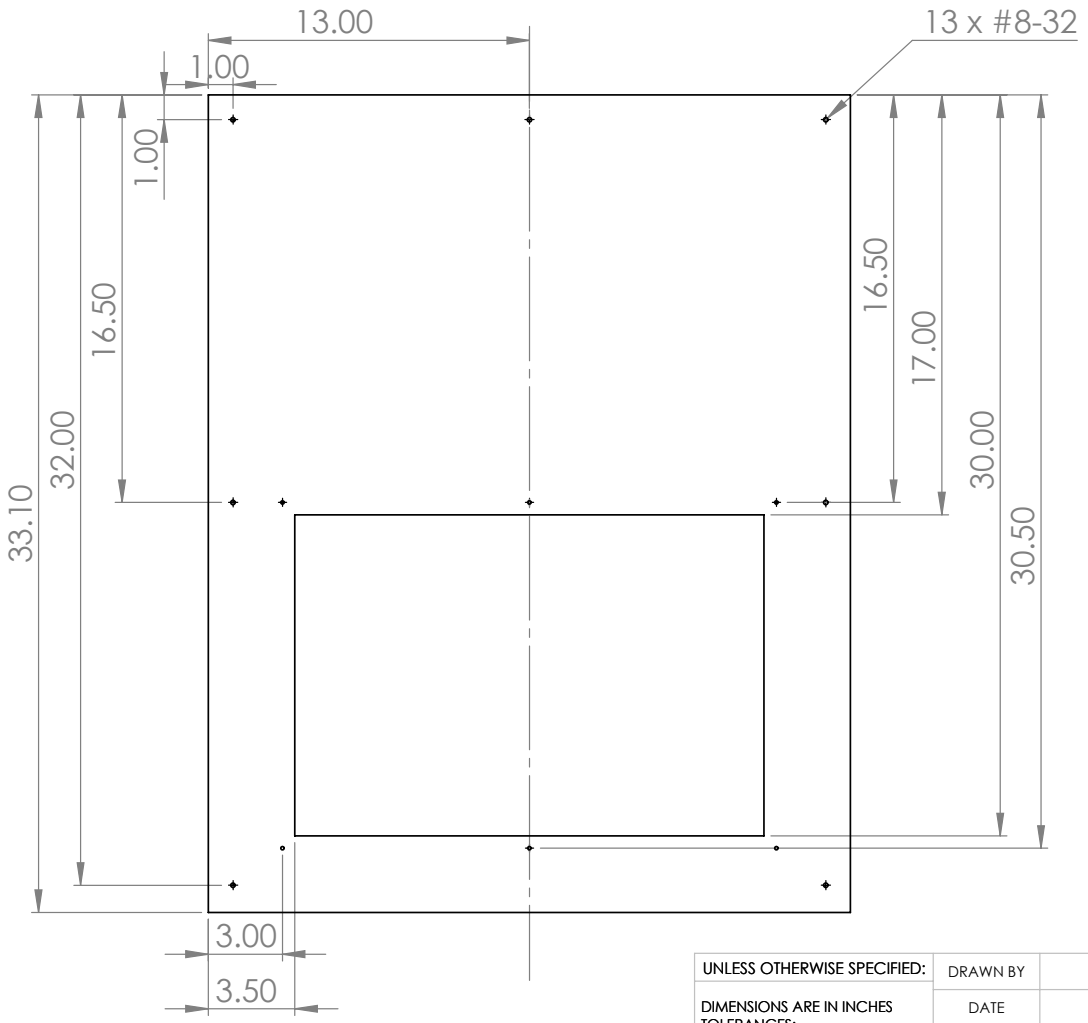
Cooper Machine Co.

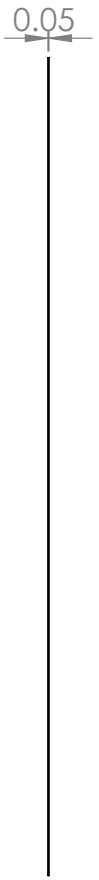
TITLE: Shell Base

SIZE	FILE NAME	REV
A	Shell Base	1.0

SCALE: 1:8 | WEIGHT: 10.82 | SHEET 1 OF 1

5 4 3 2 1





UNLESS OTHERWISE SPECIFIED:	DRAWN BY	K. Yuk
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	Frame and Shell
INTERPRET GEOMETRIC TOLERANCING PER:		CMC Notchmatic
MATERIAL 1023 Carbon Steel Sheet (SS)	SUBSYSTEM	Structural
FINISH	COMMENTS: same side as controls	
DO NOT SCALE DRAWING		

Cooper Machine Co.

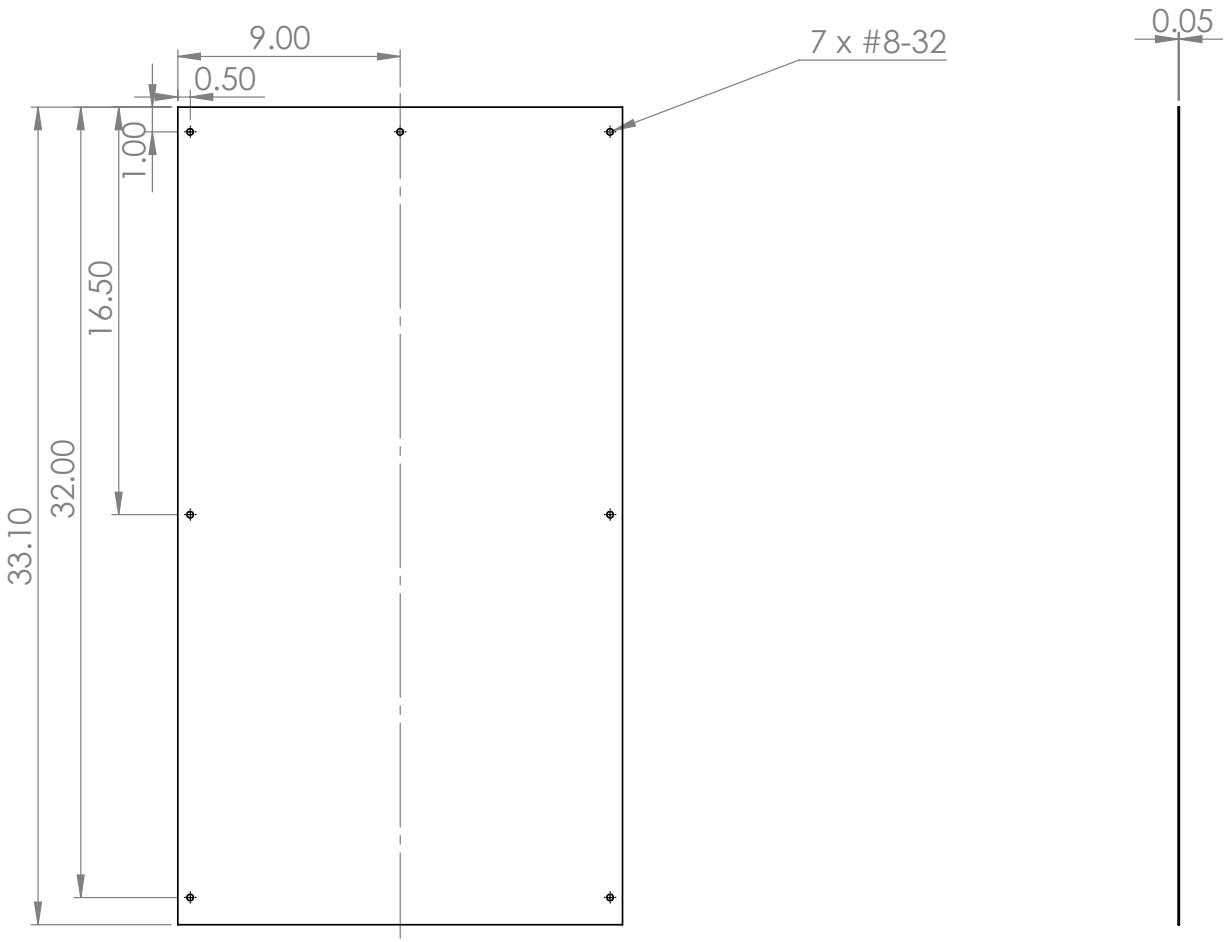
TITLE:

Shell Front

SIZE	FILE NAME	REV
A	Shell Front (facing controls)	1.0

SCALE: 1:7 | WEIGHT: 8.36 | SHEET 1 OF 1

5 4 3 2 1



UNLESS OTHERWISE SPECIFIED:	DRAWN BY	K. Yuk
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	Frame and Shell
		CMC Notchmatic
INTERPRET GEOMETRIC TOLERANCING PER:		
MATERIAL 1023 Carbon Steel Sheet (SS)	SUBSYSTEM	Structural
FINISH	COMMENTS: Shell Opposite Bed	
DO NOT SCALE DRAWING		

Cooper Machine Co.

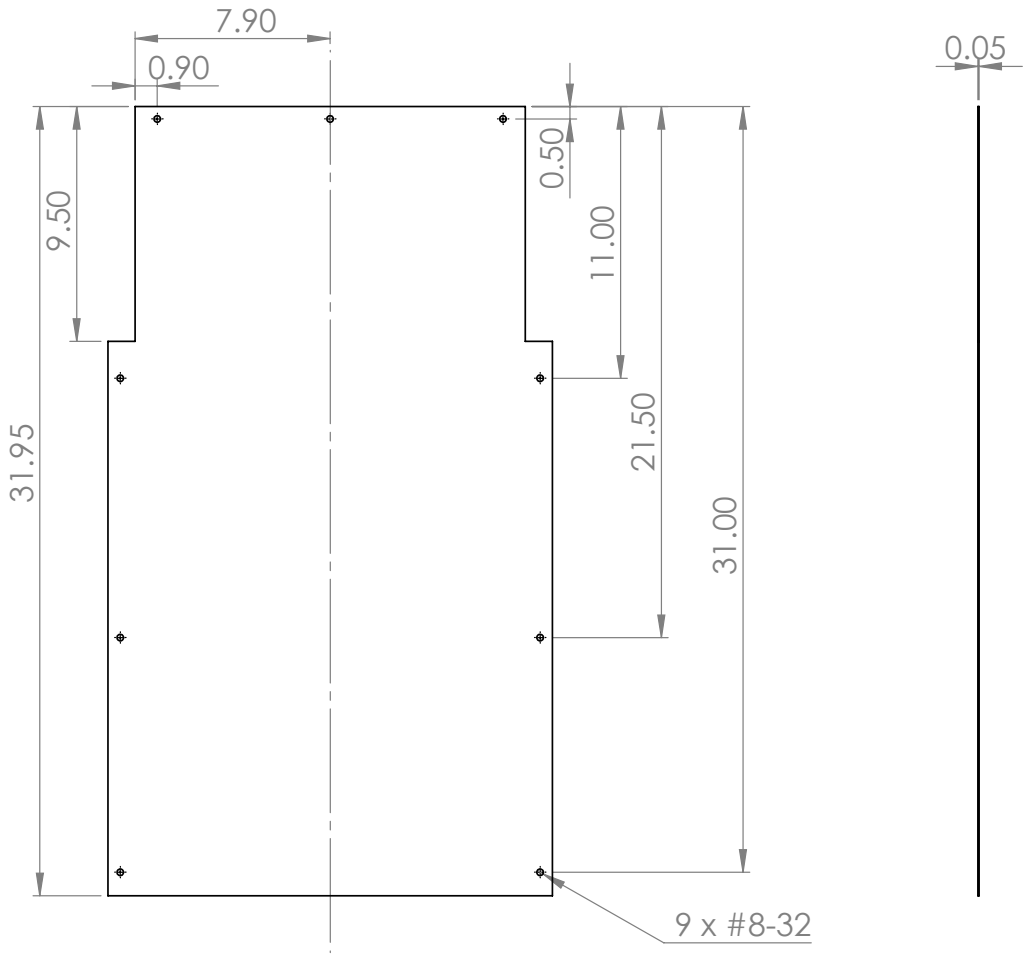
TITLE:

Left Shell

SIZE	FILE NAME	REV
A	Shell Left (away from bed)	1.0

SCALE: 1:7 | WEIGHT: 8.11 | SHEET 1 OF 1

5 4 3 2 1



UNLESS OTHERWISE SPECIFIED:	DRAWN BY	K. Yuk
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	Frame and Shell
		CMC Notchmatic
INTERPRET GEOMETRIC TOLERANCING PER:		
MATERIAL 1023 Carbon Steel Sheet (SS)	SUBSYSTEM	Structural
FINISH	COMMENTS: Facing Bed	
DO NOT SCALE DRAWING		

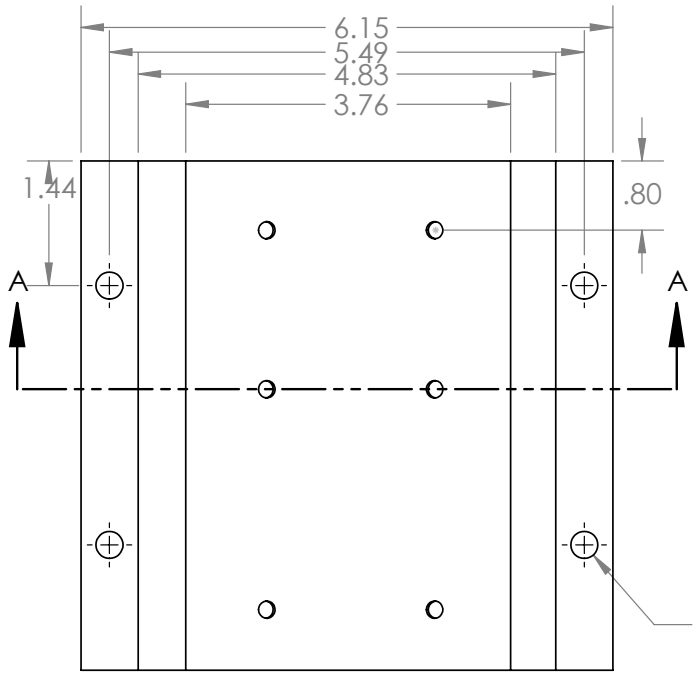
Cooper Machine Co.

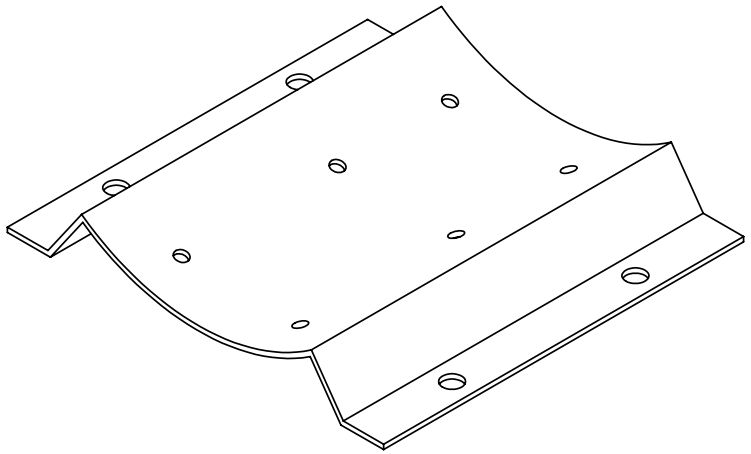
TITLE: Shell Right

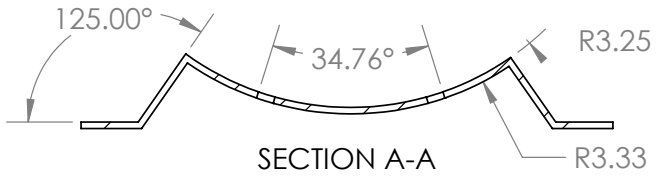
SIZE	FILE NAME	REV
A	Shell Right (under the bed)	1.0

SCALE: 1:7 | WEIGHT: 7.55 | SHEET 1 OF 1

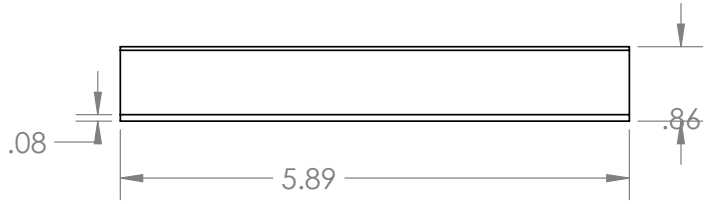
5 4 3 2 1







SECTION A-A



UNLESS OTHERWISE SPECIFIED:	DRAWN BY	K. Yuk
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	Frame and Shell
INTERPRET GEOMETRIC TOLERANCING PER:		CNC Notchmatic
MATERIAL ASTM A36 Steel	SUBSYSTEM	
FINISH	COMMENTS: Spindle Motor Mount	
DO NOT SCALE DRAWING		

Cooper Machine Co.

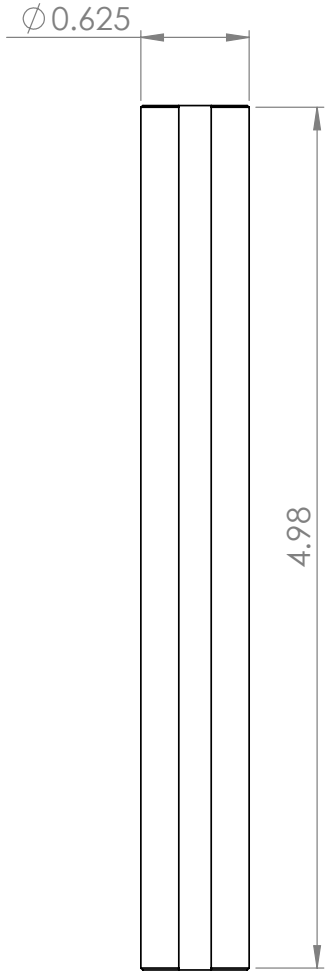
TITLE:
Spindle Motor Mount

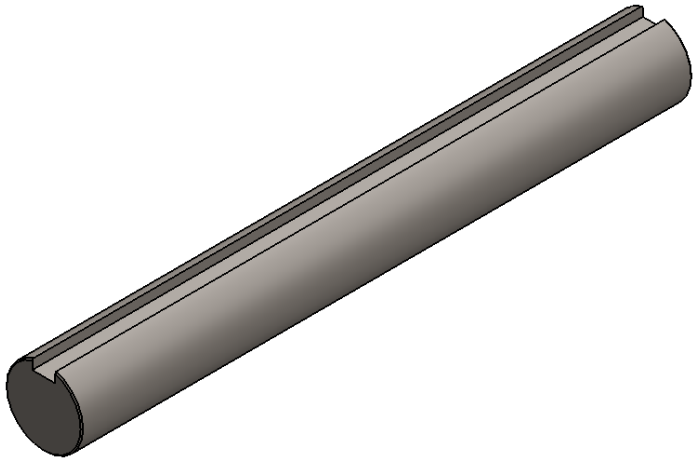
SIZE	FILE NAME	REV
A	Spindle Motor Mount	1.0

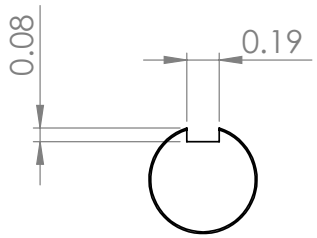
SCALE: 1:2 | WEIGHT: 0.89 | SHEET 1 OF 1

5 4 3 2 1

5.2 Driveline

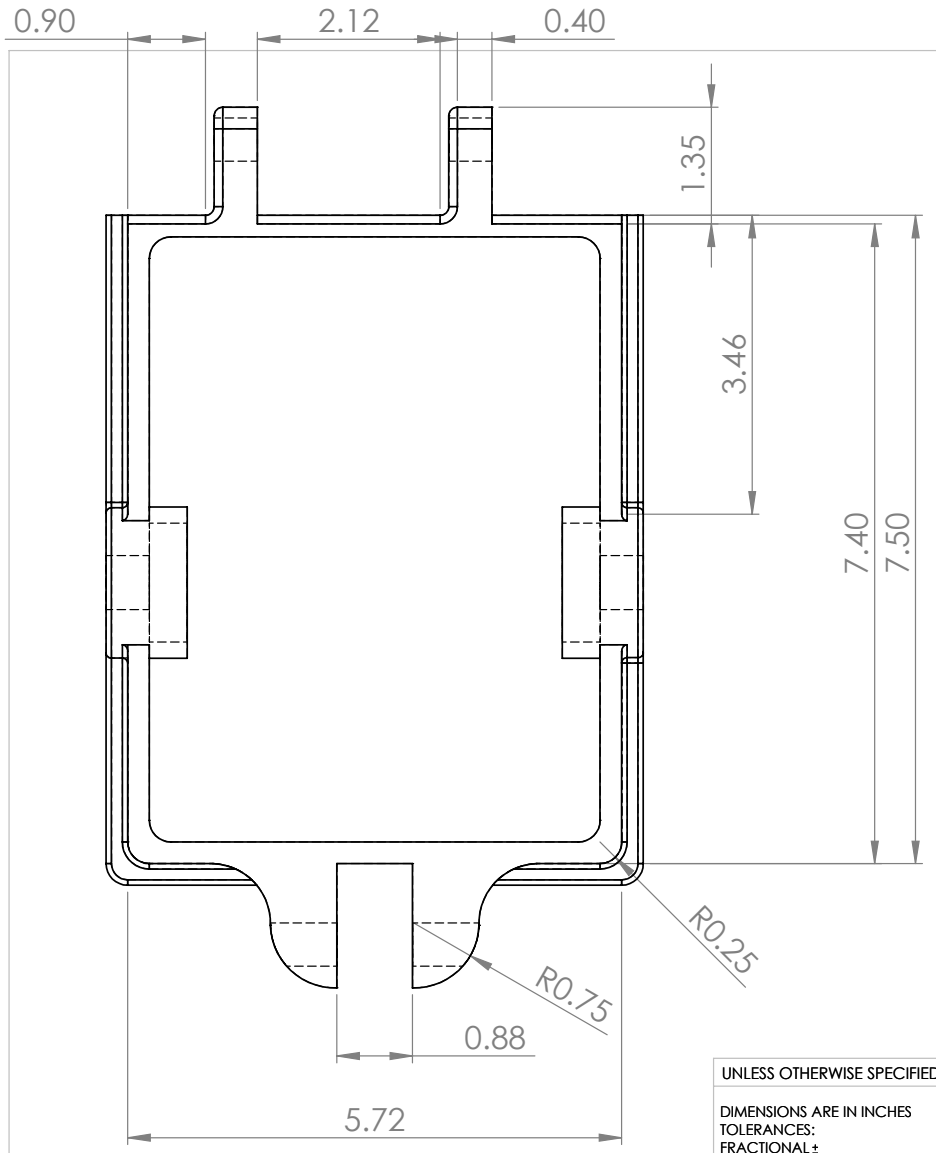


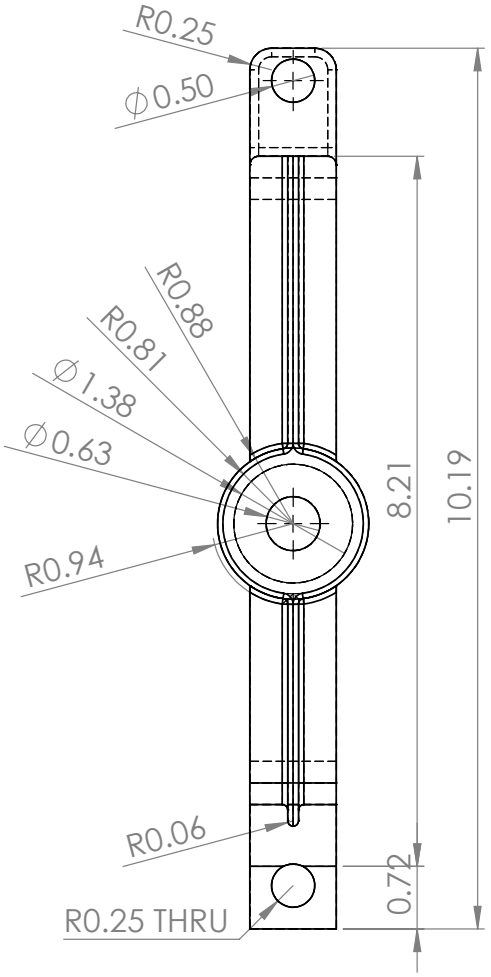




UNLESS OTHERWISE SPECIFIED:	DRAWN BY	J. Song	Cooper Machine Co.
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014	TITLE:
	APPLICATION		
INTERPRET GEOMETRIC TOLERANCING PER:	NEXT ASSY		
MATERIAL			SIZE: A — FILE NAME: Variator Countershaft — REV: 1.0
FINISH	SUBSYSTEM		
DO NOT SCALE DRAWING	COMMENTS:		SCALE: 1:2 — WEIGHT: — SHEET 1 OF 1

5 4 3 2 1





UNLESS OTHERWISE SPECIFIED:	DRAWN BY	J. Song
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014
	APPLICATION	
INTERPRET GEOMETRIC TOLERANCING PER:	NEXT ASSY	
MATERIAL	SUBSYSTEM	
FINISH	COMMENTS:	
DO NOT SCALE DRAWING		

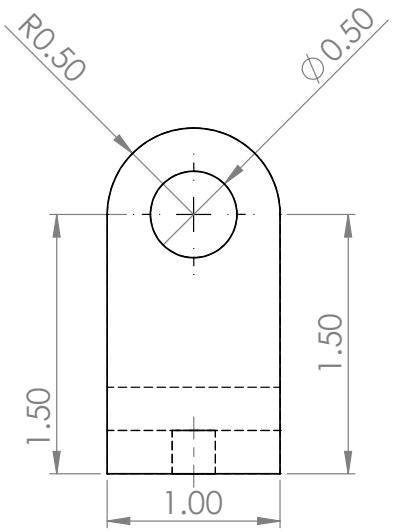
Cooper Machine Co.

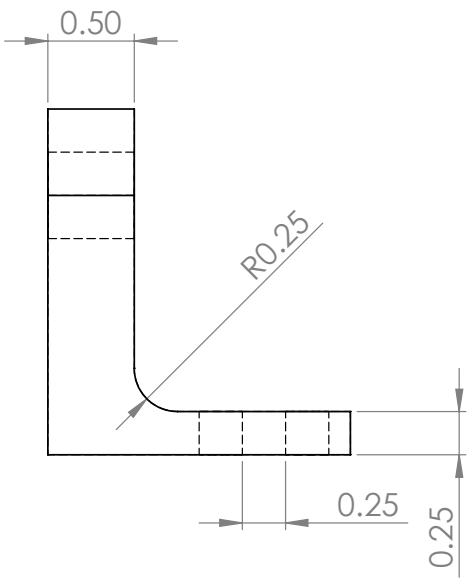
TITLE:

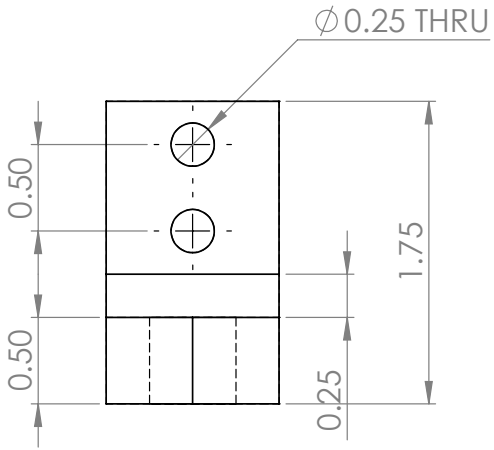
SIZE	FILE NAME	REV
A	Variator Frame	1.0

SCALE: 1:5 | WEIGHT: | SHEET 1 OF 1

5 4 3 2 1







UNLESS OTHERWISE SPECIFIED:	DRAWN BY	J. Song
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	Variator
INTERPRET GEOMETRIC TOLERANCING PER:		
MATERIAL AISI 1015 Steel, Cold Drawn (SS)	SUBSYSTEM	Driveline
FINISH	COMMENTS:	
DO NOT SCALE DRAWING		

Cooper Machine Co.

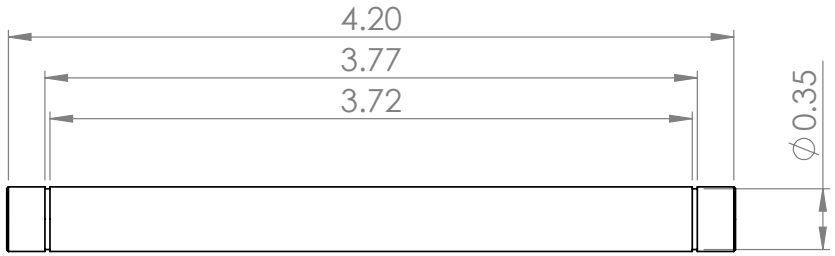
TITLE:

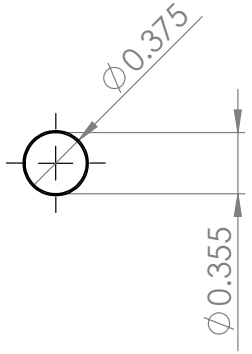
Variator Mounting Block

SIZE	FILE NAME	REV
A	Variator Mounting Blocks	1.0

SCALE: 1:1 | WEIGHT: 0.33 | SHEET 1 OF 1

5 4 3 2 1





UNLESS OTHERWISE SPECIFIED:	DRAWN BY	J. Song
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	
INTERPRET GEOMETRIC TOLERANCING PER:		
MATERIAL	SUBSYSTEM	
FINISH	COMMENTS:	
DO NOT SCALE DRAWING		

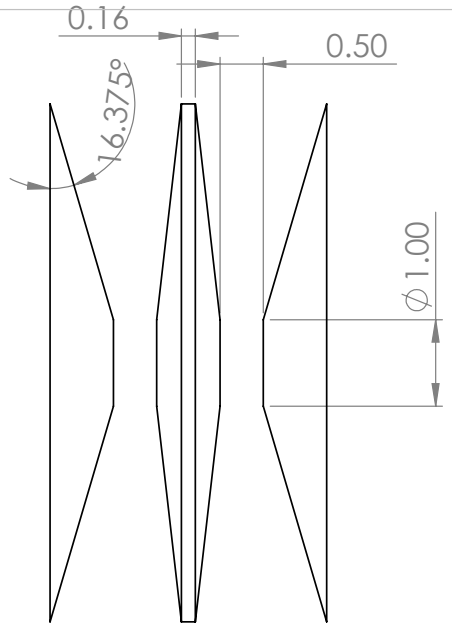
Cooper Machine Co.

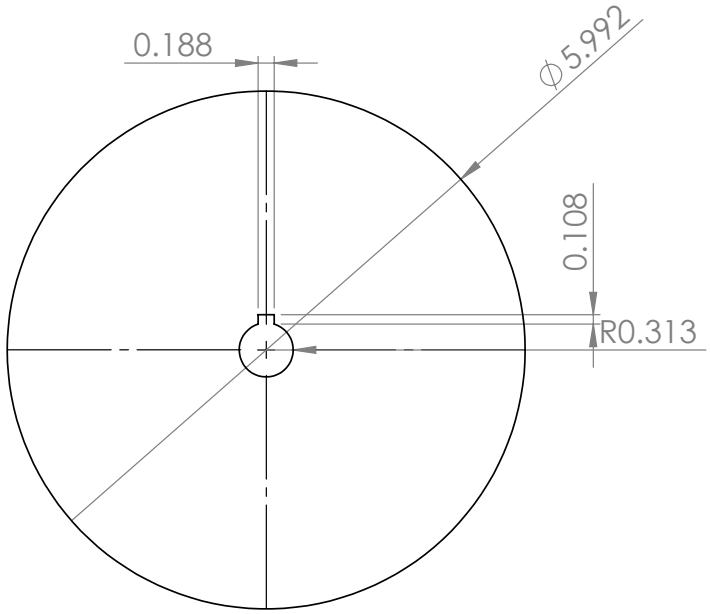
TITLE:

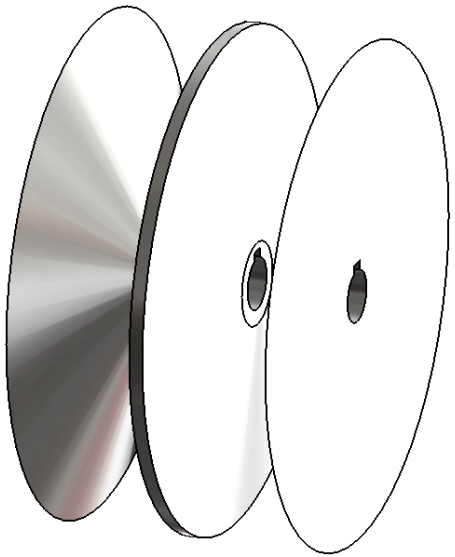
SIZE	FILE NAME	REV
A	Variator Pivot Axle	1.0

SCALE: 1:1 | WEIGHT: | SHEET 1 OF 1

5 4 3 2 1

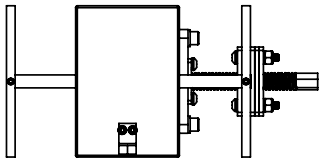


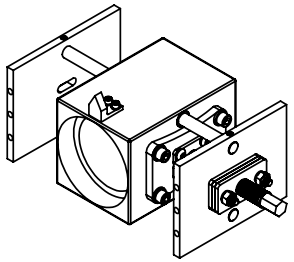


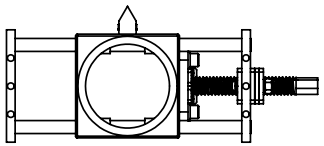


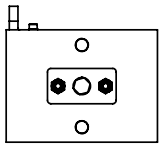
UNLESS OTHERWISE SPECIFIED:	DRAWN BY	J. Song	Cooper Machine Co.
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014	TITLE:
	APPLICATION		
INTERPRET GEOMETRIC TOLERANCING PER:	NEXT ASSY		SIZE: A — FILE NAME: Variator Pulley — REV: 1.0
MATERIAL	SUBSYSTEM		
FINISH	COMMENTS:		SCALE: 1:5 — WEIGHT: — SHEET 1 OF 1
DO NOT SCALE DRAWING			

5 4 3 2 1









UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ± INTERPRET GEOMETRIC TOLERANCING PER: MATERIAL FINISH DO NOT SCALE DRAWING	DRAWN BY	J. Zorko
	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	Eccentric Headstock
	SUBSYSTEM	Driveline
	COMMENTS:	

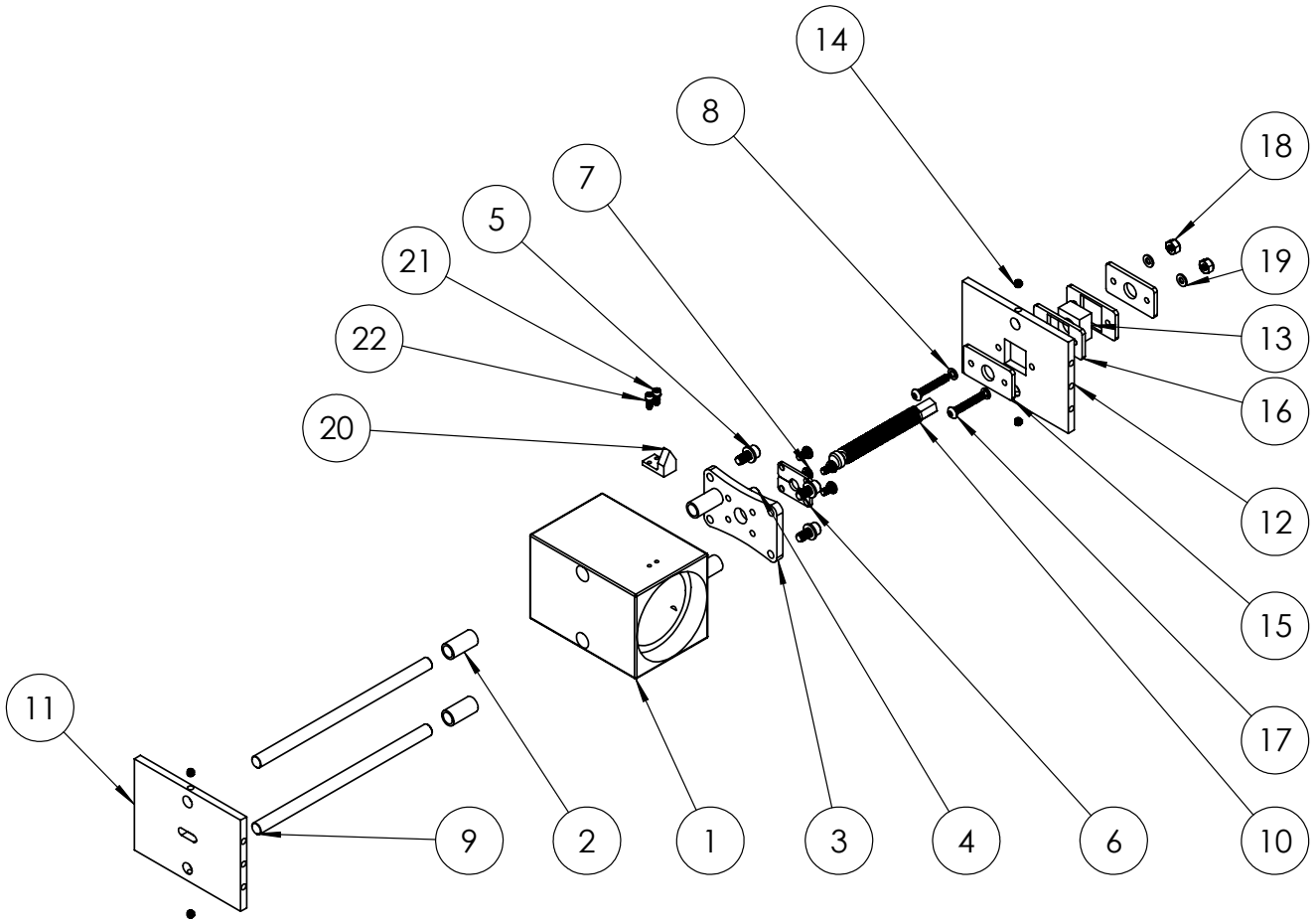
Cooper Machine Co.

TITLE:
Eccentric Adjuster

SIZE	FILE NAME	REV
A	Eccentric Adjuster	1.5

SCALE: 1:5 | WEIGHT: | SHEET 1 OF 3

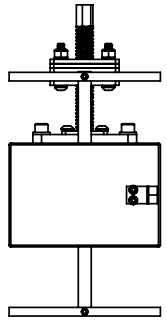
5 4 3 2 1



UNLESS OTHERWISE SPECIFIED:	DRAWN BY	J. Zorko	Cooper Machine Co.
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014	TITLE: Eccentric Adjuster
	APPLICATION		
	NEXT ASSY	Eccentric Headstock	
INTERPRET GEOMETRIC TOLERANCING PER:			
MATERIAL	SUBSYSTEM	Driveline	SIZE A | FILE NAME Eccentric Adjuster | REV 1.5
FINISH	COMMENTS:		SCALE: 1:5 | WEIGHT: | SHEET 2 OF 3
DO NOT SCALE DRAWING			

5 4 3 2 1

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Eccentric - Spindle Nose Bearing Block		1
2	SAE 863 - 2868T74 Super Oilite Eccentric Sleeve Bearing		4
3	Eccentric - ACME Termination Plate		1
4	1-4 - 28 .5 Socket Cap Bolt		4
5	1 - 4 Spring Lock Washer		4
6	Eccentric - ACME Ball Retainer		2
7	10-32 - 0.375 Button Socket Cap Bolt		4
8	No. 10 Spring Lock Washer		6
9	Eccentric - Slide Rail		2
10	Eccentric - ACME Adjuster		1
11	Eccentric - Outside Rail End Plate		1
12	Eccentric - Inner Rail End Plate		1
13	1-2 - 10 ACME Square Nut		1
14	10-32 Cup Point Set Screw		4
15	Eccentric - ACME Adjuster Nut Retaining Plate		2
16	Eccentric - ACME Adjuster Nut Spacer		2
17	10-32 - 1.25 Button Socket Cap Bolt		2
18	90715A115		2
19	No. 10 Flat Washer		2
20	Notch Indicator		1
21	6-32 - 0.375 Socket Cap Bolt		2
22	No. 6 Spring Lock Washer		2



UNLESS OTHERWISE SPECIFIED:	DRAWN BY	J. Zorko
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	Eccentric
INTERPRET GEOMETRIC TOLERANCING PER:		Headstock
MATERIAL		
	SUBSYSTEM	Driveline
FINISH	COMMENTS:	
DO NOT SCALE DRAWING		

Cooper Machine Co.

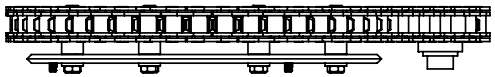
TITLE:

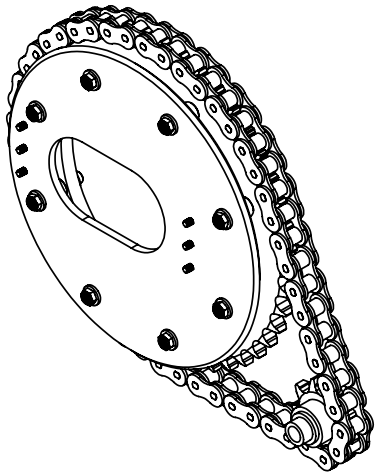
Eccentric Adjuster

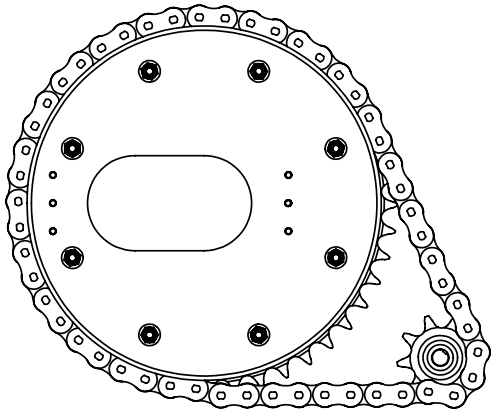
SIZE	FILE NAME	REV
A	Eccentric Adjuster	1.5

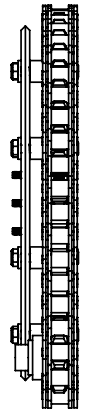
SCALE: 1:5 | WEIGHT: | SHEET 3 OF 3

5 4 3 2 1



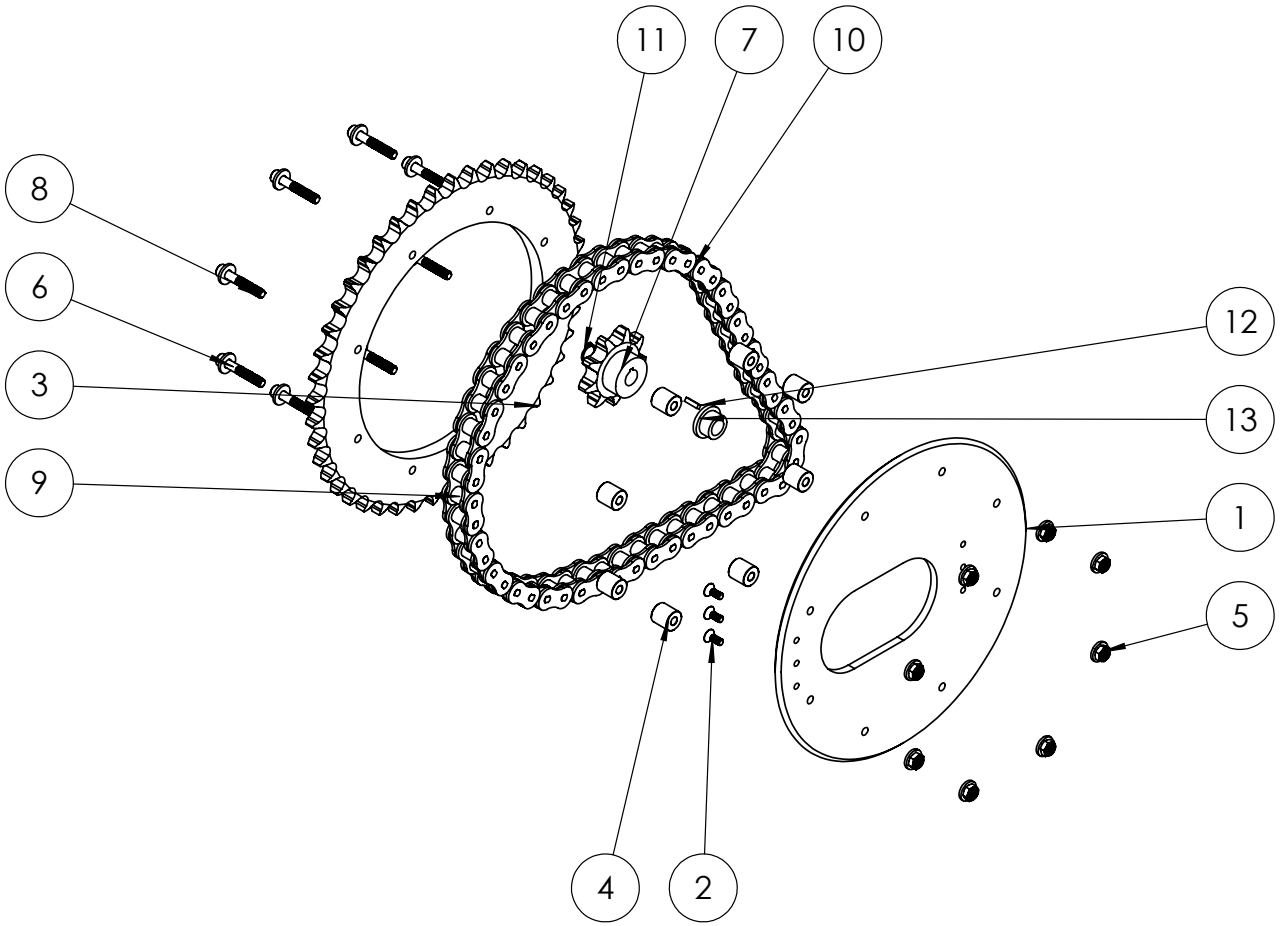






UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ± INTERPRET GEOMETRIC TOLERANCING PER: MATERIAL FINISH DO NOT SCALE DRAWING	DRAWN BY	J. Zorko	Cooper Machine Co. TITLE: Chain Drive
	DATE	12/17/2014	
	APPLICATION		
	NEXT ASSY	Eccentric Headstock	
	SUBSYSTEM	Driveline	SIZE A | FILE NAME Eccentric Chain Drive | REV 2.0
	COMMENTS:		SCALE: 1:5 | WEIGHT: | SHEET 1 OF 3

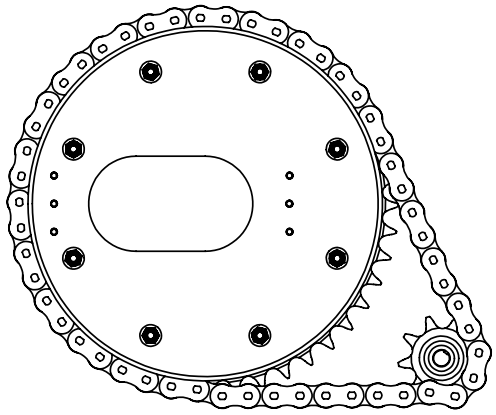
5 4 3 2 1



UNLESS OTHERWISE SPECIFIED:	DRAWN BY	J. Zorko	Cooper Machine Co.
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014	TITLE: Chain Drive
	APPLICATION		
	NEXT ASSY	Eccentric Headstock	
INTERPRET GEOMETRIC TOLERANCING PER:			
MATERIAL	SUBSYSTEM	Driveline	SIZE A | FILE NAME Eccentric Chain Drive | REV 2.0
FINISH	COMMENTS:		
DO NOT SCALE DRAWING			SCALE: 1:5 | WEIGHT: | SHEET 2 OF 3

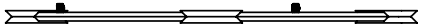
5 4 3 2 1

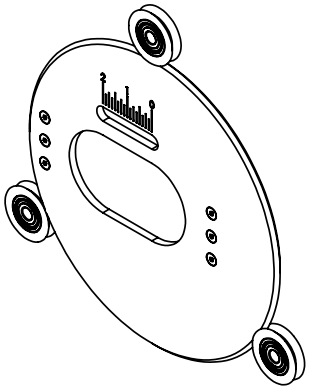
ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Spindle Carrier Rear Plate MKIII		1
2	10-32 - 0.5 - Countersunk Bolt		6
3	No. 60 Eccentric Drive Sprocket - 45T		1
4	Eccentric Drive - Spacer Bushing		8
5	1-4 28 Lo-Pro Nylock 94945A210		8
6	1 - 4 SAE Spec Flat Washer - 91950A029		16
7	No. 60 Eccentric Drive Sprocket - 9T		1
8	1-4 28 1.5 Socket Cap Bolt - 91251A446		8
9	No. 60 Roller Chain - Roller Half		26
10	No. 60 Roller Chain - Link Half		26
11	.5in snapring - 97633A200		1
12	Eccentric Drive Sprocket Key		1
13	Alloy 932 Sleeve Bearing - 7815K33		1

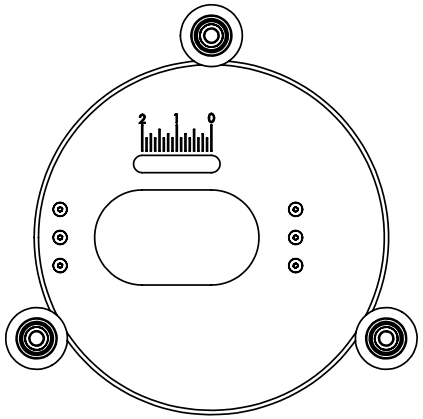


UNLESS OTHERWISE SPECIFIED:	DRAWN BY	J. Zorko	Cooper Machine Co.
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014	TITLE: Chain Drive
	APPLICATION		
	NEXT ASSY	Eccentric Headstock	
INTERPRET GEOMETRIC TOLERANCING PER:			
MATERIAL	SUBSYSTEM	Driveline	SIZE A | FILE NAME Eccentric Chain Drive | REV 2.0
FINISH	COMMENTS:		
DO NOT SCALE DRAWING			SCALE: 1:5 | WEIGHT: | SHEET 3 OF 3

5 4 3 2 1



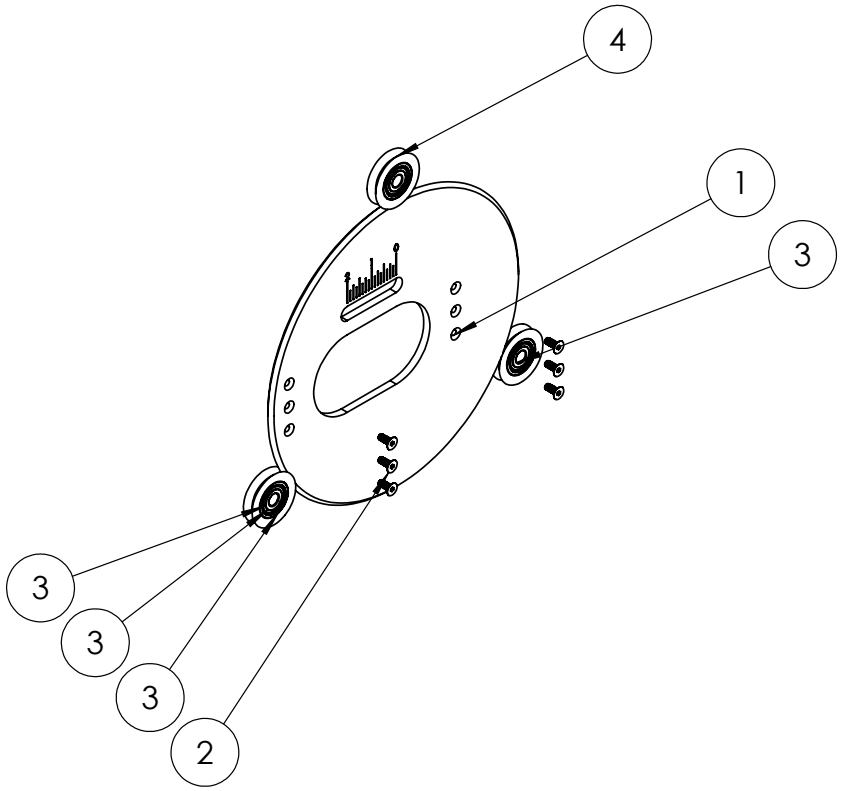




UNLESS OTHERWISE SPECIFIED:	DRAWN BY	J. Zorko	Cooper Machine Co.
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014	TITLE: Eccentric
	APPLICATION		
	NEXT ASSY	Headstock	
INTERPRET GEOMETRIC TOLERANCING PER:			SIZE A / FILE NAME Eccentric Front / REV 3.0
MATERIAL	SUBSYSTEM	Driveline	
FINISH	COMMENTS:		SCALE: 1:5 / WEIGHT: / SHEET 1 OF 2
DO NOT SCALE DRAWING			

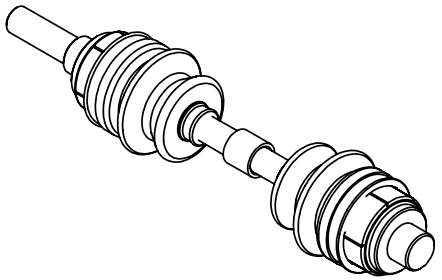
5 4 3 2 1

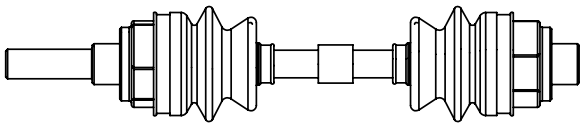
ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Spindle Carrier Front Plate MKIII		1
2	10-32 - 0.5 - Countersunk Bolt		6
3	Carrier Bearing - SKF 6200-Z_2_03		3
4	Carrier Bearing Guide Roller		3

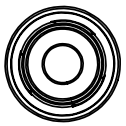


UNLESS OTHERWISE SPECIFIED:	DRAWN BY	J. Zorko	Cooper Machine Co.
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014	TITLE: Eccentric
	APPLICATION		
	NEXT ASSY	Headstock	
INTERPRET GEOMETRIC TOLERANCING PER:			SIZE: A — FILE NAME: Eccentric Front — REV: 3.0
MATERIAL	SUBSYSTEM	Driveline	
FINISH	COMMENTS:		SCALE: 1:5 — WEIGHT: — SHEET 2 OF 2
DO NOT SCALE DRAWING			

5 4 3 2 1

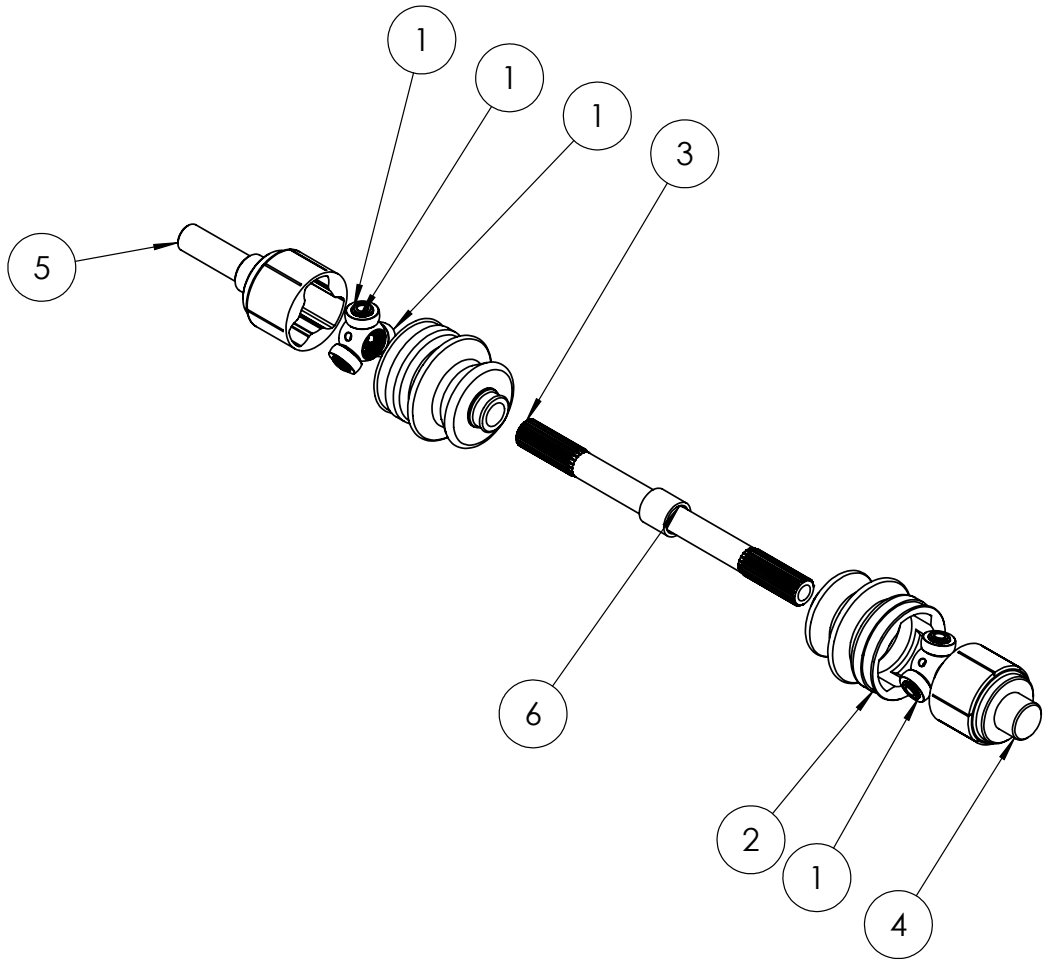






UNLESS OTHERWISE SPECIFIED:	DRAWN BY	J. Zorko	Cooper Machine Co.
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014	TITLE: CV Joint
	APPLICATION		
	NEXT ASSY	Headstock	
INTERPRET GEOMETRIC TOLERANCING PER:			SIZE A / FILE NAME Spindle Driveshaft / REV 1.0
MATERIAL	SUBSYSTEM	Driveline	
FINISH	COMMENTS:		SCALE: 1:5 / WEIGHT: / SHEET 1 OF 3
DO NOT SCALE DRAWING			

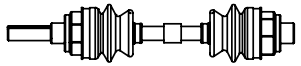
5 4 3 2 1



UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN BY	J. Zorko	Cooper Machine Co.
	DATE	12/17/2014	TITLE: CV Joint
	APPLICATION		
	NEXT ASSY	Headstock	
INTERPRET GEOMETRIC TOLERANCING PER:			
MATERIAL	SUBSYSTEM	Driveline	SIZE A / FILE NAME Spindle Driveshaft / REV 1.0
FINISH	COMMENTS:		
DO NOT SCALE DRAWING			SCALE: 1:5 / WEIGHT: / SHEET 2 OF 3

5 4 3 2 1

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	D4672-TA(1)	CV Knuckle	2
2	Driveshaft Boot		2
3	MKIII Driveshaft		1
4	Tripod Housing - Torsen - Rear		1
5	Tripod Housing - Torsen - Front		1
6	Driveshaft Reinforcing Sleeve		1



UNLESS OTHERWISE SPECIFIED:	DRAWN BY	J. Zorko
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	Headstock
INTERPRET GEOMETRIC TOLERANCING PER:		
MATERIAL	SUBSYSTEM	Driveline
FINISH	COMMENTS:	
DO NOT SCALE DRAWING		

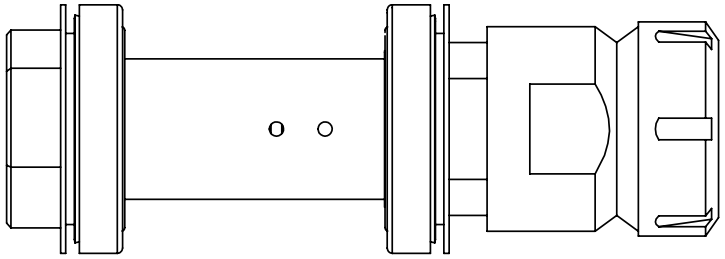
Cooper Machine Co.

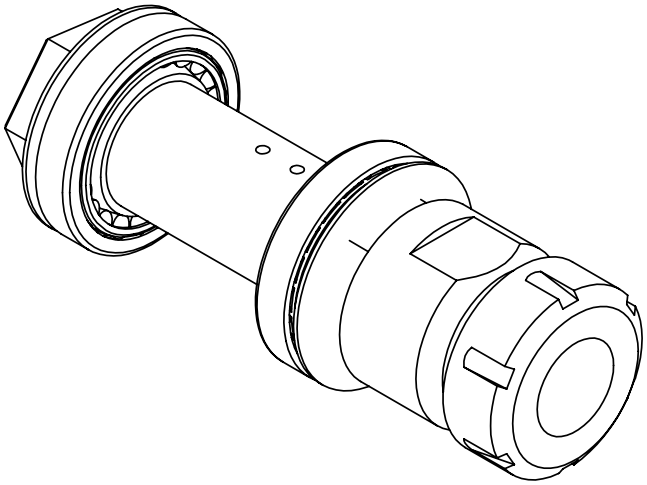
TITLE: CV Joint

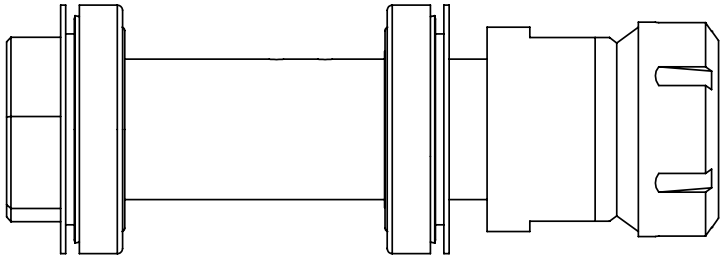
SIZE	FILE NAME	REV
A	Spindle Driveshaft	1.0

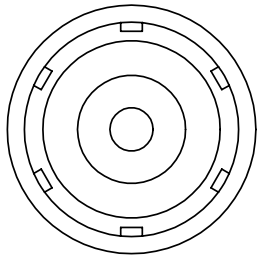
SCALE: 1:10 WEIGHT: SHEET 3 OF 3

5 4 3 2 1



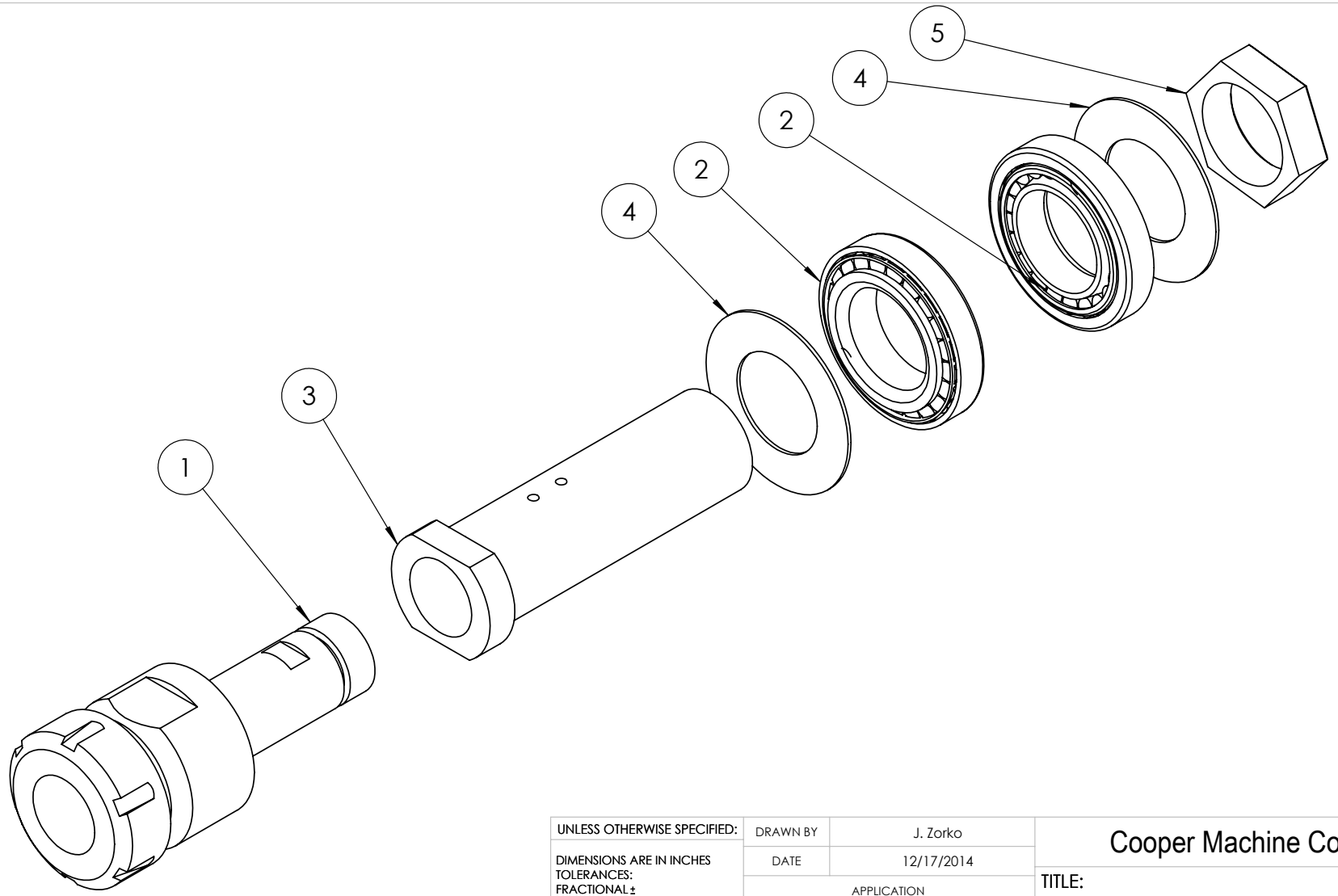






UNLESS OTHERWISE SPECIFIED:	DRAWN BY	J. Zorko	Cooper Machine Co.
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014	TITLE: Spindle Nose
	APPLICATION		
	NEXT ASSY	Eccentric Headstock	
INTERPRET GEOMETRIC TOLERANCING PER:			
MATERIAL	SUBSYSTEM	Driveline	SIZE A | FILE NAME Spindle Nose | REV 2.0
FINISH	COMMENTS:		
DO NOT SCALE DRAWING			SCALE: 1:2 | WEIGHT: | SHEET 1 OF 3

5 4 3 2 1



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DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	Eccentric
		Headstock
	SUBSYSTEM	Driveline
INTERPRET GEOMETRIC TOLERANCING PER:	COMMENTS:	
MATERIAL		
FINISH		
DO NOT SCALE DRAWING		

Cooper Machine Co.

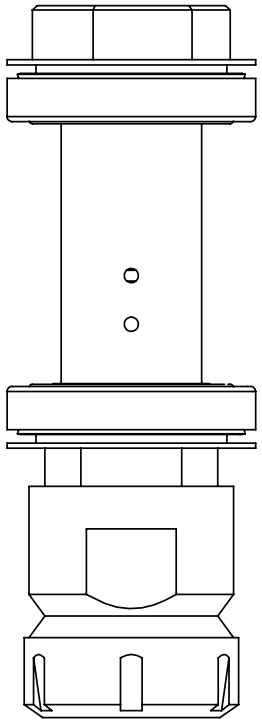
TITLE: Spindle Nose

SIZE	FILE NAME	REV
A	Spindle Nose	2.0

SCALE: 1:2 | WEIGHT: | SHEET 2 OF 3

5 4 3 2 1

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Maritool ER40 Collet Holder		1
2	Spindle Bearing - Nose - SKF 18590_18520_Q_2_03		2
3	Spindle Nose Sleeve		1
4	Spindle Nose Bearing Shield		2
5	Spindle Nose Preload Nut		1



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DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	Eccentric
		Headstock
INTERPRET GEOMETRIC TOLERANCING PER:		
MATERIAL	SUBSYSTEM	Driveline
FINISH	COMMENTS:	
DO NOT SCALE DRAWING		

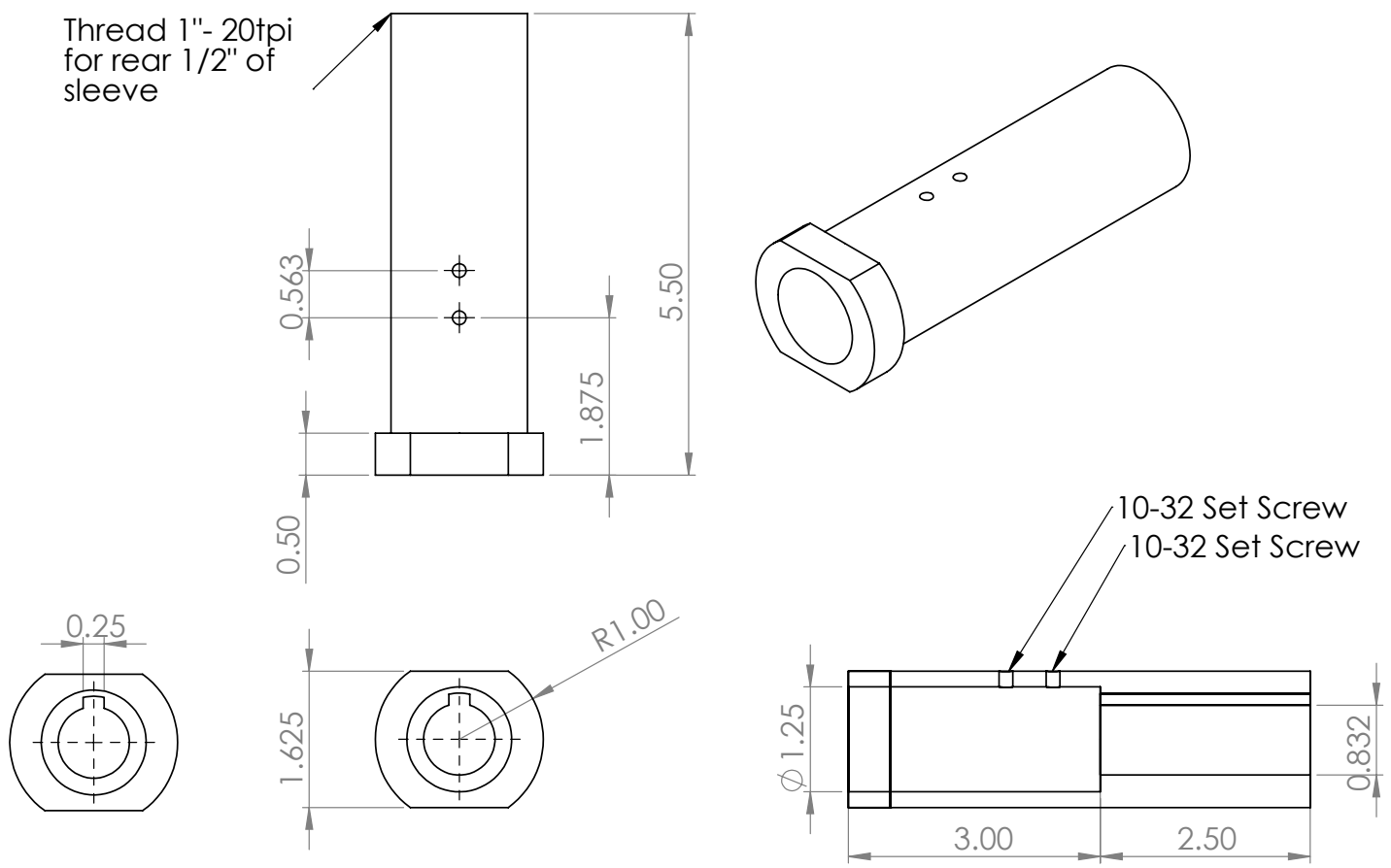
Cooper Machine Co.

TITLE: Spindle Nose

SIZE	FILE NAME	REV
A	Spindle Nose	2.0

SCALE: 1:2 | WEIGHT: | SHEET 3 OF 3

5 4 3 2 1



UNLESS OTHERWISE SPECIFIED:	DRAWN BY	J. Zorko
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	
INTERPRET GEOMETRIC TOLERANCING PER:		
MATERIAL	SUBSYSTEM	
FINISH	COMMENTS:	
DO NOT SCALE DRAWING		

Cooper Machine Co.

TITLE:

SIZE	FILE NAME	REV
A	Spindle Nose Sleeve	3.0

SCALE: 1:2 | WEIGHT: | SHEET 1 OF 1

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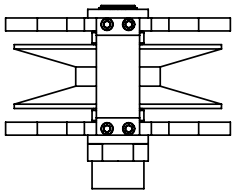

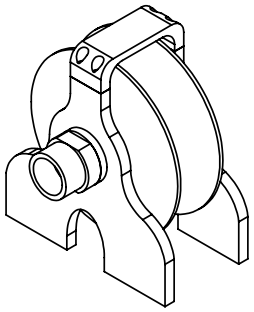

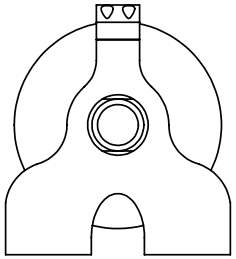

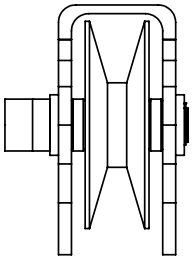

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	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	Headstock
	SUBSYSTEM	Driveline
	COMMENTS:	

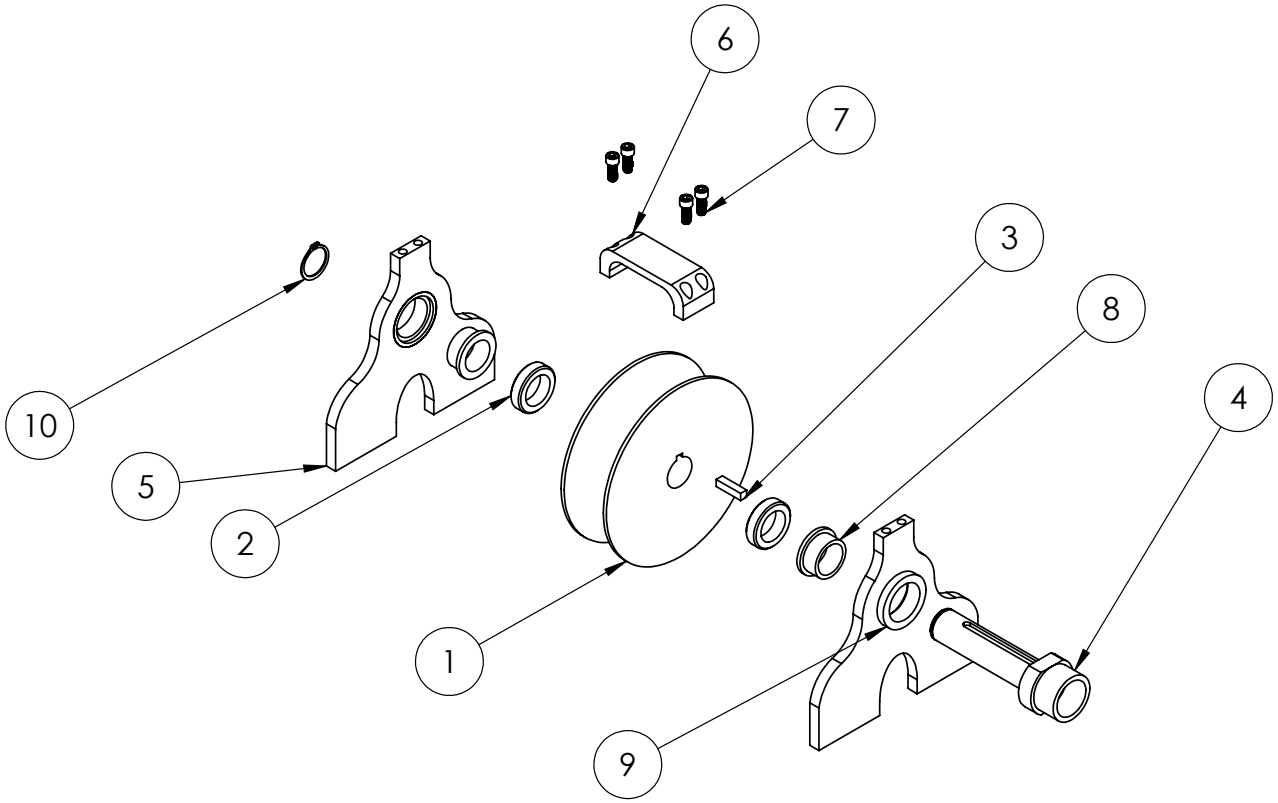
Cooper Machine Co.

TITLE: Spindle Pulley

SIZE	FILE NAME	REV
A	Spindle Pulley	2.0

SCALE: 1:5 | WEIGHT: | SHEET 1 OF 3

5 4 3 2 1



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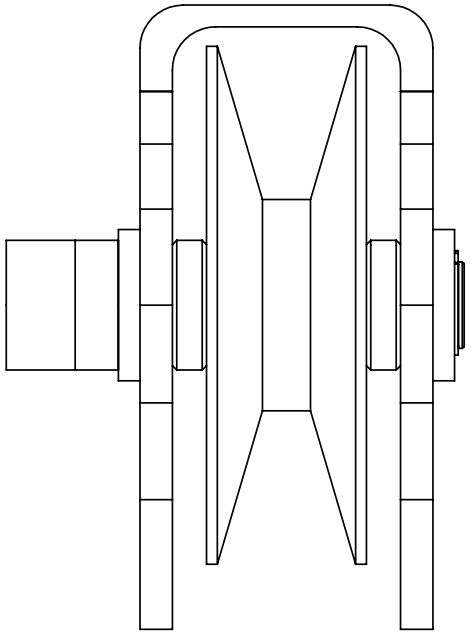
5 4 3 2 1

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Spindle Drive Pulley		1
2	Spindle Pulley Spacer		2
3	.25in Key Spindle Pulley Key		1
4	Spindle Pulley Drive Axle		1
5	Spindle Pulley Rear Frame		2
6	Spindle Pulley Frame Crossbar		1
7	1-4 - 28 .625 Bolt		4
8	Spindle Pulley Sleeve Bearing - 3113K36		2
9	Spindle Pulley Sleeve Bearing Adapter		2
10	1 in Snap Ring		1



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DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	Headstock
INTERPRET GEOMETRIC TOLERANCING PER:		
MATERIAL	SUBSYSTEM	Driveline
FINISH	COMMENTS:	
DO NOT SCALE DRAWING		

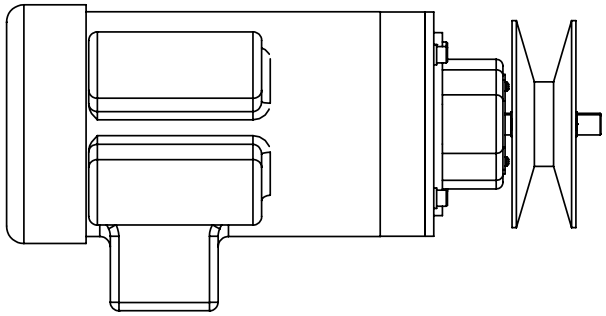
Cooper Machine Co.

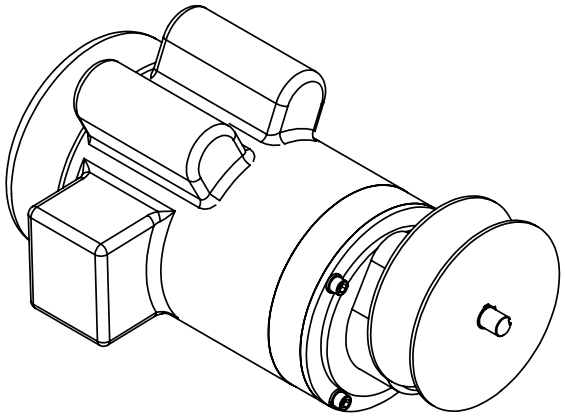
TITLE: Spindle Pulley

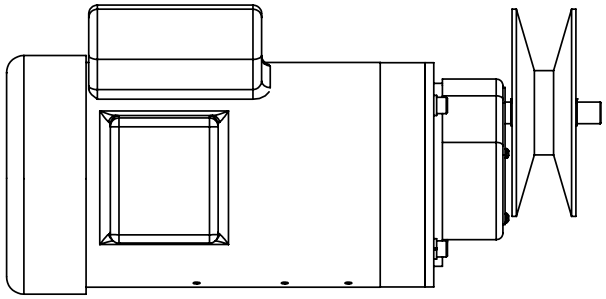
SIZE	FILE NAME	REV
A	Spindle Pulley	2.0

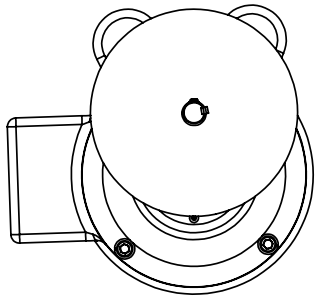
SCALE: 1:2 | WEIGHT: | SHEET 3 OF 3

5 4 3 2 1



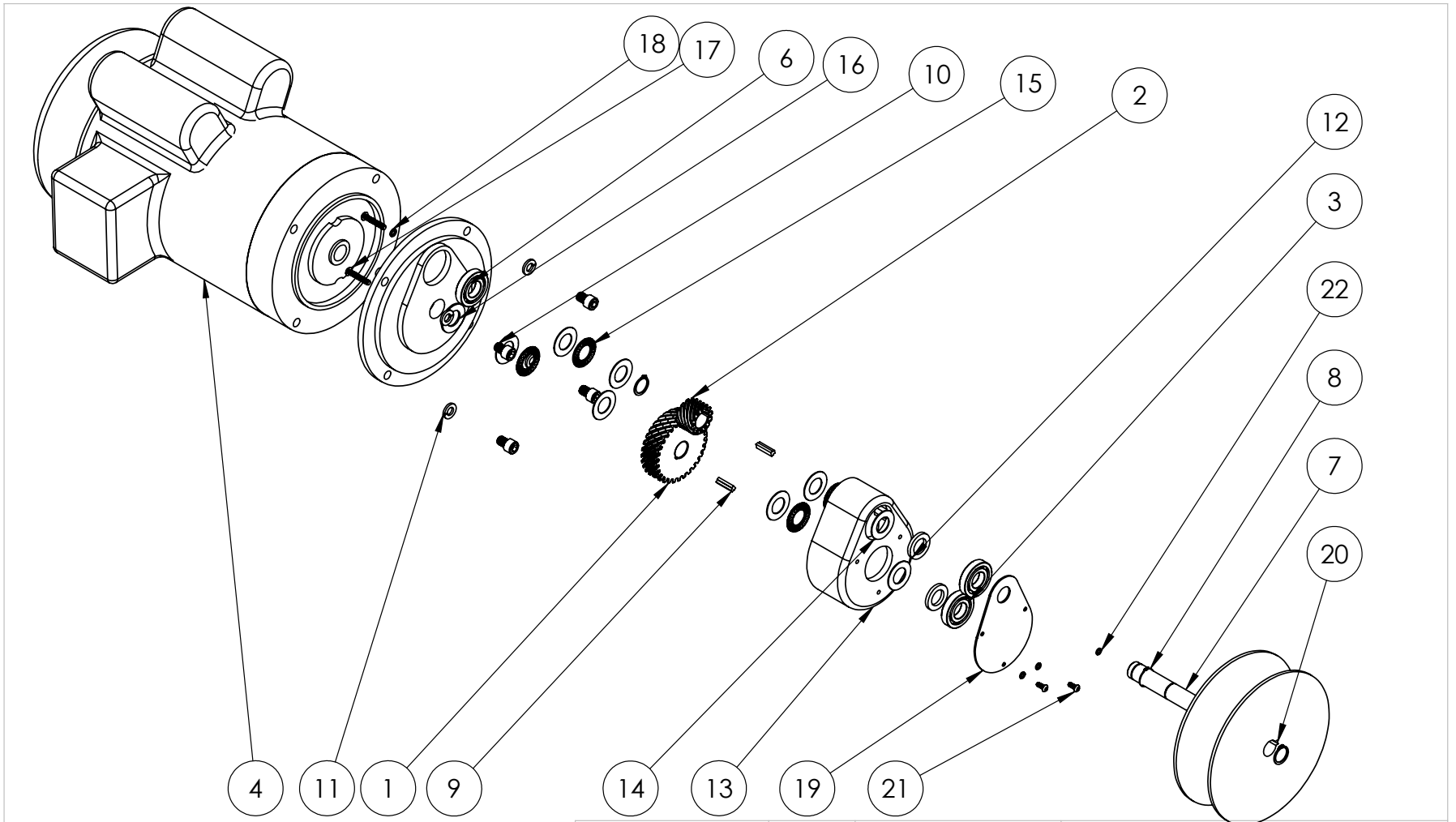






UNLESS OTHERWISE SPECIFIED:	DRAWN BY	J. Zorko	Cooper Machine Co.
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014	TITLE: Spindle Gearbox
	APPLICATION	Spindle Gearbox	
INTERPRET GEOMETRIC TOLERANCING PER:	NEXT ASSY		SIZE A | FILE NAME Spindle Gearbox | REV 2.0
MATERIAL	SUBSYSTEM	Driveline	
FINISH	COMMENTS:		SCALE: 1:10 WEIGHT: | SHEET 1 OF 3
DO NOT SCALE DRAWING			

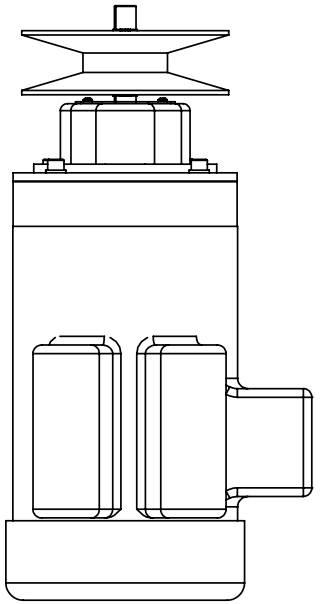
5 4 3 2 1



UNLESS OTHERWISE SPECIFIED:	DRAWN BY	J. Zorko	Cooper Machine Co.
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014	TITLE: Spindle Gearbox
	APPLICATION	Spindle Gearbox	
INTERPRET GEOMETRIC TOLERANCING PER:	NEXT ASSY		SIZE A | FILE NAME Spindle Gearbox | REV 2.0
MATERIAL			
FINISH	SUBSYSTEM	Driveline	
DO NOT SCALE DRAWING	COMMENTS:		SCALE: 1:5 | WEIGHT: | SHEET 2 OF 3

5 4 3 2 1

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Boston Gear H1230L		1
2	Boston Gear H1212R		1
3	3760T4	.625 Bore Ball Bearing	3
4	Spindle Motor		1
5	Spindle Motor Shaft		1
6	Spindle Gearbox Casing - Rear		1
7	Spindle Gearbox Output Shaft		1
8	97633A230	.625 Bore Snap Ring	3
9	Spindle Motor Split Key		2
10	Gearbox Rear Mount Bolt		4
11	5-16 Spring Lock Washer		4
12	Spindle Gearbox Spacer		2
13	Spindle Gearbox Casing -Front		1
14	5909K45		8
15	5909K32		4
16	Aux Gearbox Spacer		1
17	8-32 -1 in gearbox bolt		3
18	No. 8 Spring Lock Washer		3
19	Spindle Gearbox Dust Cap - Data Plate		1
20	Spindle Motor Pulley		1
21	6-32 - 0.375 Button Socket Bolt		3
22	No. 6 Spring Lock Washer		3
23	Spindle Pulley Key		1



UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL

FINISH

DO NOT SCALE DRAWING

DRAWN BY	J. Zorko
DATE	12/17/2014
APPLICATION	
NEXT ASSY	Spindle Gearbox
SUBSYSTEM	Driveline
COMMENTS:	

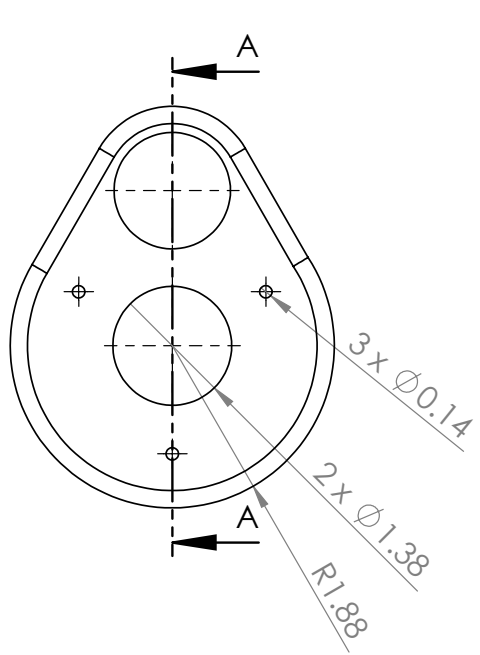
Cooper Machine Co.

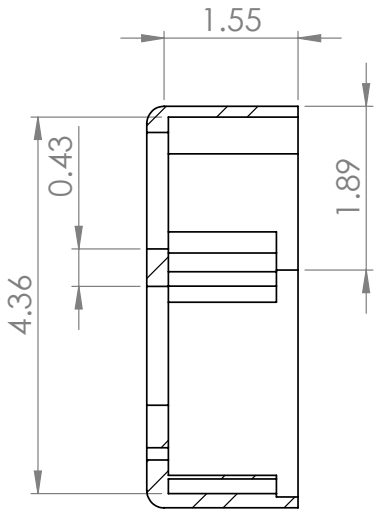
TITLE:
Spindle Gearbox

SIZE	FILE NAME	REV
A	Spindle Gearbox	2.0

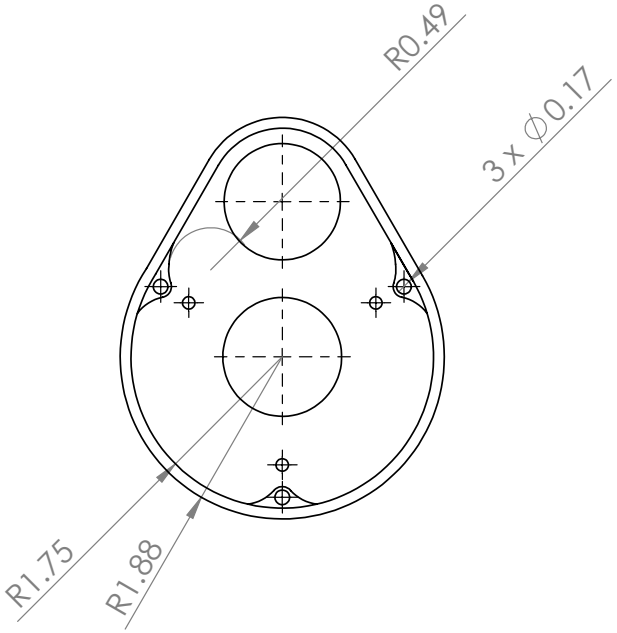
SCALE: 1:5 | WEIGHT: | SHEET 3 OF 3

5 4 3 2 1





SECTION A-A
SCALE 1 : 2



UNLESS OTHERWISE SPECIFIED:	DRAWN BY	J. Song
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/18/2014
	APPLICATION	Spndle Gearbox Subassembly
INTERPRET GEOMETRIC TOLERANCING PER:	NEXT ASSY	CMC Notchmatic
MATERIAL AISI 4130 Steel, normalized at 870C	PROJECT	
FINISH	COMMENTS:	
DO NOT SCALE DRAWING		

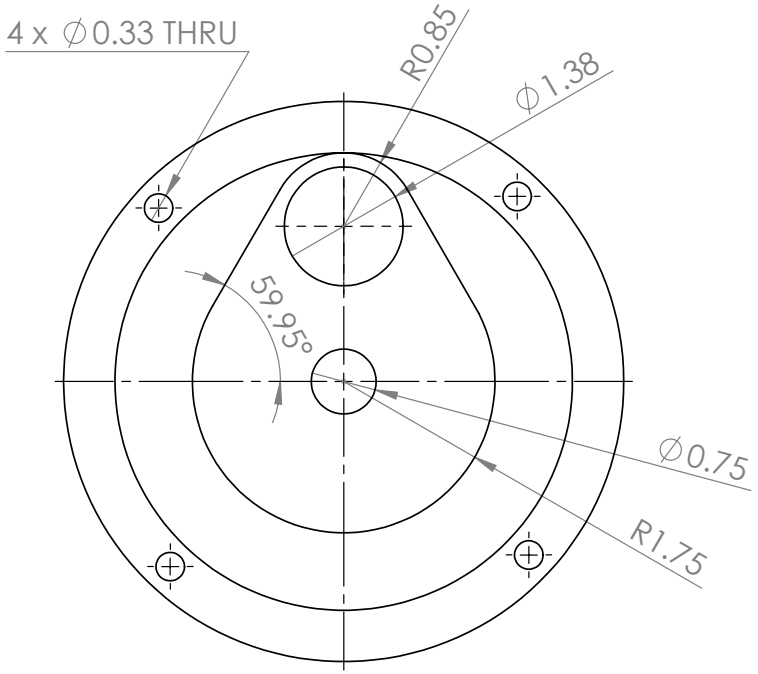
Cooper Machine Co.

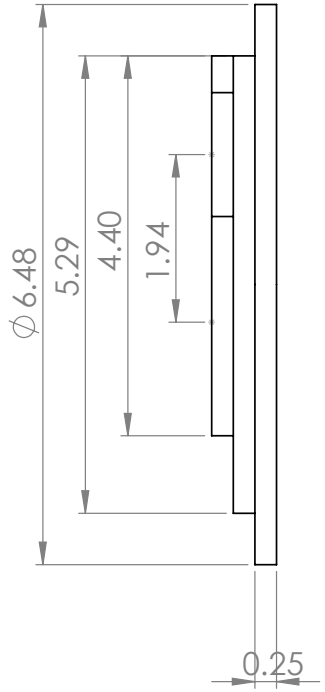
TITLE:

Spindle Gearbox Casing (Front)

SIZE	FILE NAME	REV
A	Spindle Gearbox Casing Front	1.0
SCALE: 1:1.5	WEIGHT: 1.42	SHEET 1 OF 1

5 4 3 2 1





UNLESS OTHERWISE SPECIFIED:	DRAWN BY	J. Zorko
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/18/2014
	APPLICATION	Spindle Gearbox Subassembly
INTERPRET GEOMETRIC TOLERANCING PER:	NEXT ASSY	CMC Notchmatic
MATERIAL AISI 4130 Steel, annealed at 865C	SYSTEM	
FINISH	COMMENTS:	
DO NOT SCALE DRAWING		

Cooper Machine Co.

TITLE:

Spindle Gearbox Casing (Rear)

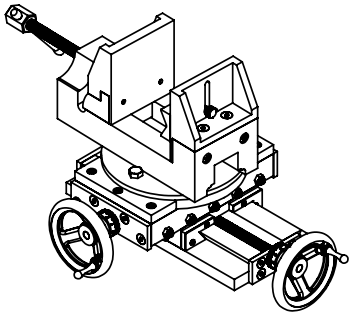
SIZE	FILE NAME	REV
A	Spindle Gearbox Casing Rear	1.0

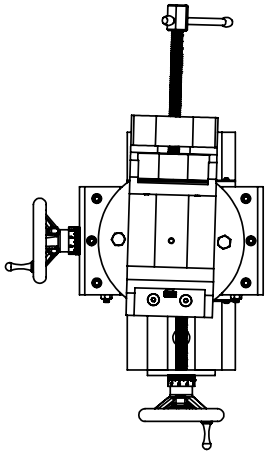
SCALE: 1:2 | WEIGHT: 3.37 | SHEET 1 OF 1

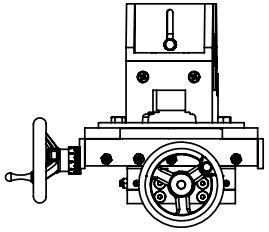
5 4 3 2 1

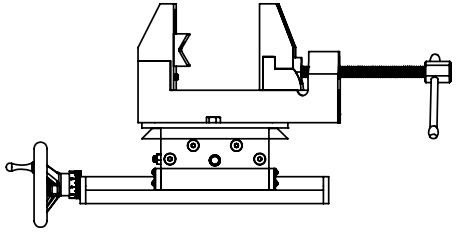
5.3 Fixturing

5.3.1 Dovetail stage





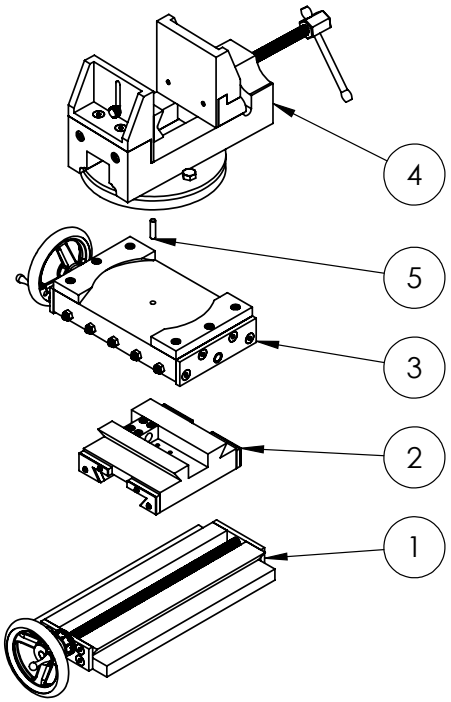




UNLESS OTHERWISE SPECIFIED:	DRAWN BY	J. Song	Cooper Machine Co.
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014	TITLE: Fixturing
	APPLICATION		
	NEXT ASSY	CMC Notchmatic	
INTERPRET GEOMETRIC TOLERANCING PER:			SIZE A | FILE NAME fixturing | REV 1.0
MATERIAL	SUBSYSTEM	Fixturing	
FINISH	COMMENTS:		SCALE: 1:8 | WEIGHT: | SHEET 1 OF 2
DO NOT SCALE DRAWING			

5 4 3 2 1

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	stage-bottom	Lower Dovetail Stage	1
2	stage-middle	Mid Dovetail Stage	1
3	stage-top	Upper Dovetail Stage	1
4	vise-swivel	Mounted Vise	1
5	97395A491	vise swivel locating pin	1



UNLESS OTHERWISE SPECIFIED:	DRAWN BY	J. Song
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	CMC Notchmatic
INTERPRET GEOMETRIC TOLERANCING PER:		
MATERIAL	SUBSYSTEM	Fixturing
FINISH	COMMENTS:	
DO NOT SCALE DRAWING		

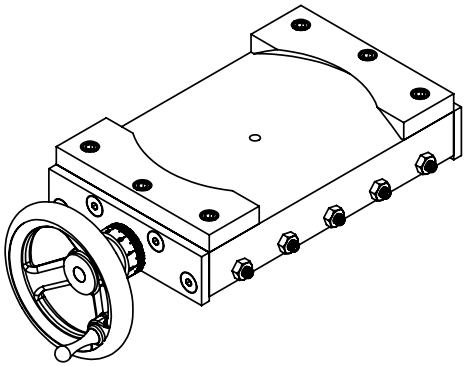
Cooper Machine Co.

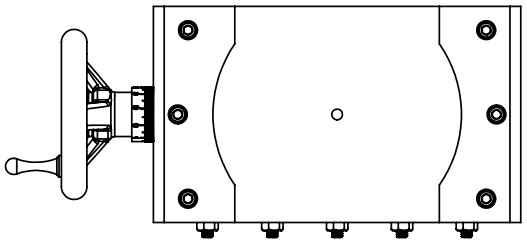
TITLE: Fixturing

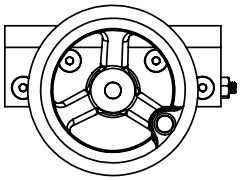
SIZE	FILE NAME	REV
A	fixturing	1.0

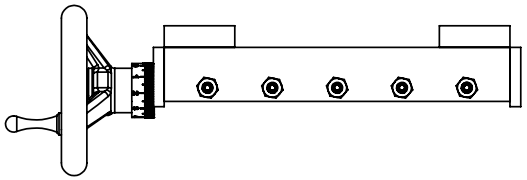
SCALE: 1:8 | WEIGHT: | SHEET 2 OF 2

5 4 3 2 1









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	APPLICATION	
	NEXT ASSY	Fixturing
INTERPRET GEOMETRIC TOLERANCING PER:		
MATERIAL	SUBSYSTEM	Fixturing
FINISH	COMMENTS:	
DO NOT SCALE DRAWING		

Cooper Machine Co.

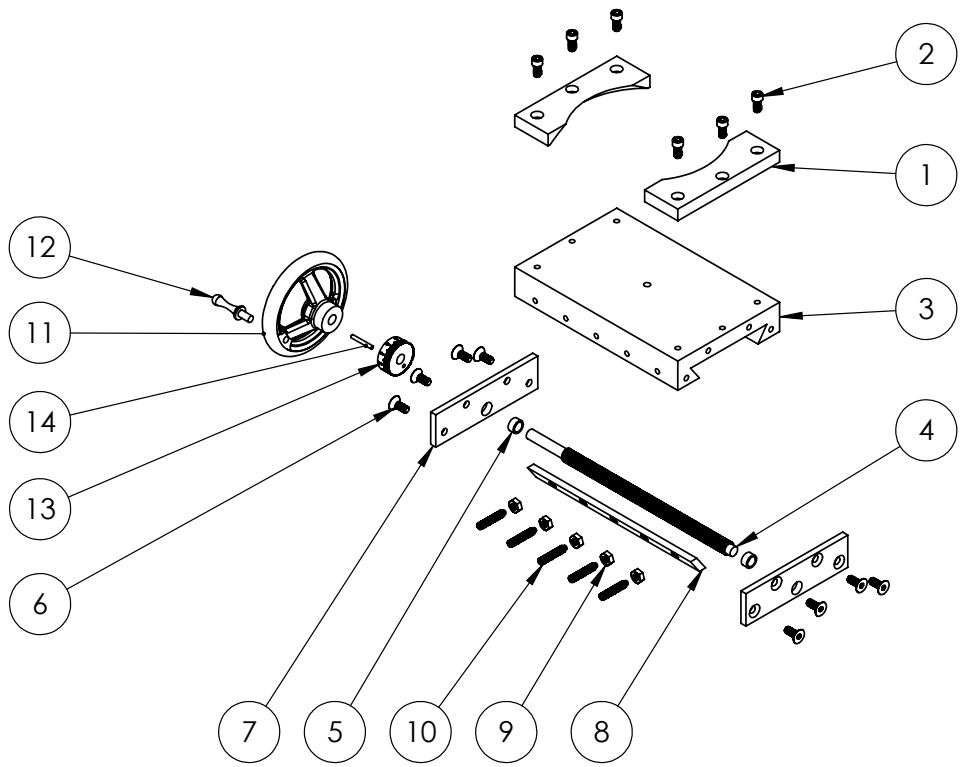
TITLE:
Upper Dovetail Stage

SIZE	FILE NAME	REV
A	stage-top	1.0

SCALE: 1:4 | WEIGHT: | SHEET 1 OF 2

5 4 3 2 1

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	swivel-blocks-body-1	Swivel Block	2
2	91251A537	swivel block mount screw	6
3	dovetail-top	Top dovetail	1
4	screw-y	Y Lead screw	1
5	screw-bearing	Lead screw bearing	2
6	91253A539	End plate mount screw	8
7	end-plate-female	Female end plate	2
8	gib	Gib	1
9	93181A029	Gib lock nut	5
10	92505A545	Gib screw	5
11	100mm Handwheel - Fixturing Spec	Handwheel	1
12	100mm Handwheel - Knob	Handwheel knob	1
13	dial	Handwheel Dial	1
14	98381A310	handwheel dial locating pin	1



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	APPLICATION	
	NEXT ASSY	Fixturing
INTERPRET GEOMETRIC TOLERANCING PER:		
MATERIAL	SUBSYSTEM	Fixturing
FINISH	COMMENTS:	
DO NOT SCALE DRAWING		

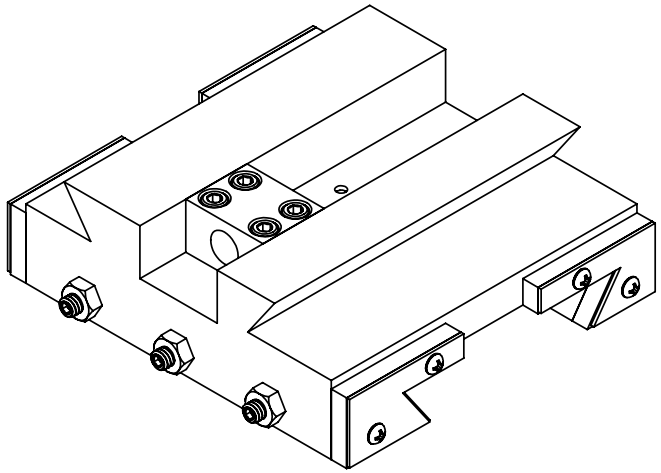
Cooper Machine Co.

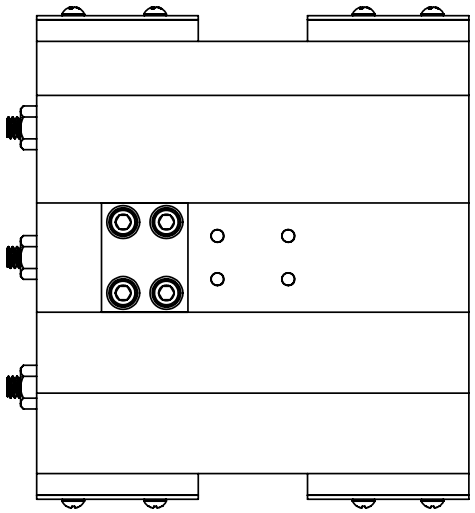
TITLE:
Upper Dovetail Stage

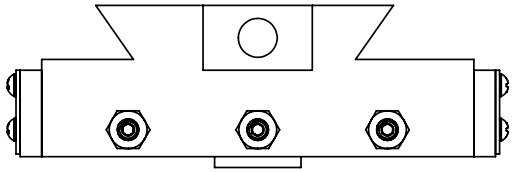
SIZE	FILE NAME	REV
A	stage-top	1.0

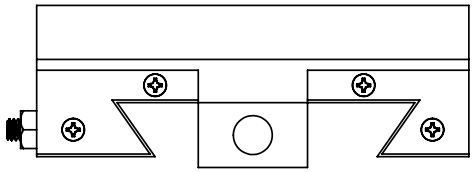
SCALE: 1:6 | WEIGHT: | SHEET 2 OF 2

5 4 3 2 1





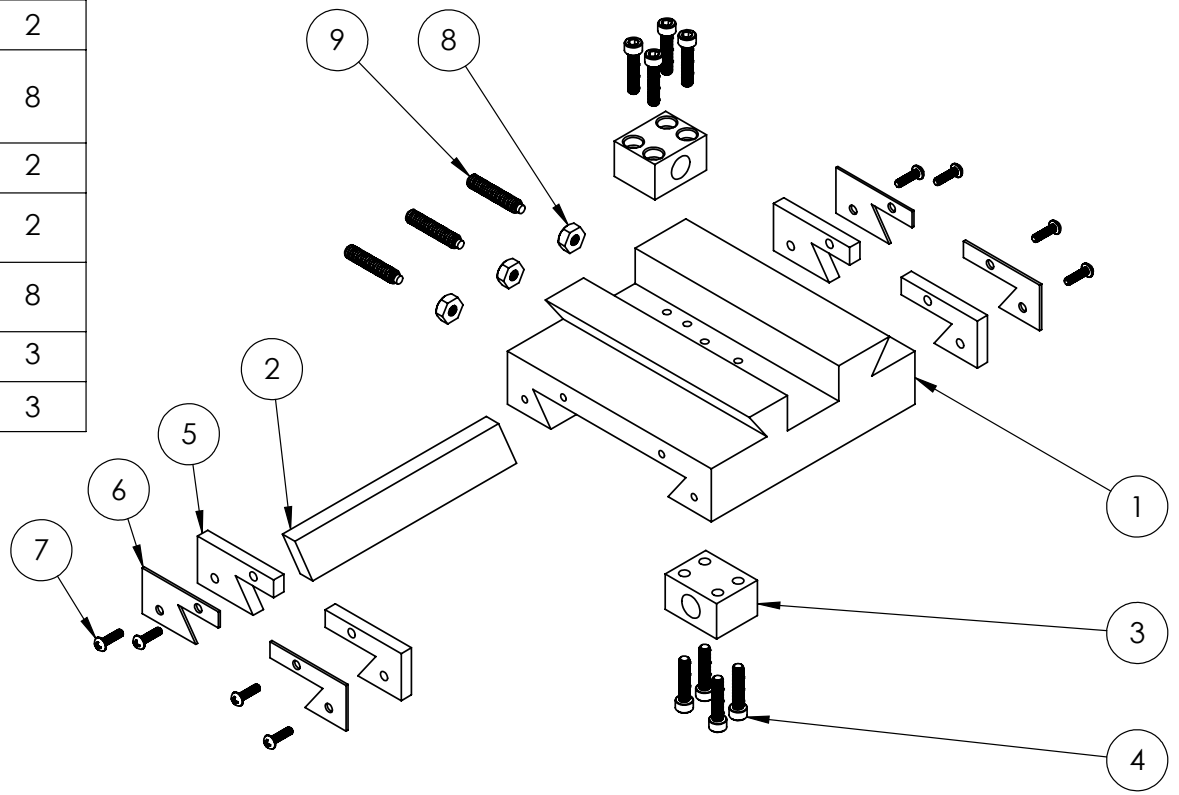




UNLESS OTHERWISE SPECIFIED:	DRAWN BY	J. Song	Cooper Machine Co.
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014	TITLE: Mid Dovetail Stage
	APPLICATION		
	NEXT ASSY	Fixturing	
INTERPRET GEOMETRIC TOLERANCING PER:			
MATERIAL	SUBSYSTEM	Fixturing	SIZE A | FILE NAME stage-middle | REV 1.0
FINISH	COMMENTS:		SCALE: 1:2 | WEIGHT: | SHEET 1 OF 2
DO NOT SCALE DRAWING			

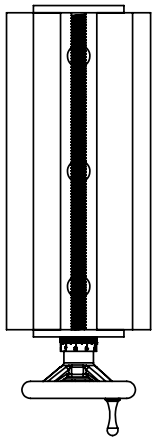
5 4 3 2 1

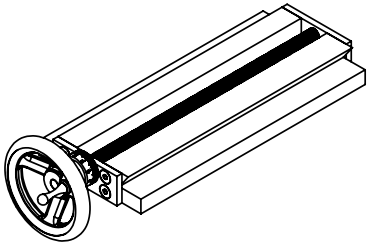
ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	dovetail-mid	Middle Dovetail	1
2	gib	Gib	1
3	acme-nut	Acme nut	2
4	91251A346	acme nut mount screw	8
5	way-wiper	Way wipers	2
6	way-wiper-plates	Way wiper plates	2
7	91773A148	way wiper screw	8
8	93181A029	gib lock nut	3
9	92505A545	Gib screw	3

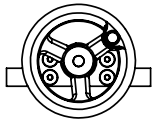


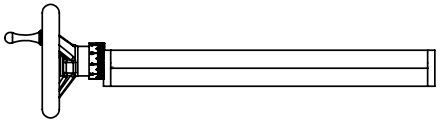
UNLESS OTHERWISE SPECIFIED:	DRAWN BY	J. Song	Cooper Machine Co.
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014	TITLE: Mid Dovetail Stage
	APPLICATION		
	NEXT ASSY	Fixturing	
INTERPRET GEOMETRIC TOLERANCING PER:			
MATERIAL	SUBSYSTEM	Fixturing	SIZE A | FILE NAME stage-middle | REV 1.0
FINISH	COMMENTS:		SCALE: 1:3 | WEIGHT: | SHEET 2 OF 2
DO NOT SCALE DRAWING			

5 4 3 2 1









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DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	Fixturing
INTERPRET GEOMETRIC TOLERANCING PER:		
MATERIAL	SUBSYSTEM	Fixturing
FINISH	COMMENTS:	
DO NOT SCALE DRAWING		

Cooper Machine Co.

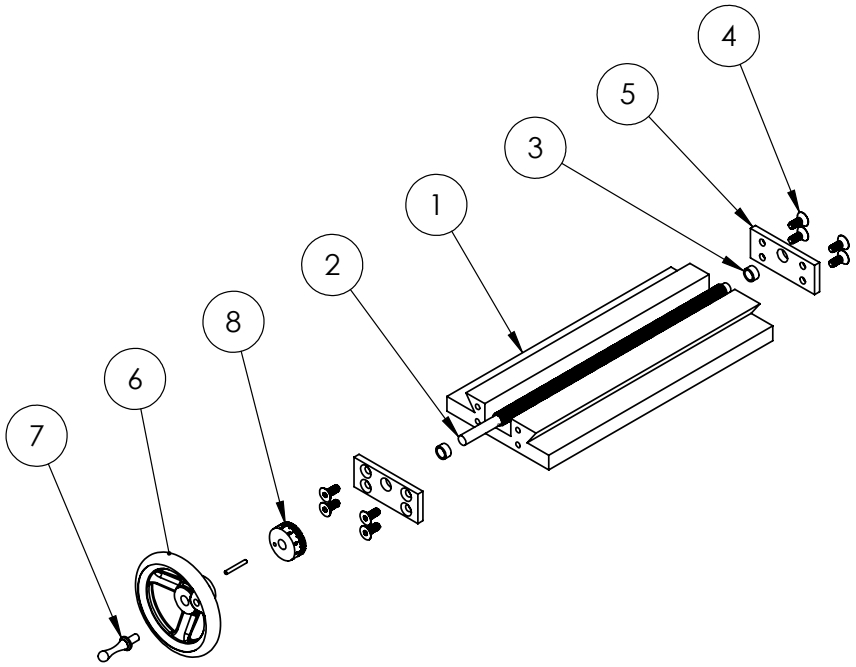
TITLE:
Lower Dovetail Stage

SIZE	FILE NAME	REV
A	stage-bottom	1.0

SCALE: 1:6 | WEIGHT: | SHEET 1 OF 2

5 4 3 2 1

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	dovetail-bottom	Bottom Dovetail	1
2	screw-x	Lead Screw X	1
3	screw-bearing	Lead screw bearing	2
4	91253A539	End plate mount screw	8
5	end-plate-male	Male dovetail end plate	2
6	100mm Handwheel - Fixturing Spec	Handwheel	1
7	100mm Handwheel - Knob	Handwheel knob	1
8	dial	Handwheel Dial	1
9	98381A310	handwheel dial locating pin	1



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DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	Fixturing
INTERPRET GEOMETRIC TOLERANCING PER:		
MATERIAL	SUBSYSTEM	Fixturing
FINISH	COMMENTS:	
DO NOT SCALE DRAWING		

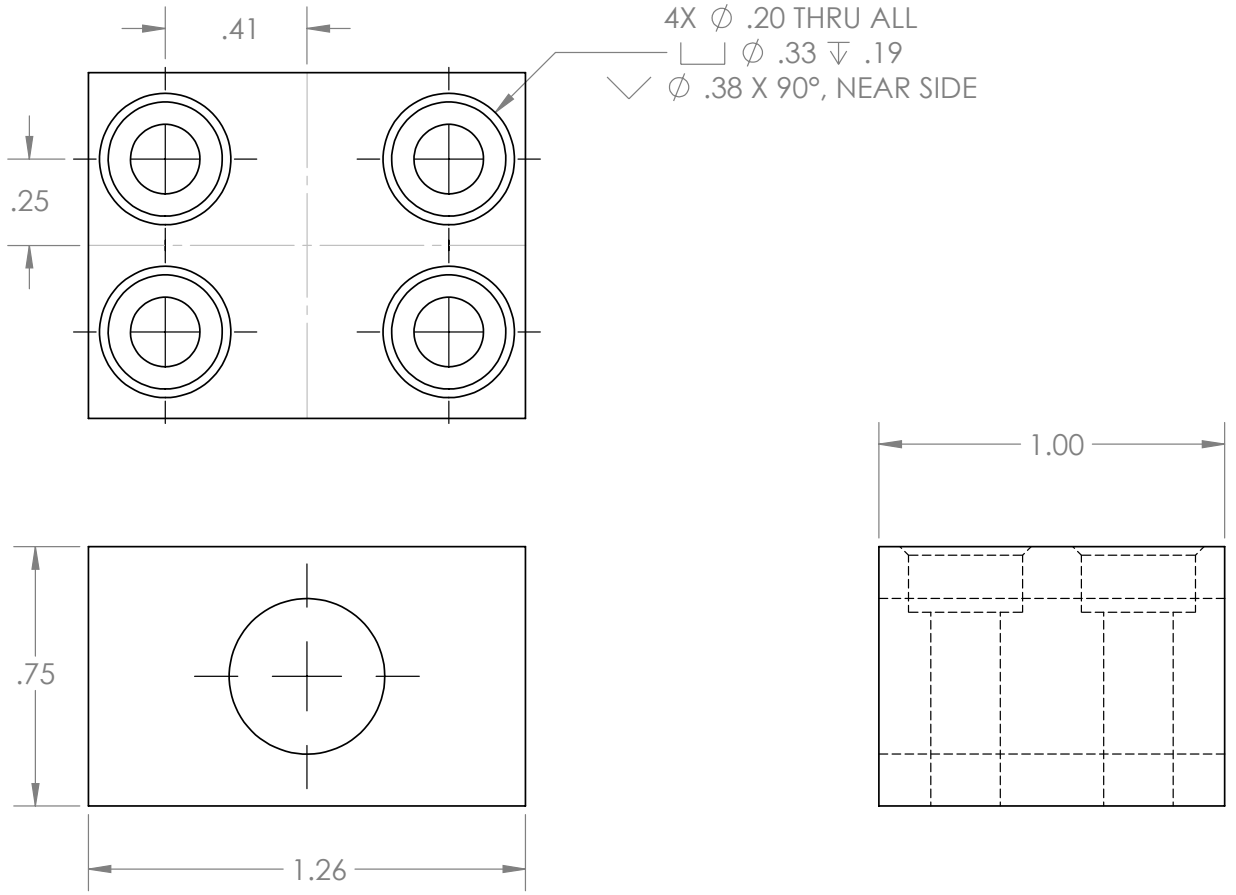
Cooper Machine Co.

TITLE:
Lower Dovetail Stage

SIZE	FILE NAME	REV
A	stage-bottom	1.0

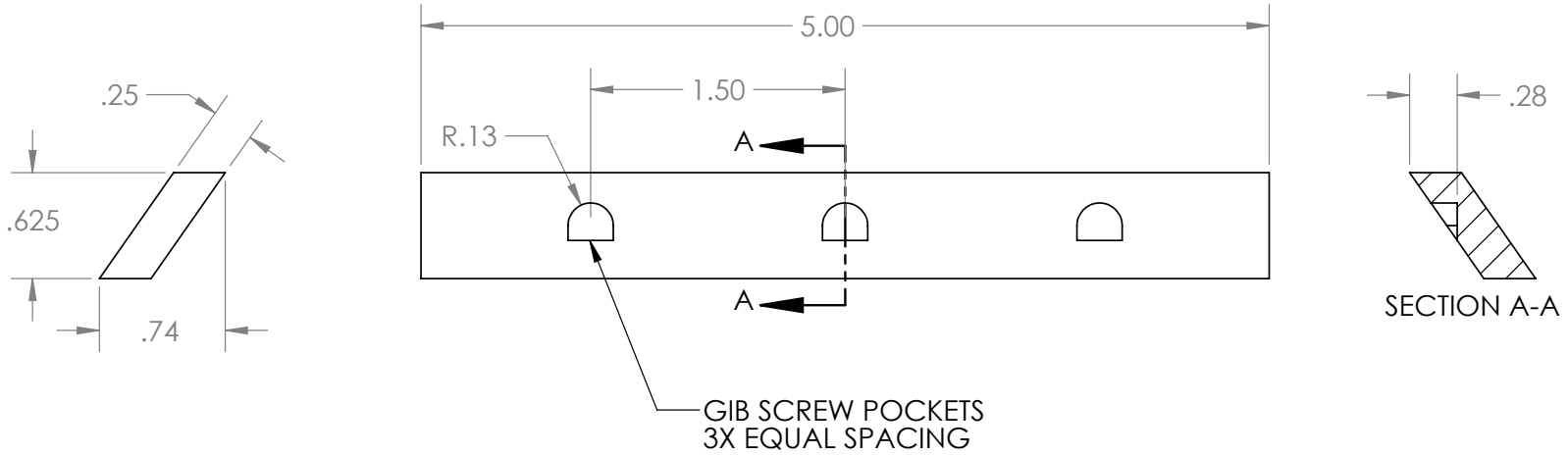
SCALE: 1:6 | WEIGHT: | SHEET 2 OF 2

5 4 3 2 1



UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ± INTERPRET GEOMETRIC TOLERANCING PER: MATERIAL Brass FINISH DO NOT SCALE DRAWING	DRAWN BY	J. Song	Cooper Machine Co. TITLE: Acme nut
	DATE	12/17/2014	
	APPLICATION		
	NEXT ASSY	Mid Dovetail Stage Upper Dovetail Stage	
	SUBSYSTEM	Fixturing	
	COMMENTS:		SIZE A | FILE NAME acme-nut | REV 1.0 SCALE: 2:1 | WEIGHT: 0.20 | SHEET 1 OF 1

5 4 3 2 1



UNLESS OTHERWISE SPECIFIED:	DRAWN BY	J. Song
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	Mid Dovetail Stage
		Upper Dovetail Stage
INTERPRET GEOMETRIC TOLERANCING PER:		
MATERIAL Gray Cast Iron	SUBSYSTEM	Fixturing
FINISH	COMMENTS: 1. gib-x; 2. gib-y	
DO NOT SCALE DRAWING		

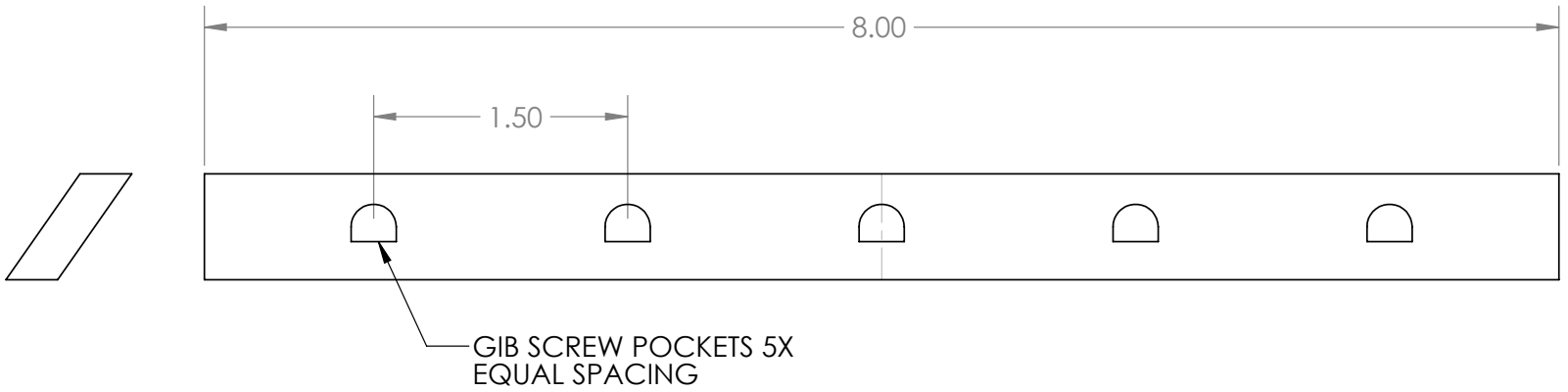
Cooper Machine Co.

TITLE: Gib

SIZE	FILE NAME	REV
A	gib	1.0

SCALE: 1:1 | WEIGHT: 0.39 | SHEET 1 OF 2

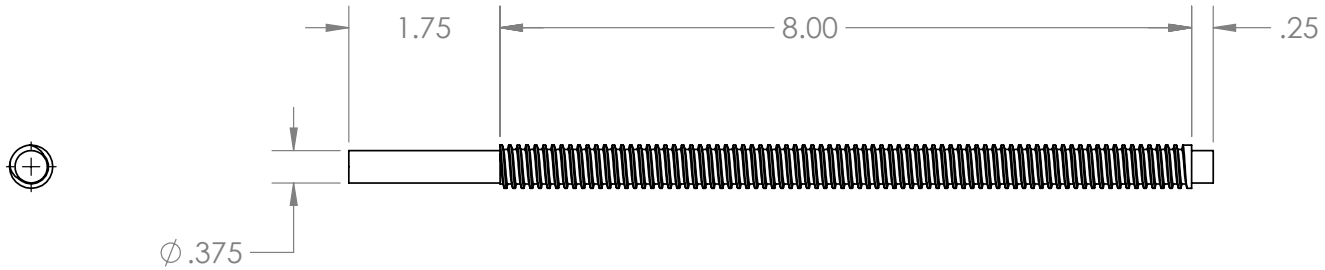
5 4 3 2 1



UNLESS OTHERWISE SPECIFIED:	DRAWN BY	J. Song
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	Mid Dovetail Stage
INTERPRET GEOMETRIC TOLERANCING PER:		
MATERIAL Gray Cast Iron	SUBSYSTEM	Fixturing
FINISH	COMMENTS: 1. gib-x; 2. gib-y	
DO NOT SCALE DRAWING		

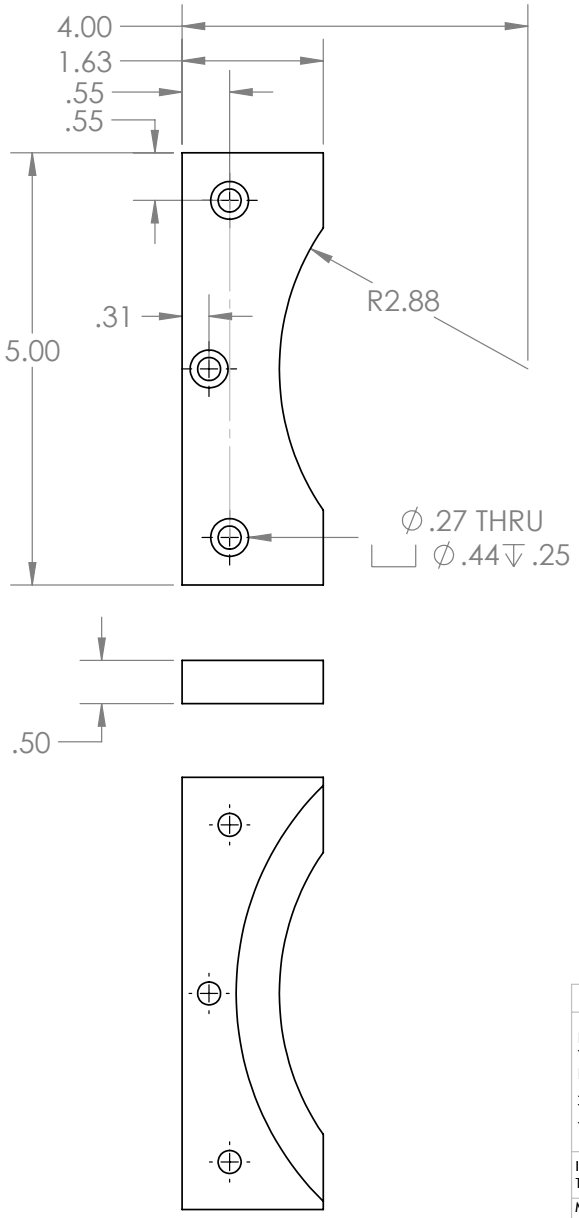
Cooper Machine Co.		
TITLE: Gib		
SIZE A	FILE NAME gib	REV 1.0
SCALE: 1:1	WEIGHT: 0.39	SHEET 2 OF 2

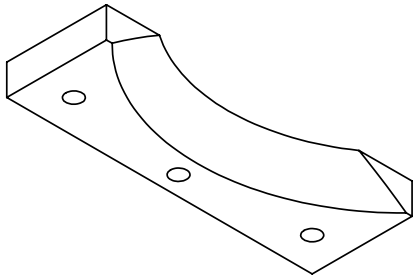
5 4 3 2 1

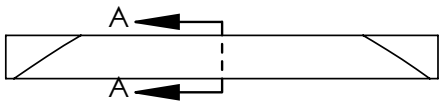


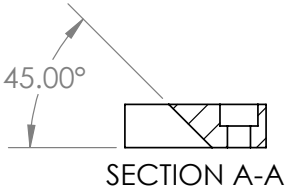
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN BY	J. Song	Cooper Machine Co.
	DATE	12/17/2014	TITLE: Y Lead screw
	APPLICATION		
	NEXT ASSY	Upper Dovetail Stage	
INTERPRET GEOMETRIC TOLERANCING PER:			
MATERIAL Material <not specified>	SUBSYSTEM	Fixturing	SIZE A / FILE NAME screw-y / REV 1.0
FINISH	COMMENTS: 1/2-10 2G Acme screw		SCALE: 1:2 / WEIGHT: 0.05 / SHEET 1 OF 1
DO NOT SCALE DRAWING			

5 4 3 2 1









UNLESS OTHERWISE SPECIFIED:	DRAWN BY	J. Song
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	Upper Dovetail Stage
INTERPRET GEOMETRIC TOLERANCING PER:		
MATERIAL Malleable Cast Iron	SUBSYSTEM	Fixturing
FINISH	COMMENTS:	
DO NOT SCALE DRAWING		

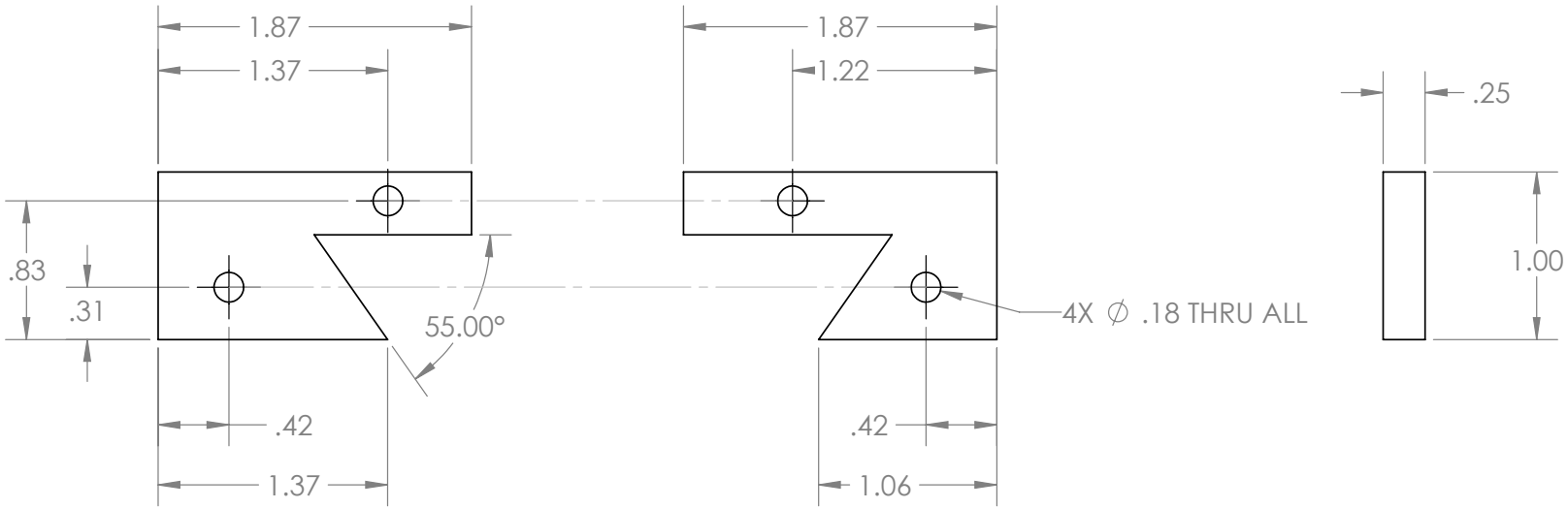
Cooper Machine Co.

TITLE: Swivel Block

SIZE	FILE NAME	REV
A	swivel-blocks-body-1	1.0

SCALE: 1:2 | WEIGHT: 0.75 | SHEET 1 OF 1

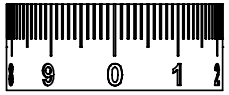
5 4 3 2 1



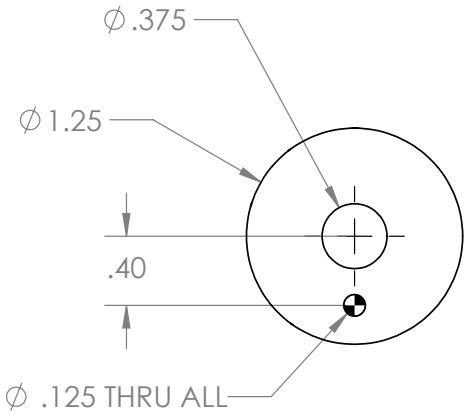
UNLESS OTHERWISE SPECIFIED:	DRAWN BY	J. Song
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	Mid Dovetail Stage
INTERPRET GEOMETRIC TOLERANCING PER:		
MATERIAL SAE F5 Wool Felt	SUBSYSTEM	Fixturing
FINISH	COMMENTS:	
DO NOT SCALE DRAWING		

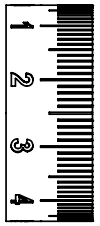
Cooper Machine Co.		
TITLE: Way wipers		
SIZE A	FILE NAME way-wiper	REV 1.0
SCALE: 1:1	WEIGHT: 0.02	SHEET 1 OF 1

5 4 3 2 1



Numbers 0-9 engraved or etched. Line resolution .001in on 1/2-10 lead screw.





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	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	Lower Dovetail Stage
		Upper Dovetail Stage
INTERPRET GEOMETRIC TOLERANCING PER:		
MATERIAL 6061-T6 (SS)	SUBSYSTEM	Fixturing
FINISH	COMMENTS: check part document font for numbers	
DO NOT SCALE DRAWING		

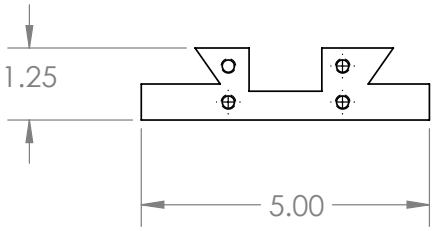
Cooper Machine Co.

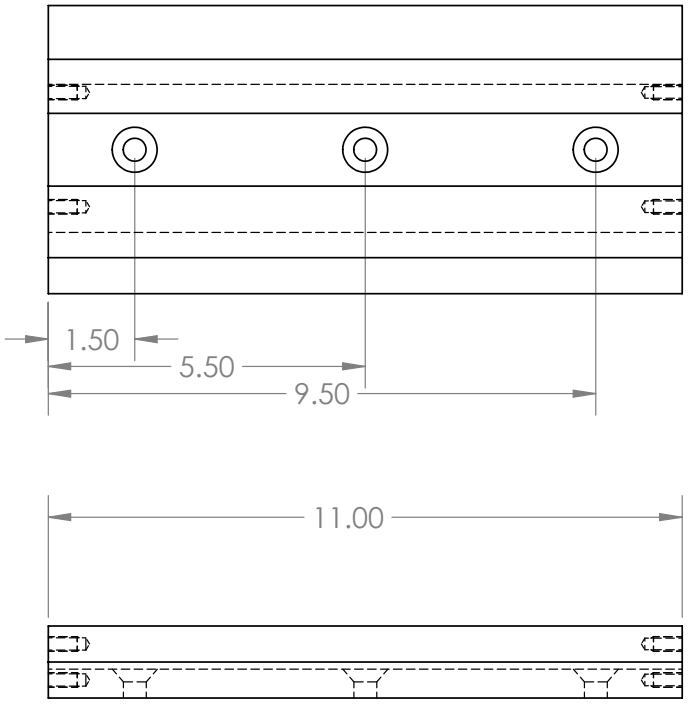
TITLE: Handwheel Dial

SIZE	FILE NAME	REV
A	dial	1.0

SCALE: 3:1 | WEIGHT: 0.05 | SHEET 1 OF 1

5 4 3 2 1





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	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	Lower Dovetail Stage
INTERPRET GEOMETRIC TOLERANCING PER:		
MATERIAL Ductile Iron	SUBSYSTEM	Fixturing
FINISH	COMMENTS: mounts to machine bed	
DO NOT SCALE DRAWING		

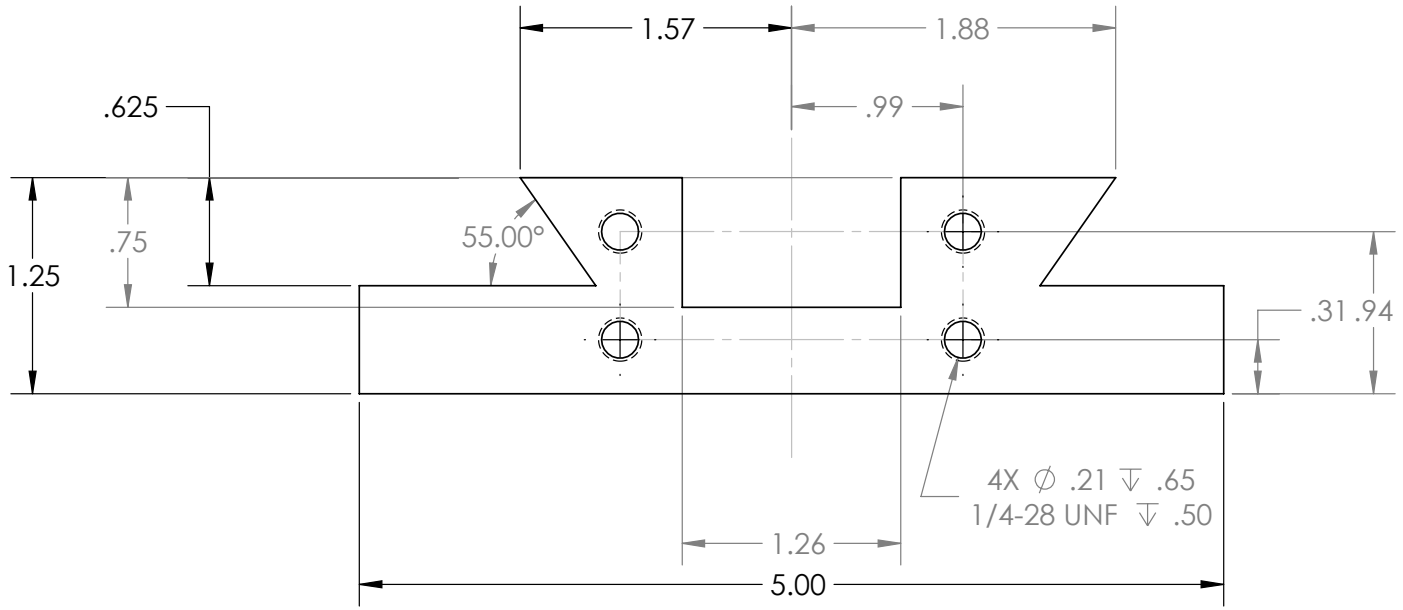
Cooper Machine Co.

TITLE:
Bottom Dovetail

SIZE	FILE NAME	REV
A	dovetail-bottom	1.0

SCALE: 1:3 | WEIGHT: 11.32 | SHEET 1 OF 2

5 4 3 2 1



UNLESS OTHERWISE SPECIFIED:	DRAWN BY	J. Song
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	Lower Dovetail Stage
INTERPRET GEOMETRIC TOLERANCING PER:		
MATERIAL Ductile Iron	SUBSYSTEM	Fixturing
FINISH	COMMENTS: mounts to machine bed	
DO NOT SCALE DRAWING		

Cooper Machine Co.

TITLE:
Bottom Dovetail

SIZE	FILE NAME	REV
A	dovetail-bottom	1.0

SCALE: 1:1 | WEIGHT: 11.32 | SHEET 2 OF 2

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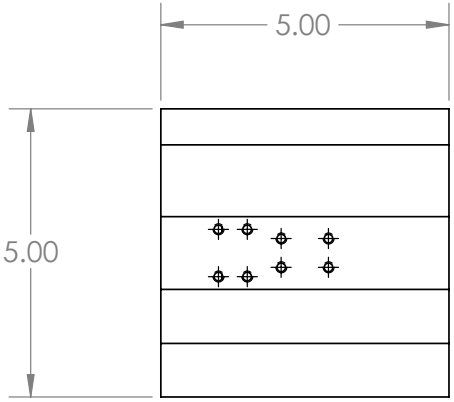
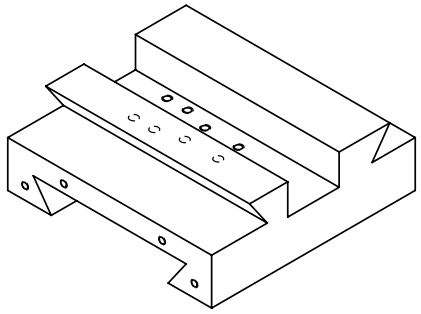
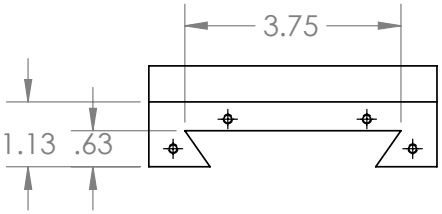
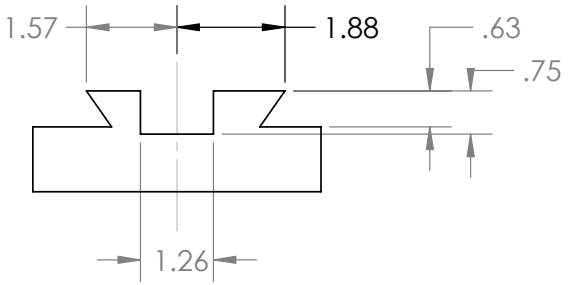
5 4 3 2 1









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UNLESS OTHERWISE SPECIFIED:	DRAWN BY	J. Song
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	Mid Dovetail Stage
INTERPRET GEOMETRIC TOLERANCING PER:		
MATERIAL Ductile Iron	SUBSYSTEM	Fixturing
FINISH	COMMENTS: 1. geometry; 2. holes	
DO NOT SCALE DRAWING		

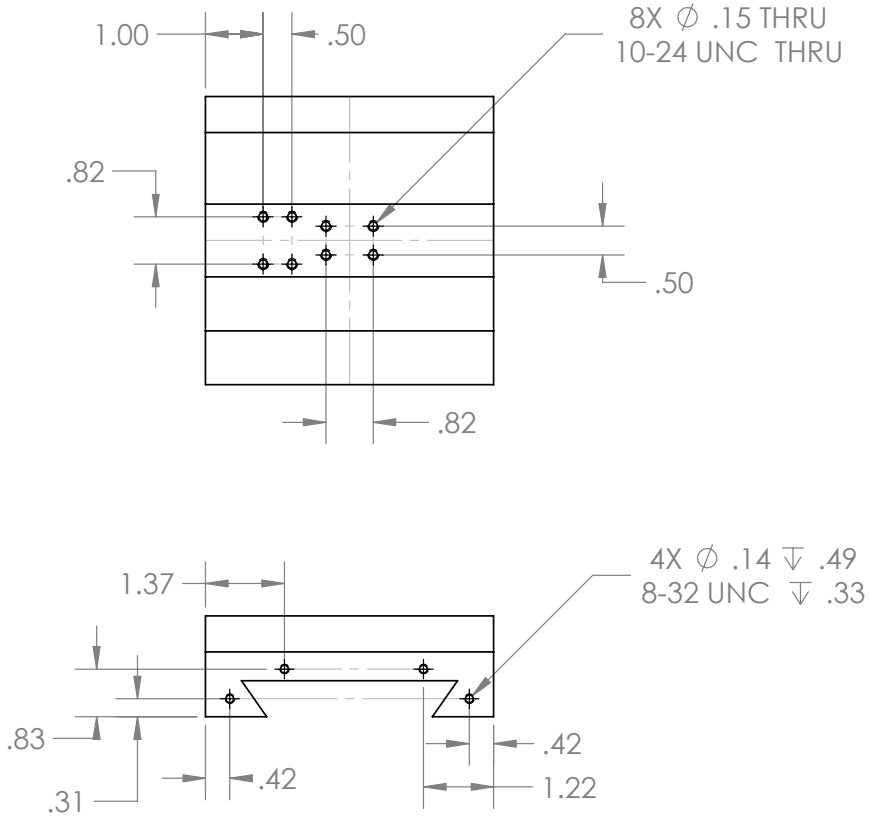
Cooper Machine Co.

TITLE:
Middle Dovetail

SIZE	FILE NAME	REV
A	dovetail-mid	1.0

SCALE: 1:3 | WEIGHT: 5.70 | SHEET 1 OF 2

5 4 3 2 1



UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN BY	J. Song	Cooper Machine Co.
	DATE	12/17/2014	TITLE: Middle Dovetail
	APPLICATION		
	NEXT ASSY	Mid Dovetail Stage	
INTERPRET GEOMETRIC TOLERANCING PER:			SIZE A / FILE NAME dovetail-mid / REV 1.0
MATERIAL Ductile Iron	SUBSYSTEM	Fixturing	
FINISH	COMMENTS: 1. geometry; 2. holes		SCALE: 1:3 / WEIGHT: 5.70 / SHEET 2 OF 2
DO NOT SCALE DRAWING			

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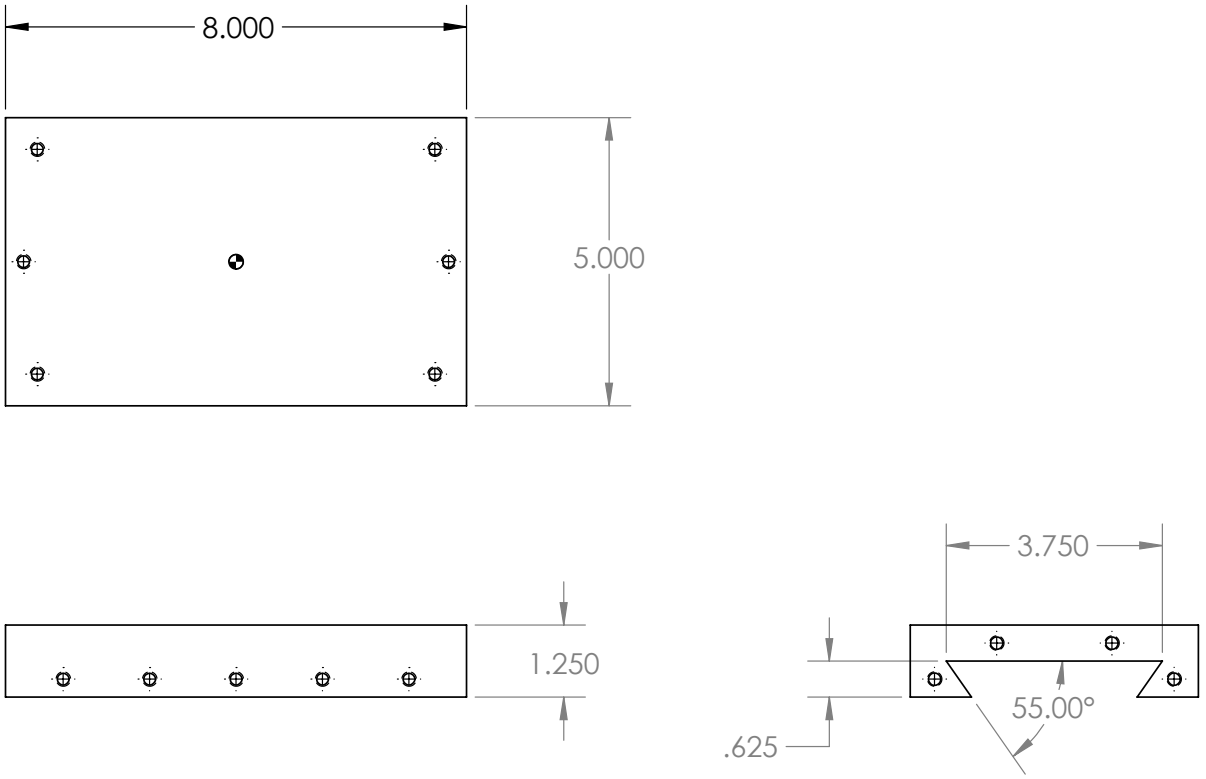
5 4 3 2 1



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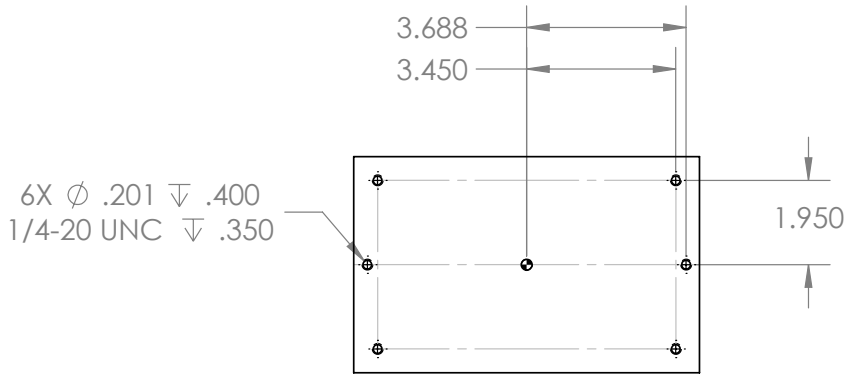
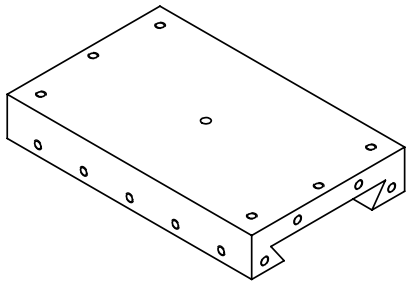
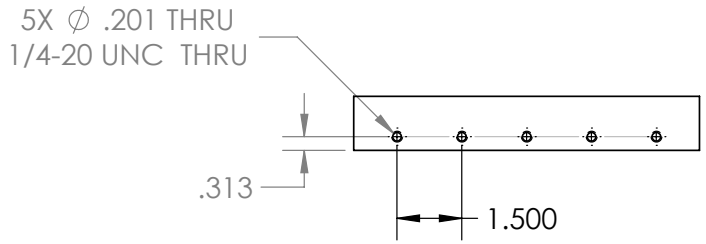
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	Upper Dovetail Stage
INTERPRET GEOMETRIC TOLERANCING PER:		
MATERIAL Ductile Iron	SUBSYSTEM	Fixturing
FINISH	COMMENTS: 1. dovetail geometry; 2. hole geometry	
DO NOT SCALE DRAWING		

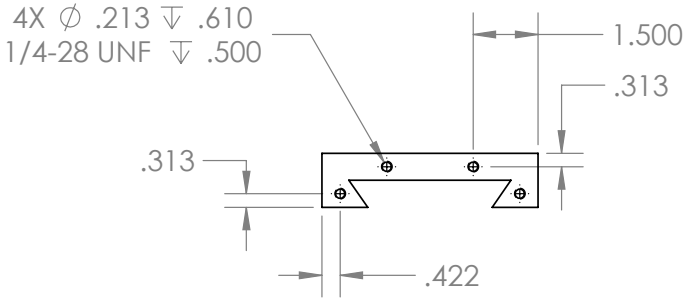
Cooper Machine Co.		
TITLE: Top dovetail		
SIZE A	FILE NAME dovetail-top	REV 1.0
SCALE: 1:3	WEIGHT: 8.47	SHEET 1 OF 2

5 4 3 2 1









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DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	Upper Dovetail Stage
INTERPRET GEOMETRIC TOLERANCING PER:		
MATERIAL: Ductile Iron	SUBSYSTEM	Fixturing
FINISH	COMMENTS: 1. dovetail geometry; 2. hole geometry	
DO NOT SCALE DRAWING		

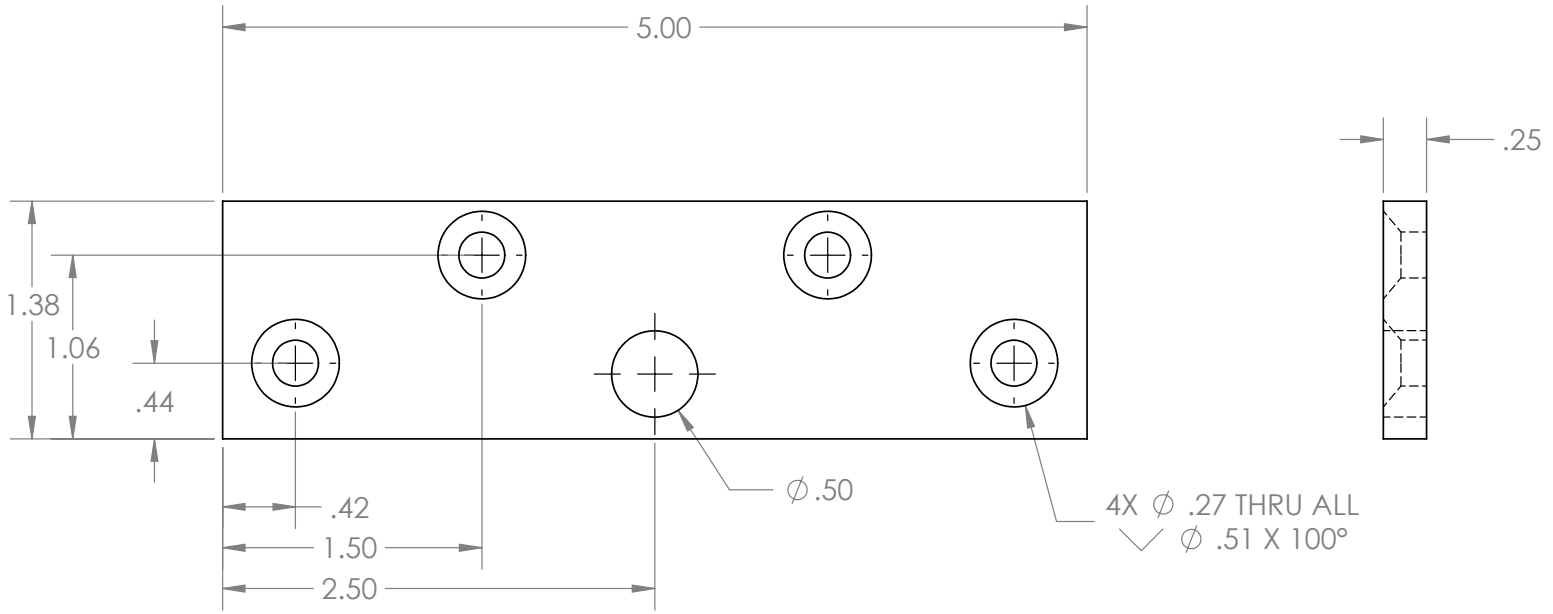
Cooper Machine Co.

TITLE: Top dovetail

SIZE	FILE NAME	REV
A	dovetail-top	1.0

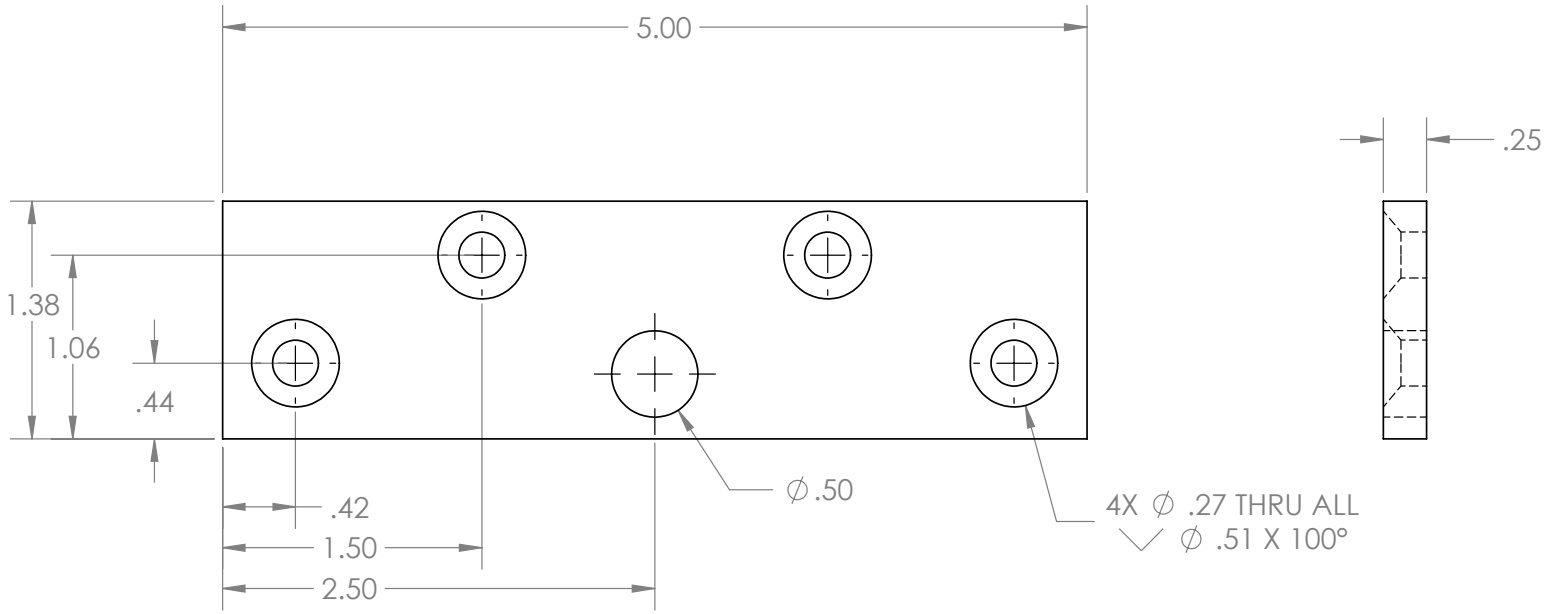
SCALE: 1:4 | WEIGHT: 8.47 | SHEET 2 OF 2

5 4 3 2 1



UNLESS OTHERWISE SPECIFIED:	DRAWN BY	J. Song	Cooper Machine Co.
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014	TITLE: Female end plate
	APPLICATION		
	NEXT ASSY	Upper Dovetail Stage	
INTERPRET GEOMETRIC TOLERANCING PER:			SIZE A / FILE NAME end-plate-female / REV 1.0
MATERIAL 6061-T6 (SS)	SUBSYSTEM	Fixturing	
FINISH	COMMENTS:		SCALE: 1:1 / WEIGHT: 0.15 / SHEET 1 OF 1
DO NOT SCALE DRAWING			

5 4 3 2 1



UNLESS OTHERWISE SPECIFIED:	DRAWN BY	J. Song
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	Upper Dovetail Stage
INTERPRET GEOMETRIC TOLERANCING PER:		
MATERIAL 6061-T6 (SS)	SUBSYSTEM	Fixturing
FINISH	COMMENTS:	
DO NOT SCALE DRAWING		

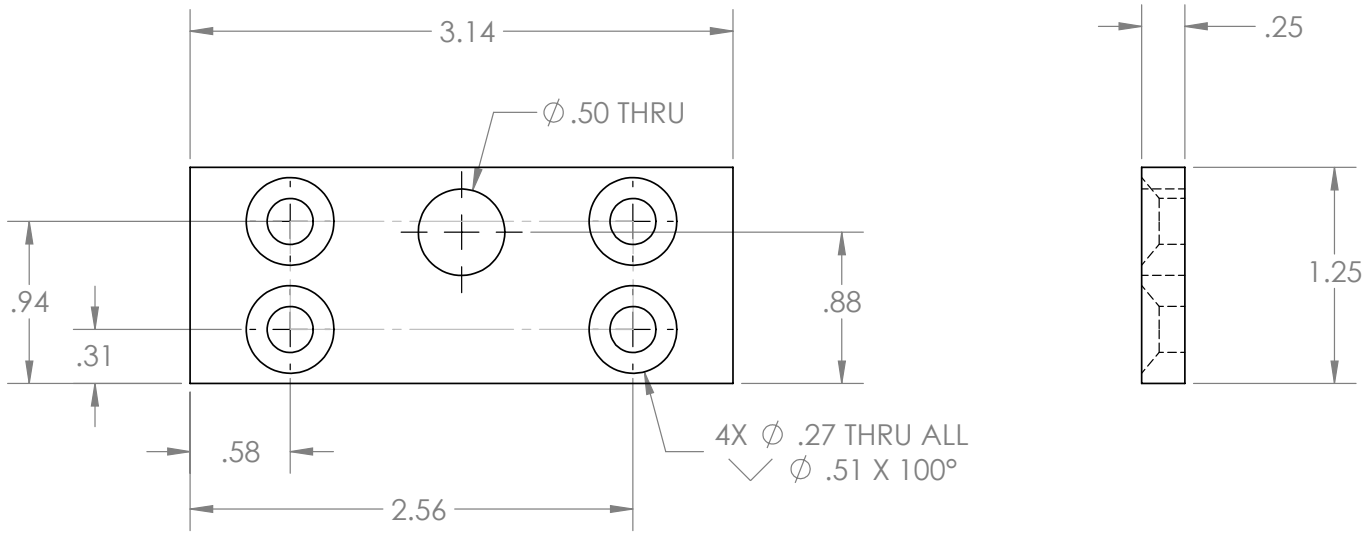
Cooper Machine Co.

TITLE: Female end plate

SIZE	FILE NAME	REV
A	end-plate-female	1.0

SCALE: 1:1 | WEIGHT: 0.15 | SHEET 1 OF 1

5 4 3 2 1



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DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	Lower Dovetail Stage
INTERPRET GEOMETRIC TOLERANCING PER:		
MATERIAL 6061-T6 (SS)	SUBSYSTEM	Fixturing
FINISH	COMMENTS: check screw bearing press fit	
DO NOT SCALE DRAWING		

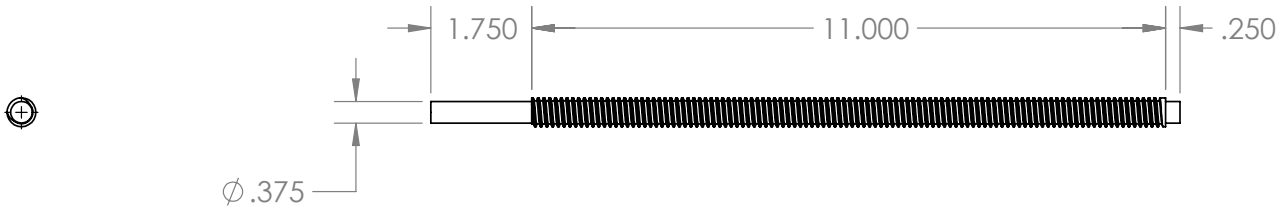
Cooper Machine Co.

TITLE: Male end plate

SIZE	FILE NAME	REV
A	end-plate-male	1.0

SCALE: 1:1 | WEIGHT: 0.08 | SHEET 1 OF 1

5 4 3 2 1



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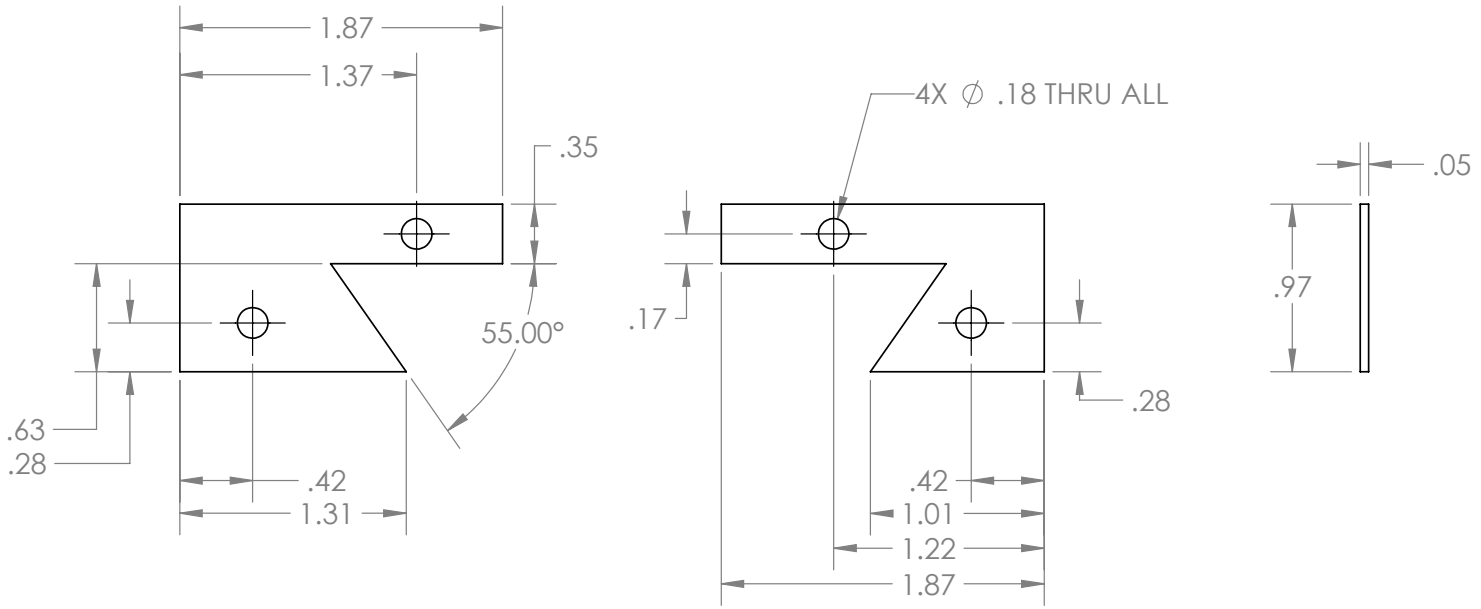
	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	Lower Dovetail Stage
INTERPRET GEOMETRIC TOLERANCING PER:		
MATERIAL Plain Carbon Steel	SUBSYSTEM	Fixturing
FINISH	COMMENTS: MSC 6053904; 1/2-10 2G Acme	
DO NOT SCALE DRAWING		

Cooper Machine Co.		
TITLE: Lead Screw X		
SIZE A	FILE NAME screw-x	REV 1.0
SCALE: 1:3	WEIGHT: 0.53	SHEET 1 OF 1

5 4 3 2 1



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UNLESS OTHERWISE SPECIFIED:	DRAWN BY	J. Song
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	Mid Dovetail Stage
INTERPRET GEOMETRIC TOLERANCING PER:		
MATERIAL Plain Carbon Steel	SUBSYSTEM	Fixturing
FINISH	COMMENTS: 18ga steel sheet	
DO NOT SCALE DRAWING		

Cooper Machine Co.

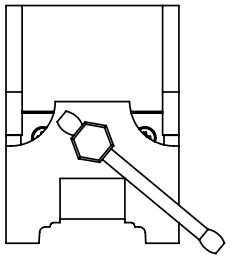
TITLE: Way wiper plates

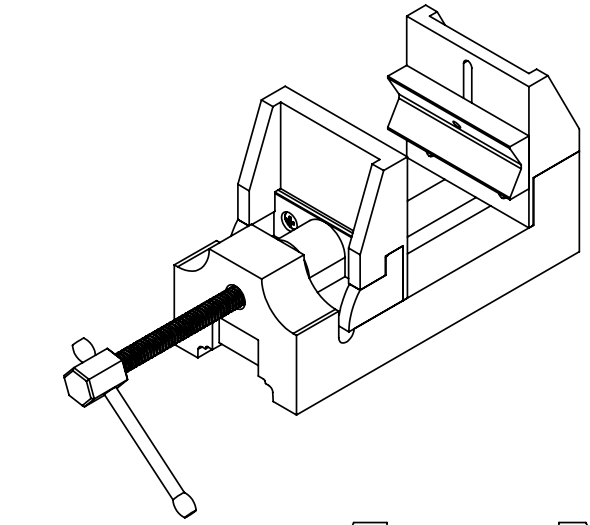
SIZE	FILE NAME	REV
A	way-wiper-plates	1.0

SCALE: 1:1 | WEIGHT: 0.03 | SHEET 1 OF 1

5 4 3 2 1

5.3.2 Vise





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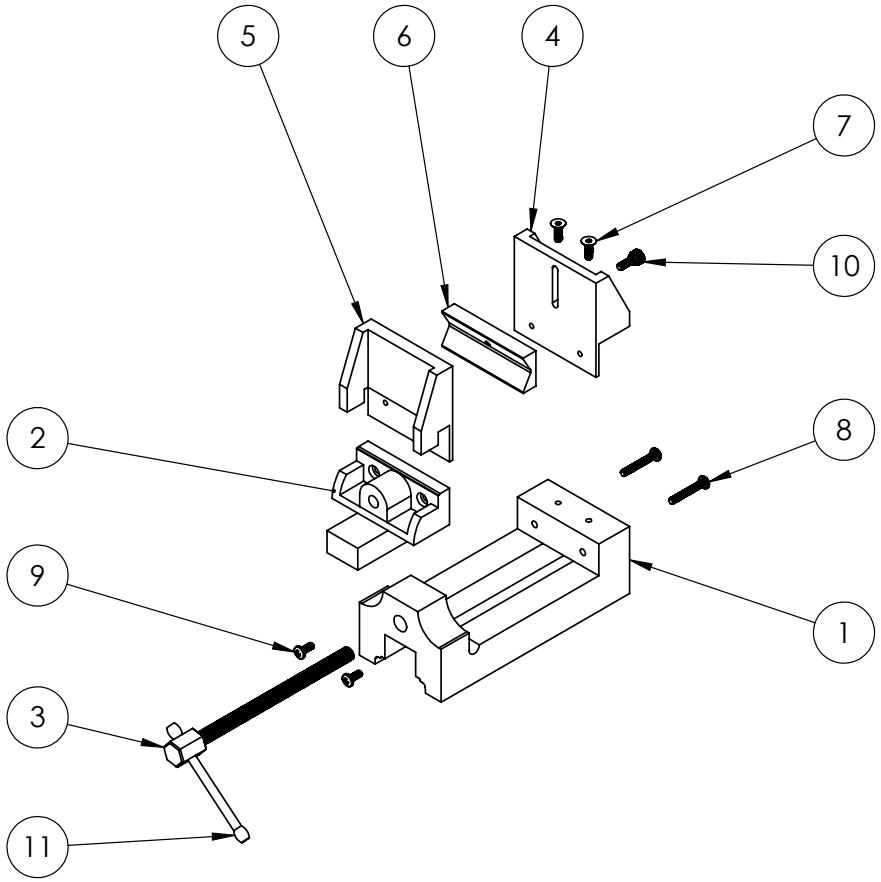
UNLESS OTHERWISE SPECIFIED:	DRAWN BY	J. Song	Cooper Machine Co.
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014	TITLE: Modified Vise
	APPLICATION	Mounted Vise	
INTERPRET GEOMETRIC TOLERANCING PER:	NEXT ASSY		SIZE A | FILE NAME vise | REV 1.0
MATERIAL	SUBSYSTEM	Fixturing	
FINISH	COMMENTS:		SCALE: 1:4 | WEIGHT: | SHEET 1 OF 2
DO NOT SCALE DRAWING			

5 4 3 2 1

ITEM NO.	PART NUMBER	DESCRIPTION	Default/ QTY.
1	body	Vise Body	1
2	floating-jaw	Floating Jaw	1
3	screw	Vise Lead Screw	1
4	stationary-jaw-mod	Stationary Jaw Extension	1
5	floating-jaw-mod	Floating Jaw Extension	1
6	v-block	V Block	1
7	91253A540	Vise Mount & Stationary Jaw Top Screw	2
8	90116A323	Stationary Jaw Side Screws	2
9	92005A423	Floating Jaw Side Screw	2
10	94567A540	Thumb Screw	1
11	Tightening Lever	Tightening lever	1



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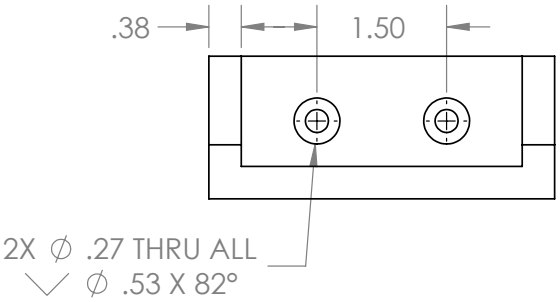
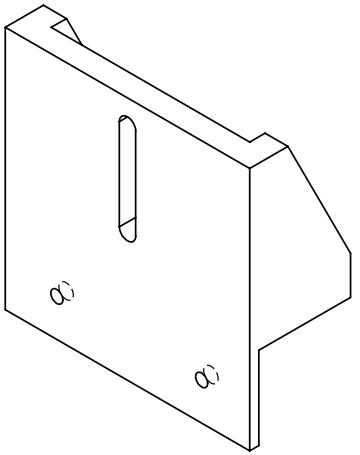
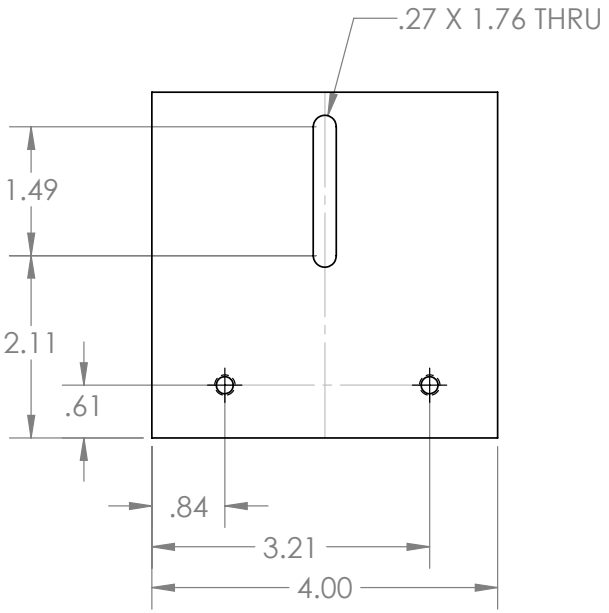
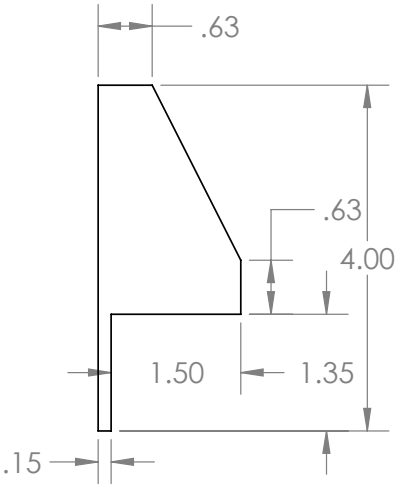
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014	TITLE: Modified Vise
	APPLICATION		
	NEXT ASSY	Mounted Vise	
INTERPRET GEOMETRIC TOLERANCING PER:			SIZE A / FILE NAME vise / REV 1.0
MATERIAL	SUBSYSTEM	Fixturing	
FINISH	COMMENTS:		SCALE: 1:6 / WEIGHT: / SHEET 2 OF 2
DO NOT SCALE DRAWING			

5 4 3 2 1



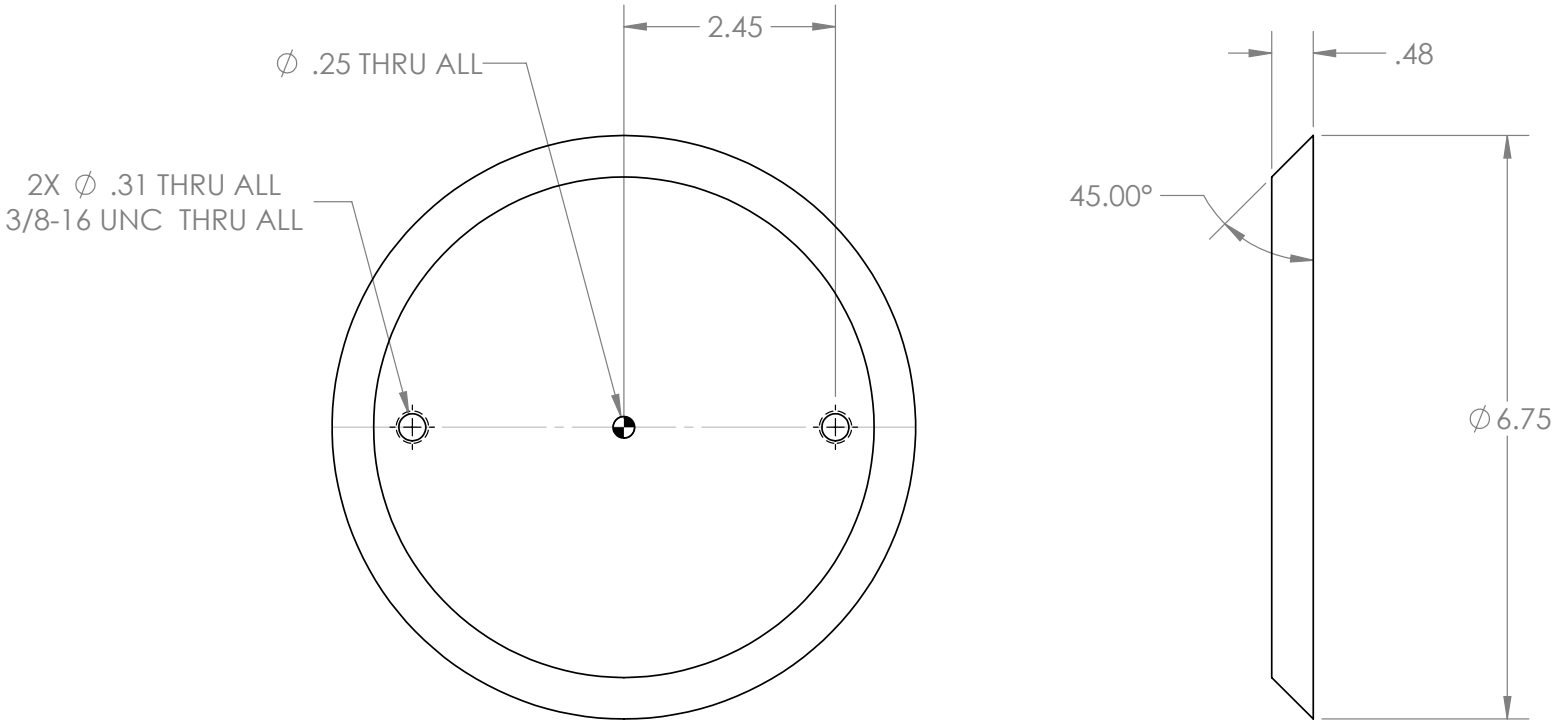






UNLESS OTHERWISE SPECIFIED:	DRAWN BY	J. Song	Cooper Machine Co.
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014	TITLE: Stationary Jaw Extension
	APPLICATION	Modified Vise	
INTERPRET GEOMETRIC TOLERANCING PER:	NEXT ASSY		
MATERIAL: Plain Carbon Steel	SUBSYSTEM	Fixturing	SIZE: A / FILE NAME: stationary-jaw-mod / REV: 1.0
FINISH	COMMENTS:		SCALE: 1:2 / WEIGHT: 2.21 / SHEET 1 OF 1
DO NOT SCALE DRAWING			

5 4 3 2 1



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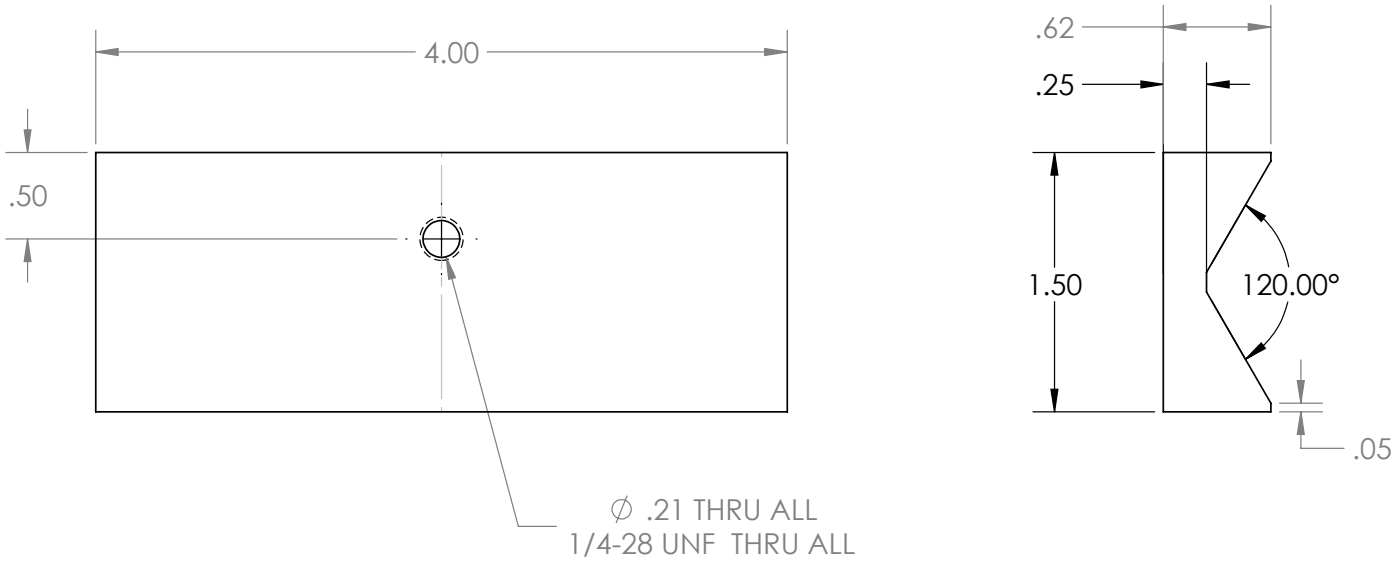
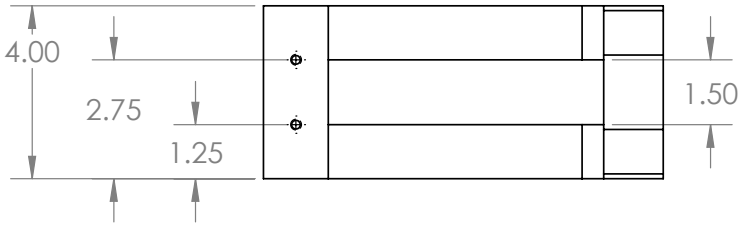
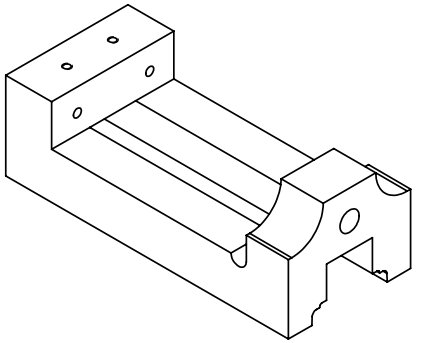
5 4 3 2 1

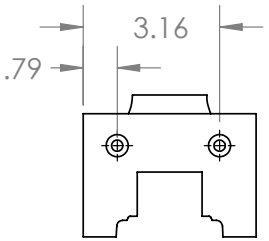


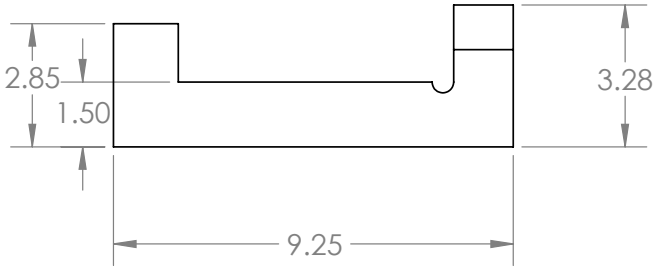
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ± INTERPRET GEOMETRIC TOLERANCING PER: MATERIAL 6061 Alloy FINISH DO NOT SCALE DRAWING	DRAWN BY	J. Song	Cooper Machine Co. TITLE: V Block SIZE A | FILE NAME v-block | REV 1.0 SCALE: 1:1 | WEIGHT: 0.25 | SHEET 1 OF 1
	DATE	12/17/2014	
	APPLICATION		
	NEXT ASSY	Modified Vise	
	SUBSYSTEM	Fixturing	
	COMMENTS:		

5 4 3 2 1









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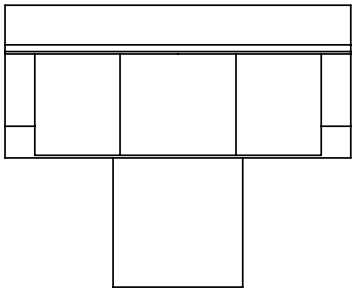
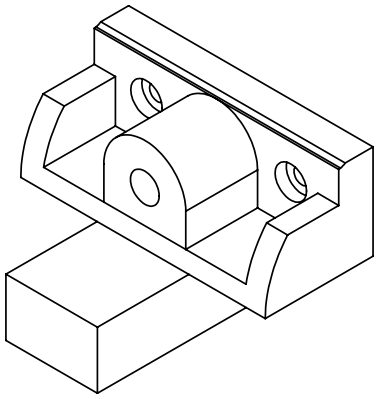
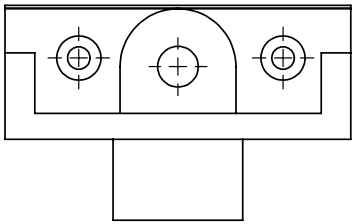
	DATE	12/17/2014
	APPLICATION	Modified Vise
INTERPRET GEOMETRIC TOLERANCING PER:	NEXT ASSY	
MATERIAL: Malleable Cast Iron	SUBSYSTEM	Fixturing
FINISH	COMMENTS:	
DO NOT SCALE DRAWING		

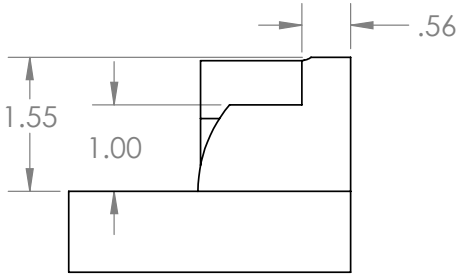
Cooper Machine Co.		
TITLE: Vise Body		
SIZE: A	FILE NAME: body	REV: 1.0
SCALE: 1:4	WEIGHT: 11.95	SHEET 1 OF 1

5 4 3 2 1









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	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	Modified Vise
INTERPRET GEOMETRIC TOLERANCING PER:		
MATERIAL Gray Cast Iron	SUBSYSTEM	Fixturing
FINISH	COMMENTS: machine existing Eron vise jaw to new shape	
DO NOT SCALE DRAWING		

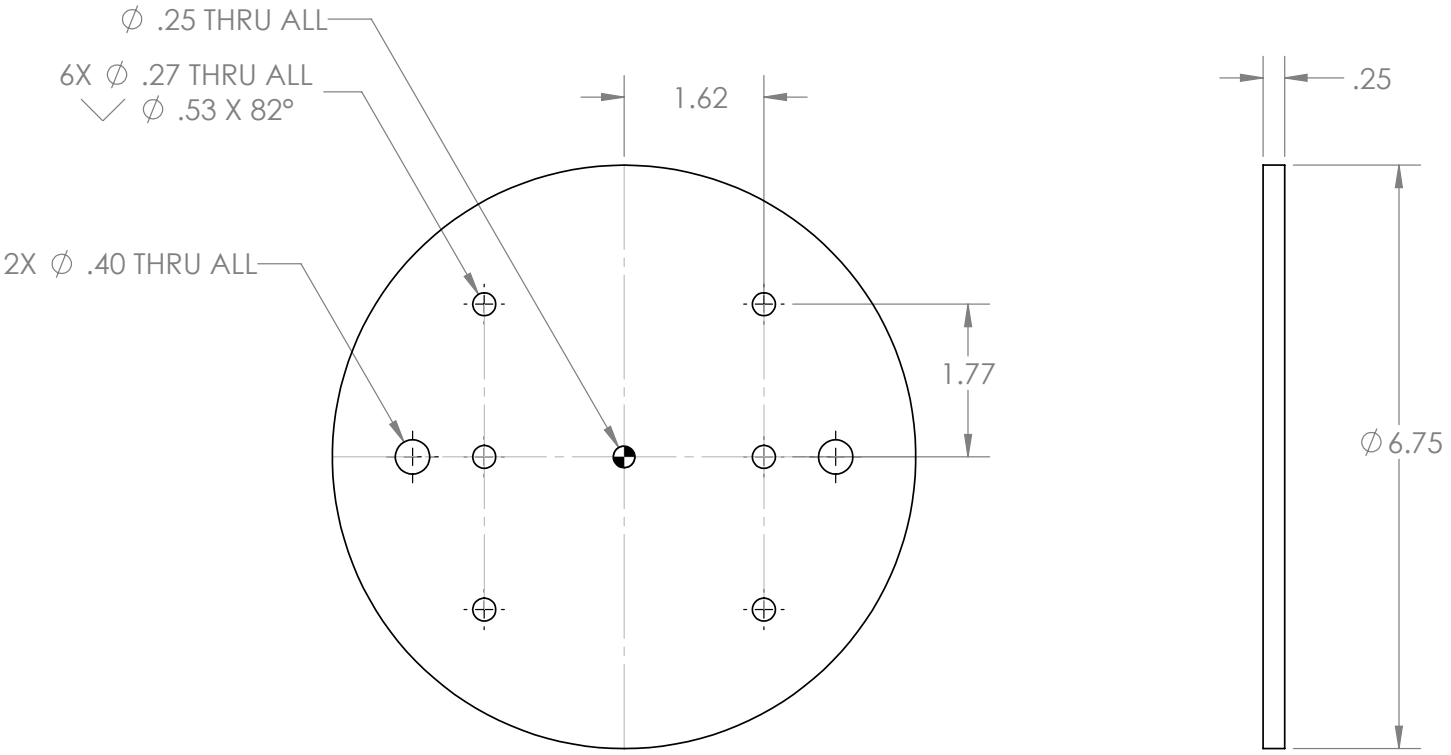
Cooper Machine Co.

TITLE:
Floating Jaw

SIZE	FILE NAME	REV
A	floating-jaw	1.0

SCALE: 1:2 | WEIGHT: 2.95 | SHEET 1 OF 1

5 4 3 2 1



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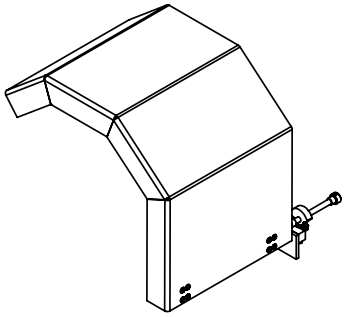
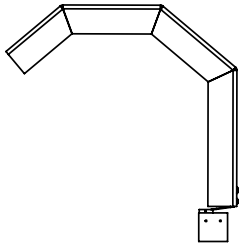
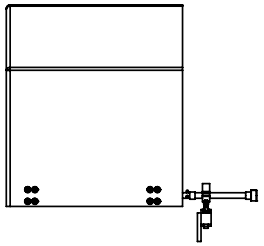
5 4 3 2 1

5.4 Electrical







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	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	
INTERPRET GEOMETRIC TOLERANCING PER:		
MATERIAL	SUBSYSTEM	
FINISH	COMMENTS:	
DO NOT SCALE DRAWING		

Cooper Machine Co.

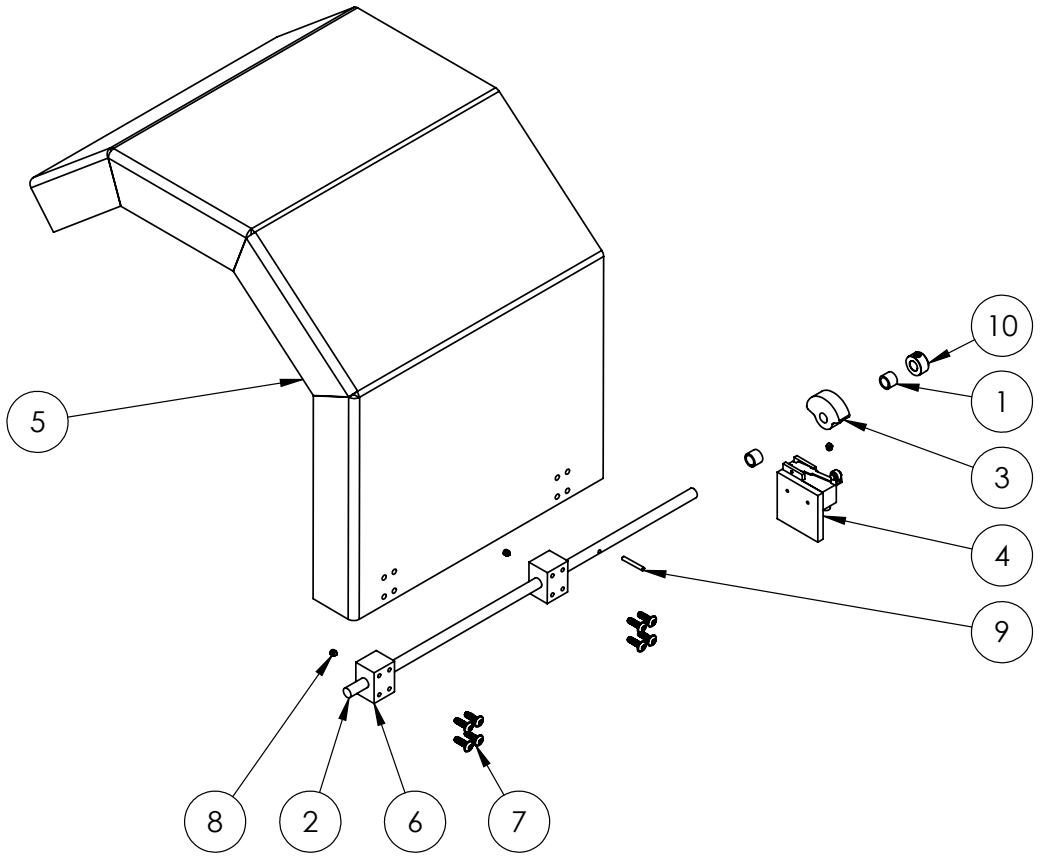
TITLE: Safety Shield

SIZE	FILE NAME	REV
A	safety-shield	1.0

SCALE: 1:12 WEIGHT: SHEET 1 OF 2

5 4 3 2 1

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	6389K349	safety shield shaft sleeve bearing	2
2	shaft	Shaft	1
3	cam	Cam	1
4	switch-mount		1
5	shield	Shield	1
6	shield-mount	Shield mount block	2
7	97654A143	Shield mount screw	8
8	92785A238	Shield block/cam set screw	3
9	98381A310	Shield shaft dowel pin	1
10	9414T8	Shield shaft collar	1



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DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	
INTERPRET GEOMETRIC TOLERANCING PER:		
MATERIAL	SUBSYSTEM	
FINISH	COMMENTS:	
DO NOT SCALE DRAWING		

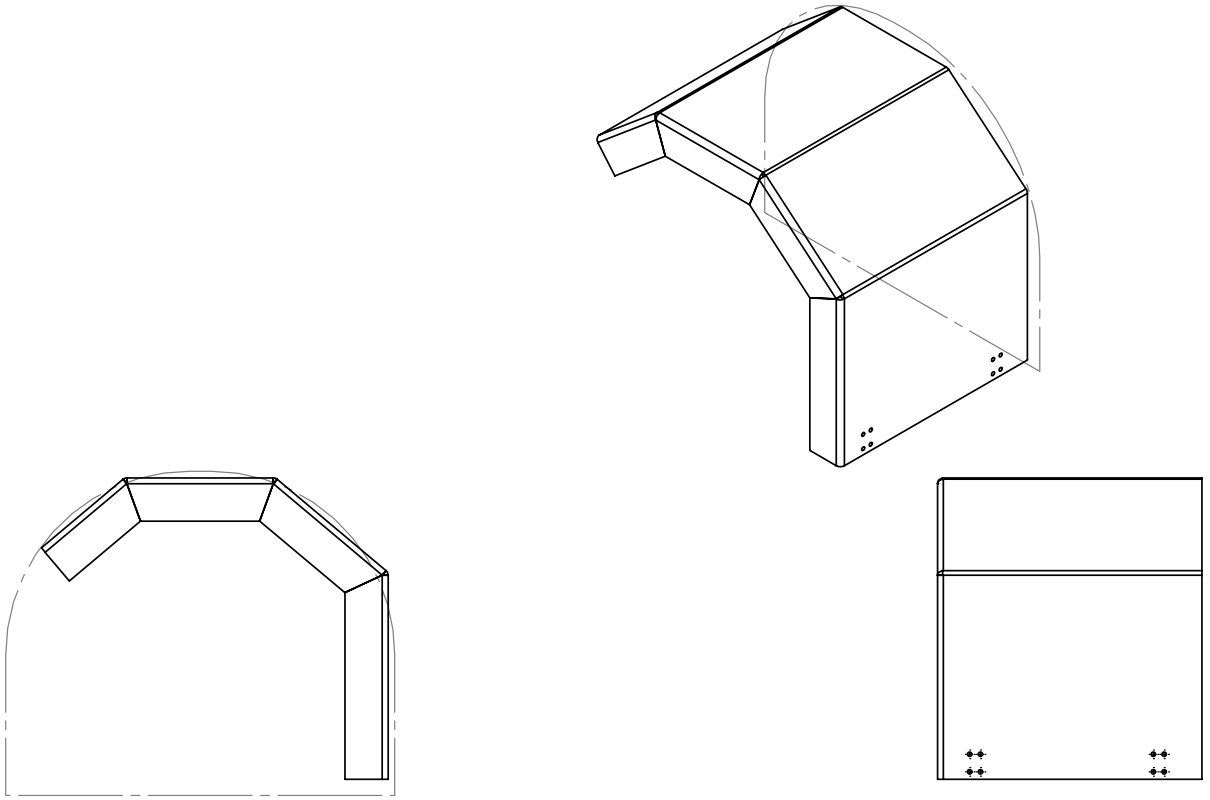
Cooper Machine Co.

TITLE: Safety Shield

SIZE	FILE NAME	REV
A	safety-shield	1.0

SCALE: 1:6 | WEIGHT: | SHEET 2 OF 2

5 4 3 2 1



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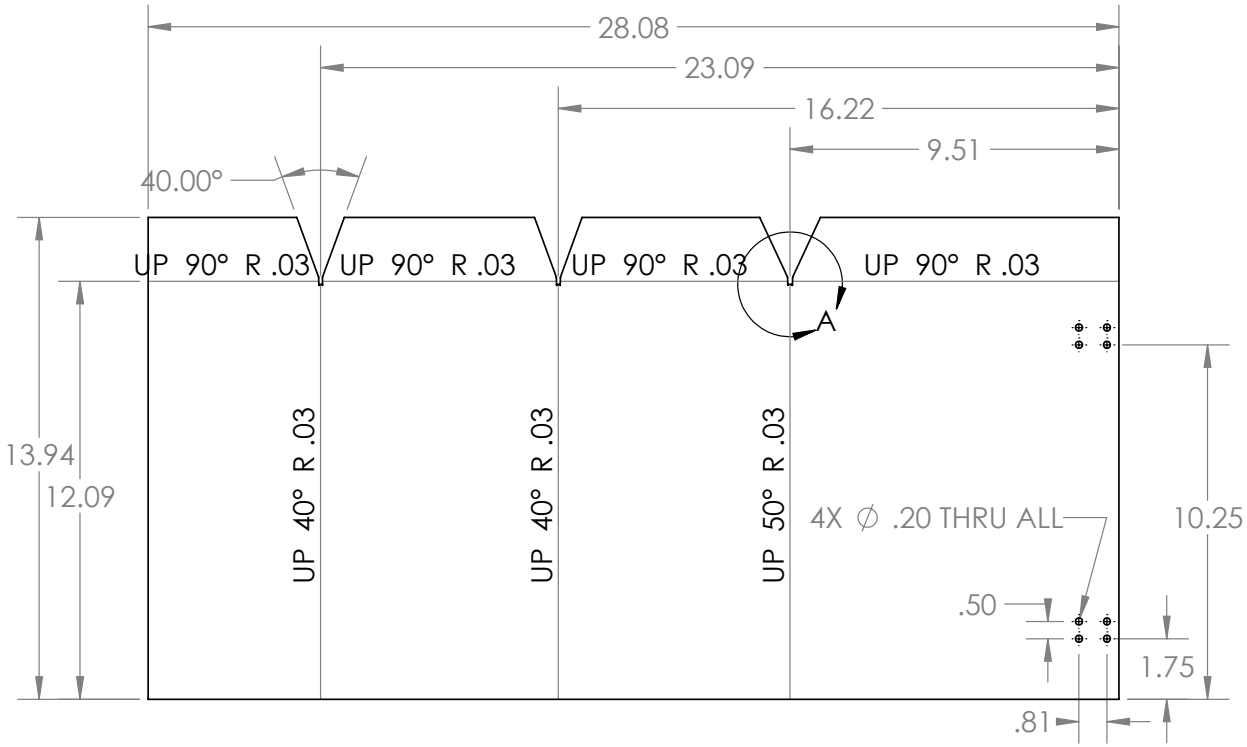
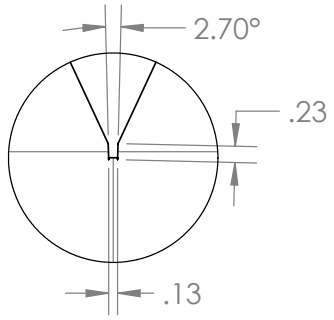
	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	Safety Shield
INTERPRET GEOMETRIC TOLERANCING PER:		
MATERIAL PC High Viscosity	SUBSYSTEM	Electrical
FINISH	COMMENTS: 1/4" polycarbonate, use strip heater	
DO NOT SCALE DRAWING		

Cooper Machine Co.		
TITLE: Shield		
SIZE A	FILE NAME shield	REV 1.0
SCALE: 1:8	WEIGHT: 3.99	SHEET 1 OF 2

5 4 3 2 1





DETAIL A
SCALE 2 : 5

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DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	Safety Shield
INTERPRET GEOMETRIC TOLERANCING PER:		
MATERIAL PC High Viscosity	SUBSYSTEM	Electrical
FINISH	COMMENTS: 1/4" polycarbonate, use strip heater	
DO NOT SCALE DRAWING		

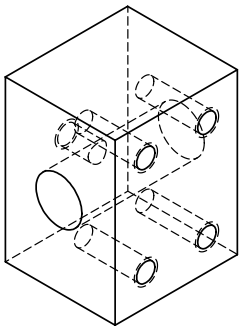
Cooper Machine Co.

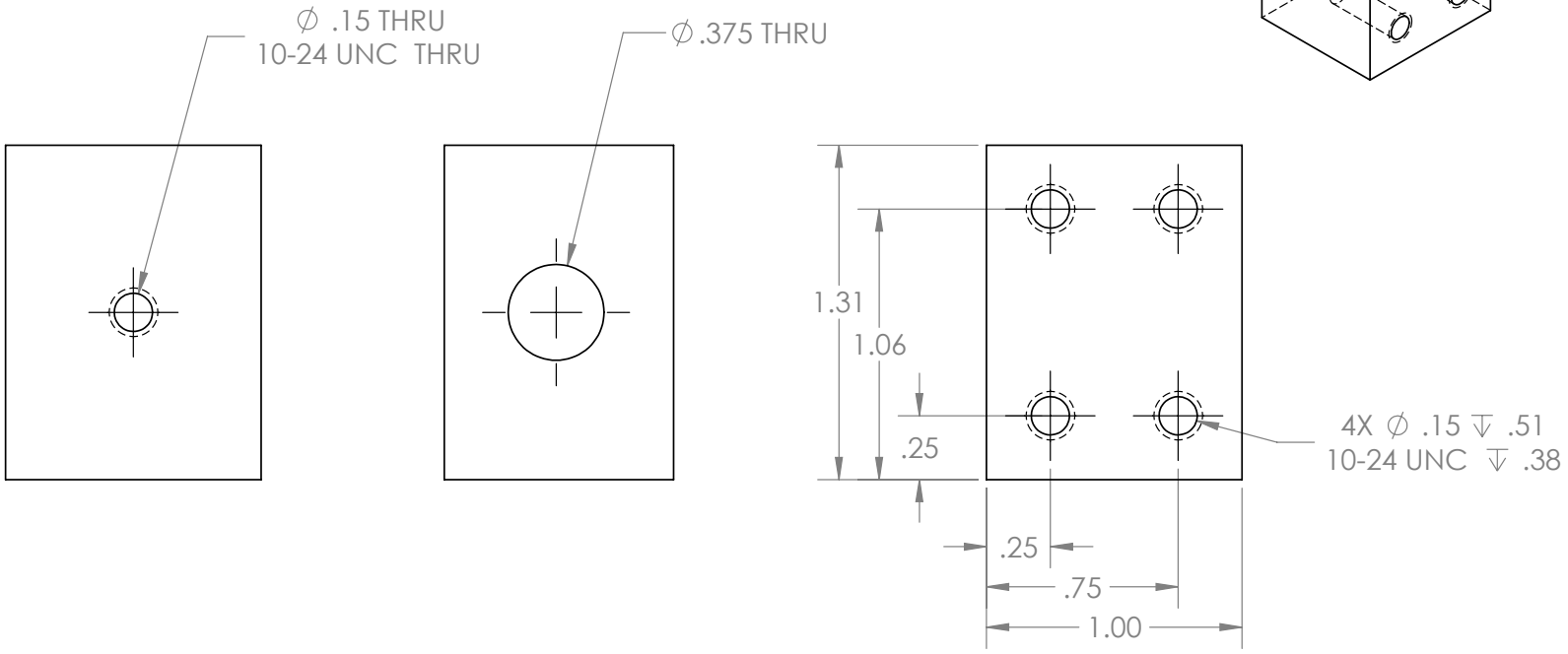
TITLE: Shield

SIZE	FILE NAME	REV
A	shield	1.0

SCALE: 1:5 | WEIGHT: 3.99 | SHEET 2 OF 2

5 4 3 2 1





UNLESS OTHERWISE SPECIFIED:	DRAWN BY	J. Song
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014
	APPLICATION	
	NEXT ASSY	Safety Shield
INTERPRET GEOMETRIC TOLERANCING PER:		
MATERIAL 6061-T6 (SS)	SUBSYSTEM	Electrical
FINISH	COMMENTS:	
DO NOT SCALE DRAWING		

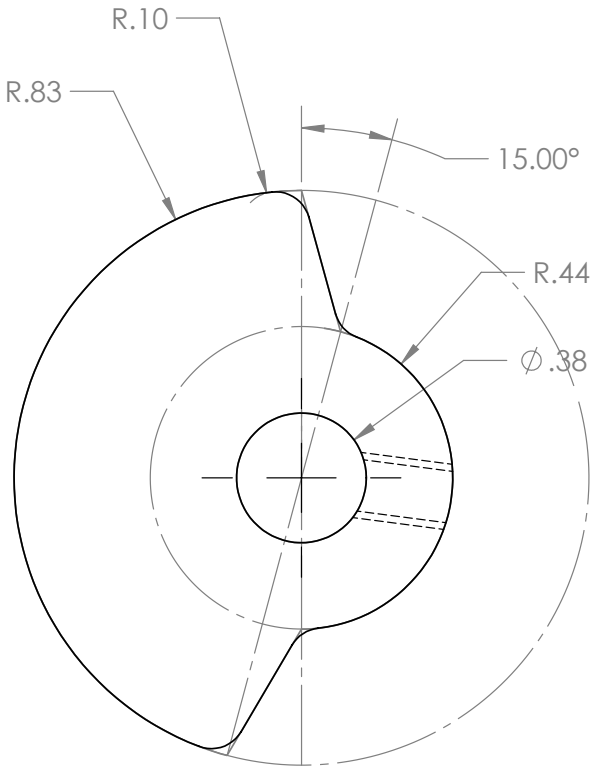
Cooper Machine Co.

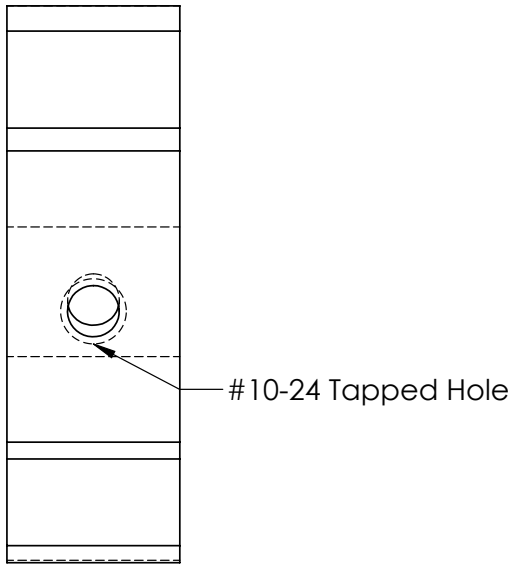
TITLE:
Shield mount block

SIZE	FILE NAME	REV
A	shield-mount	1.0

SCALE: 3:2 | WEIGHT: 0.10 | SHEET 1 OF 1

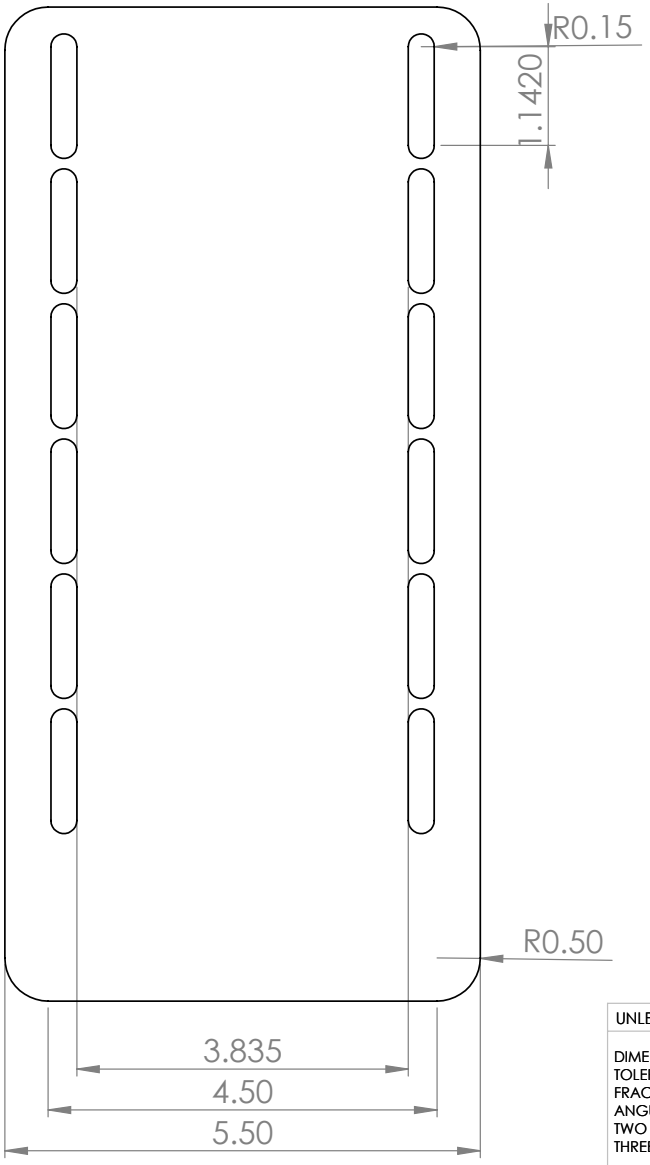
5 4 3 2 1





UNLESS OTHERWISE SPECIFIED:	DRAWN BY	J. Song	Cooper Machine Co.
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014	TITLE: Cam
	APPLICATION	Safety Shield	
INTERPRET GEOMETRIC TOLERANCING PER:	NEXT ASSY		SIZE A | FILE NAME cam | REV 1.0
MATERIAL 6061-T6 (SS)	SUBSYSTEM		
FINISH	COMMENTS:		SCALE: 2:1 | WEIGHT: 0.06 | SHEET 1 OF 1
DO NOT SCALE DRAWING			

5 4 3 2 1



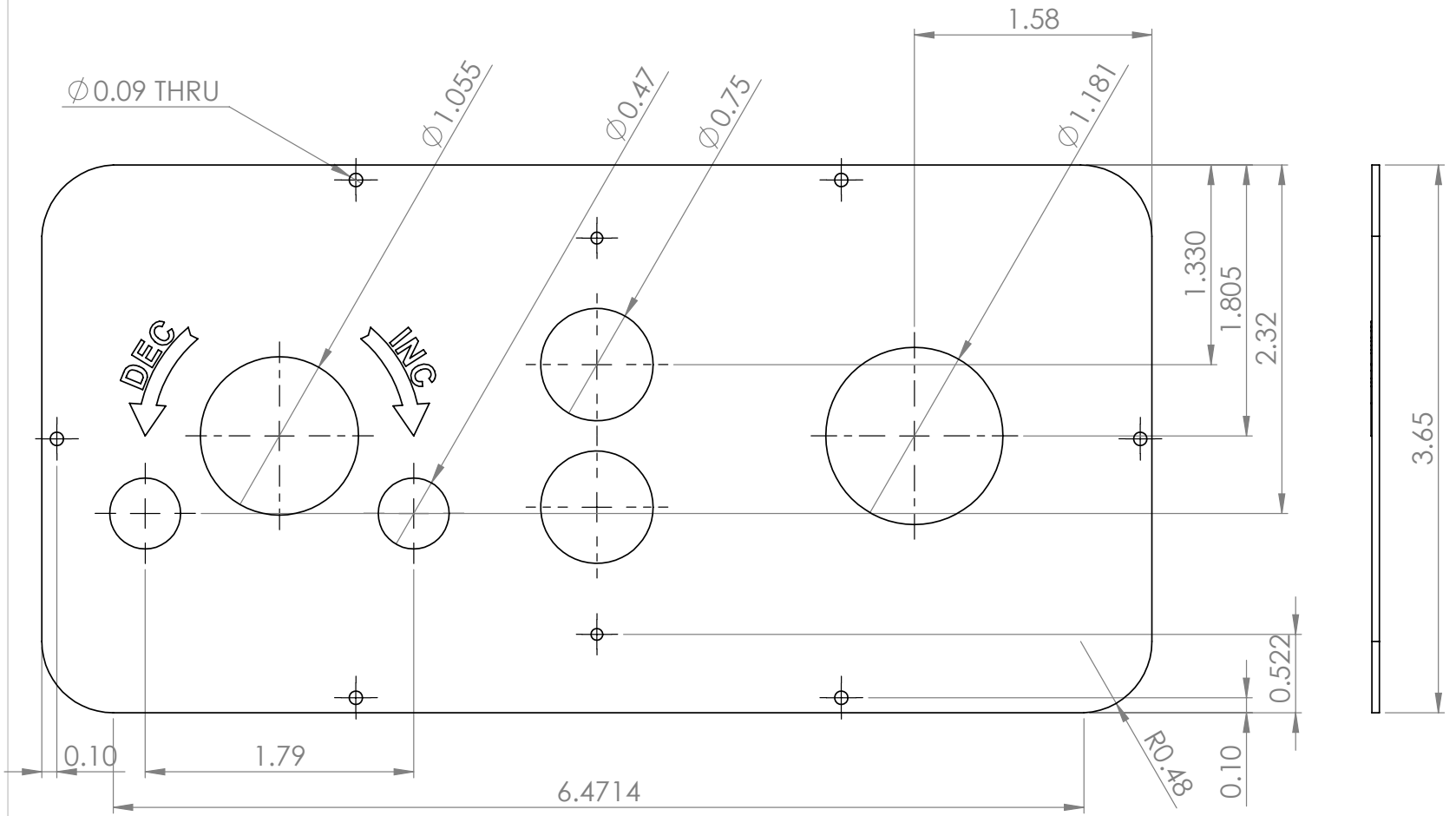
UNLESS OTHERWISE SPECIFIED:	DRAWN BY	J. Song
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014
	APPLICATION	
INTERPRET GEOMETRIC TOLERANCING PER:	NEXT ASSY	
MATERIAL		
FINISH	SUBSYSTEM	
DO NOT SCALE DRAWING	COMMENTS:	

Cooper Machine Co.

TITLE:

SIZE	FILE NAME	REV
A	Control Box Mounting Board	1.0
SCALE: 1:5	WEIGHT:	SHEET 1 OF 1

5 4 3 2 1



UNLESS OTHERWISE SPECIFIED:	DRAWN BY	J. Song	Cooper Machine Co.
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DATE	12/17/2014	TITLE:
	APPLICATION		
INTERPRET GEOMETRIC TOLERANCING PER:	NEXT ASSY		SIZE: A — FILE NAME: Control Panel — REV: 1.0
MATERIAL	SUBSYSTEM		
FINISH	COMMENTS:		SCALE: 1:2 — WEIGHT: — SHEET 1 OF 1
DO NOT SCALE DRAWING			

5 4 3 2 1

Appendix A

Datasheets

Non-Illuminated Selector Switches (Assembled)

Assembled Selector Switches

A S W 3 (1) (L) 20 (N) – 304

Function

S: Selector Switch

Series Designation

W: TW Series

Number of Positions

2: 2-Position
3: 3-Position
4: 4-Position
5: 5-Position

Spring Return Action

Blank: Maintained
1: Spring return from Right (2 or 3 position)
2: Spring return from Left (2 or 3 position)
3: 2-Way spring return from Left and Right (3 position only)

Circuit Number

(Standard circuits shown on following pages and 669.)

Contacts Terminal Style

Blank: standard
N: Fingersafe (IP20)

Contact Arrangement Code

10: 1NO 01: 1NC
20: 2NO 02: 2NC
40: 4NO 04: 4NC
11: 1NO-1NC 22: 2NO-2NC

Operator Style Code

Blank: Knob Operator
L: Lever Operator
K: Key Operator

1. Use only when interpreting part numbers. Do not use for developing part numbers.
2. Custom contact configurations available.
3. Custom key removable codes available.
4. Portions of part number inside ( ) are optional.

Non-Illuminated Selector Switches (Assembled) continued

2-Position Selector Switches

Style					Part Number		
Contact	Mounting	Operator Position L	Operator Position R		Maintained	Spring Return from Right	Spring Return from Left
		L R	L R		L R	L R	L R
1NO	1 2	O O	X O	Knob Lever Key	ASW210 ASW2L10 ASW2K10	ASW2110 ASW21L10 ASW21K10	ASW2210 ASW22L10 ASW22K10
1NC	1 2	X O	O O	Knob Lever Key	ASW201-116 ASW2L01-116 ASW2K01-116	ASW2101-116 ASW21L01-116 ASW21K01-116	ASW2201-116 ASW22L01-116 ASW22K01-116
1NO 1NC	1 2	X O	O X	Knob Lever Key	ASW211 ASW2L11 ASW2K11	ASW2111 ASW21L11 ASW21K11	ASW2211 ASW22L11 ASW22K11
2NO	1 2	O O	X X	Knob Lever Key	ASW220 ASW2L20 ASW2K20	ASW2120 ASW21L20 ASW21K20	ASW2220 ASW22L20 ASW22K20
2NC	1 2	X X	O O	Knob Lever Key	ASW202-104 ASW2L02-104 ASW2K02-104	ASW2102-104 ASW21L02-104 ASW21K02-104	ASW2202-104 ASW22L02-104 ASW22K02-104
2NO 2NC	1 2 3 4	O X O X	X O X O	Knob Lever Key	ASW222 ASW2L22 ASW2K22	ASW2122 ASW21L22 ASW21K22	ASW2222 ASW22L22 ASW22K22
2NO 2NC	1 2 3 4	O O X X	X X O O	Knob Lever Key	ASW222-111 ASW2L22-111 ASW2K22-111	ASW2122-111 ASW21L22-111 ASW21K22-111	ASW2222-111 ASW22L22-111 ASW22K22-111

Non-Illuminated Selector Switches (Assembled) continued

3-Position Selector Switches

Style						Part Number			
Contact	Mounting	Operator Position L	Operator Position C	Operator Position R		Maintained	Spring Return from Right	Spring Return from Left	Spring Return Two-Way
2NO	1 2	X 0	0 0	0 X	Knob Lever Key	ASW320 ASW3L20 ASW3K20	ASW3120 ASW31L20 ASW31K20	ASW3220 ASW32L20 ASW32K20	ASW3320 ASW33L20 ASW33K20
2NC	1 2	0 X	X—X	X—X 0	Knob Lever Key	ASW302 ASW3L02 ASW3K02	ASW3102 ASW31L02 ASW31K02	ASW3202 ASW32L02 ASW32K02	ASW3302 ASW33L02 ASW33K02
2NO 2NC	1 2 3 4	X 0 0 X—X	0 0 X—X	0 X X—X 0	Knob Lever Key	ASW322 ASW3L22 ASW3K22	ASW3122 ASW31L22 ASW31K22	ASW3222 ASW32L22 ASW32K22	ASW3322 ASW33L22 ASW33K22
2NO 2NC	1 2 3 4	X X—X 0 0	0 X—X X 0	X 0 0 X	Knob Lever Key	ASW322-309 ASW3L22-309 ASW3K22-309	ASW3122-309 ASW31L22-309 ASW31K22-309	ASW3222-309 ASW32L22-309 ASW32K22-309	ASW3322-309 ASW33L22-309 ASW33K22-309
2NO 2NC	1 2 3 4	0 0 0 0	X 0 X 0	0 X 0 X	Knob Lever Key	ASW322-310 ASW3L22-310 ASW3K22-310	ASW3122-310 ASW31L22-310 ASW31K22-310	ASW3222-310 ASW32L22-310 ASW32K22-310	ASW3322-310 ASW33L22-310 ASW33K22-310
4NO	1 2 3 4	X 0 X 0	0 0 0 0	0 X 0 X	Knob Lever Key	ASW340 ASW3L40 ASW3K40	ASW3140 ASW31L40 ASW31K40	ASW3240 ASW32L40 ASW32K40	ASW3340 ASW33L40 ASW33K40
4NC	1 2 3 4	0 X—X 0 X—X	X—X X—X X—X X—X	X—X 0 X—X 0	Knob Lever Key	ASW304 ASW3L04 ASW3K04	ASW3104 ASW31L04 ASW31K04	ASW3204 ASW32L04 ASW32K04	ASW3304 ASW33L04 ASW33K04

1. The truth table indicates the operating position of contact block when the operator is switched to that position.
   X = On (closed contacts)
   0 = Off (open contacts)
   X—X = Overlapping Contacts: Remain on (closed contacts) when switch is moved between these two positions.
2. All knob and lever selector switches come in black. Other colors are available by ordering the knob or lever separately.
3. Every key selector switch uses an identical key. The key is removable in any maintained position.
4. Custom contact configurations are available, see page 669.

4-Position Selector Switch

Style							Maintained
Contact	Mounting	Operator Position 1	Operator Position 2	Operator Position 3	Operator Position 4		Part Number
2NO 2NC	1 2 3 4	X 0 0 0	0 X 0 0	0 0 X 0	0 0 0 X	Knob Lever	ASW422-411 ASW4L22-411

5-Position Selector Switch

Style								Maintained
Contact	Mounting	Operator Position 1	Operator Position 2	Operator Position 3	Operator Position 4	Operator Position 5		Part Number
2NO 2NC	1 2 3 4	X 0 0 0	0 X 0 0	0 0 0 0	0 0 X 0	0 0 0 X	Knob Lever	ASW522-501 ASW5L22-501

Silicon Bridge Rectifiers

Silicon Bridge Rectifiers

Fig. 1

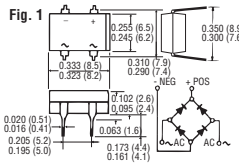


Fig. 2

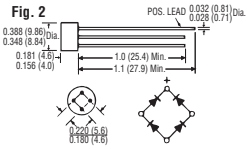


Fig. 3

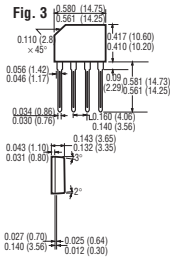


Fig. 4

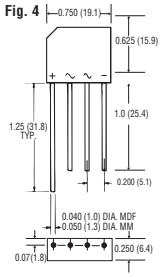


Fig. 5

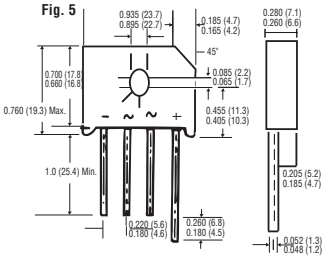
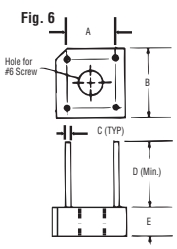


Fig. 6



	KBPC6	KBPC10P
A	0.425 (10.8)	0.500 (12.7)
B	0.600 (15.2)	0.750 (19.1)
C	0.040 (1.0)	0.050 (1.3)
D	0.750 (19.1)	0.875 (22.2)
E	0.250 (6.4)	0.275 (7.0)

Polarity shown on side of case
Positive lead by beveled corner

Fig. 7

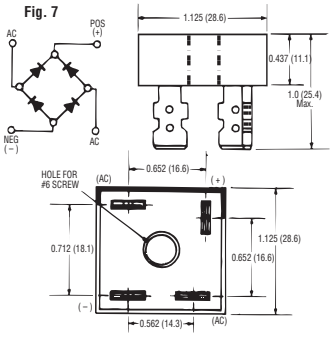
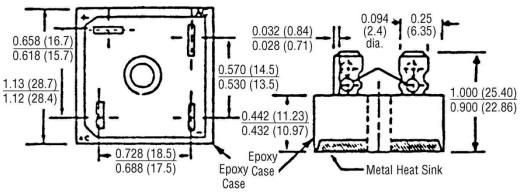


Fig. 8



Stock No.	Mfr.'s Type	Fig.	V_{RM} V_{RRM} V_{RWM}	V_R (RMS)	I_{FSM}	I_o	V_{FM}	I_{RM} T_A= 100°C	No. of Leads	EACH
70015979	DF005M	1	50 V	35 V	30 A	1.0 A @ T_A = 40°C	1.1 V	0.5 mA	4	**.64**
70015980	DF01M	1	100 V	70 V	30 A	1.0 A @ T_A = 40°C	1.1 V	0.5 mA	4	**.66**
70015981	DF02M	1	200 V	140 V	30 A	1.0 A @ T_A = 40°C	1.1 V	0.5 mA	4	**.70**
70015982	DF04M	1	400 V	280 V	30 A	1.0 A @ T_A = 40°C	1.1 V	0.5 mA	4	**.72**
70015983	DF06M	1	600 V	420 V	30 A	1.0 A @ T_A = 40°C	1.1 V	0.5 mA	4	**.78**
70016037	W005G	2	50 V	35 V	50 A	1.5 A @ T_A = 25°C	1.1 V	1.0 mA	4	**.41**
70015990	KBP401G	3	100 V	70 V	30 A	1.0 A @ T_A = 50°C	1.1 V	1.0 mA	4	**.56**
70016038	W01G	2	100 V	70 V	50 A	1.5 A @ T_A = 50°C	1.1 V	1.0 mA	4	**.56**
70016039	W02G	2	200 V	140 V	50 A	1.5 A @ T_A = 50°C	1.1 V	1.0 mA	4	**.59**
70015991	KBP404G	3	400 V	280 V	30 A	1.0 A @ T_A = 50°C	1.1 V	1.0 mA	4	**.61**
70016040	W04G	2	400 V	280 V	50 A	1.5 A @ T_A = 50°C	1.1 V	1.0 mA	4	**.61**
70015985	KBL401	4	100 V	70 V	200 A	4.0 A @ T_A = 50°C	1.1 V	1.0 mA	4	**1.55**
70015986	KBL402	4	200 V	140 V	200 A	4.0 A @ T_A = 25°C	1.1 V	1.0 mA	4	**1.54**
70016015	KBU402‡	5	200 V	140 V	200 A	4.0 A @ T_A = 65°C	1.1 V	1.0 mA	4	**.98**
70015987	KBL404	4	400 V	280 V	200 A	4.0 A @ T_A = 50°C	1.1 V	1.0 mA	4	**1.54**
70016016	KBU404‡	5	400 V	280 V	200 A	4.0 A @ T_A = 65°C	1.1 V	1.0 mA	4	**1.81**
70015988	KBL408	4	800 V	560 V	200 A	4.0 A @ T_A = 50°C	1.1 V	1.0 mA	4	**1.66**
70015989	KBL410	4	1000 V	700 V	200 A	4.0 A @ T_A = 50°C	1.1 V	1.0 mA	4	**1.93**
70016008	KBPC6005‡	6	50 V	35 V	200 A	6.0 A @ T_C = 50°C	1.1 V	1.0 mA	4	**1.40**
70016009	KBPC601‡	6	100 V	70 V	200 A	6.0 A @ T_C = 50°C	1.1 V	1.0 mA	4	**.84**
70016017	KBU602‡	5	200 V	140 V	200 A	6.0 A @ T_A = 40°C	1.1 V	1.0 mA	4	**2.07**
70016010	KBPC602‡	6	200 V	140 V	200 A	6.0 A @ T_C = 50°C	1.1 V	1.0 mA	4	**1.52**
70016018	KBU604‡	5	400 V	280 V	200 A	6.0 A @ T_A = 40°C	1.1 V	1.0 mA	4	**1.61**
70016011	KBPC604‡	6	400 V	280 V	200 A	6.0 A @ T_C = 50°C	1.1 V	1.0 mA	4	**1.54**
70016019	KBU606‡	5	600 V	420 V	200 A	6.0 A @ T_A = 40°C	1.1 V	1.0 mA	4	**2.07**
70016012	KBPC606‡	6	600 V	420 V	200 A	6.0 A @ T_C = 50°C	1.1 V	1.0 mA	4	**1.34**
70016020	KBU610‡	5	1000 V	700 V	200 A	6.0 A @ T_A = 40°C	1.1 V	1.0 mA	4	**2.41**
70016021	KBU8005‡	5	50 V	35 V	250 A	8.0 A @ T_A = 90°C	1.1 V	1.0 mA	4	**1.79**
70016022	KBU801‡	5	100 V	70 V	250 A	8.0 A @ T_A = 90°C	1.1 V	1.0 mA	4	**2.21**
70016024	KBU804‡	5	400 V	280 V	250 A	8.0 A @ T_A = 90°C	1.1 V	1.0 mA	4	**2.25**
70016025	KBU806‡	5	600 V	420 V	250 A	8.0 A @ T_A = 90°C	1.1 V	1.0 mA	4	**1.91**
70016026	KBU808‡	5	800 V	560 V	250 A	8.0 A @ T_A = 90°C	1.1 V	1.0 mA	4	**2.54**
70016027	KBU810‡	5	1000 V	700 V	250 A	8.0 A @ T_A = 90°C	1.1 V	1.0 mA	4	**2.63**
70016151	KBPC1001‡	6	100 V	70 V	250 A	10.0 A @ T_C = 50°C	1.1 V	1.0 mA	4	**1.56**
70015992	KBPC1002P‡	6	200 V	140 V	250 A	10.0 A @ T_C = 50°C	1.1 V	1.0 mA	4	**2.46**
70015993	KBPC1004P‡	6	400 V	280 V	250 A	10.0 A @ T_C = 50°C	1.1 V	1.0 mA	4	**2.54**
70016013	KBU1006‡	5	600 V	420 V	250 A	10.0 A @ T_A = 75°C	1.1 V	1.0 mA	4	**1.89**
70015994	KBPC1008P‡	6	800 V	560 V	250 A	10.0 A @ T_C = 50°C	1.1 V	1.0 mA	4	**2.86**
70016014	KBU1010‡	5	1000 V	700 V	250 A	10.0 A @ T_A = 75°C	1.1 V	1.0 mA	4	**2.71**
70015995	KBPC1010P‡	6	1000 V	700 V	250 A	10.0 A @ T_C = 50°C	1.1 V	1.0 mA	4	**3.35**
70015996	KBPC2501‡	7	100 V	70 V	300 A	25.0 A @ T_C = 55°C	1.1 V	1.0 mA	4	**4.50**
70015997	KBPC2502‡	7	200 V	140 V	300 A	25.0 A @ T_C = 55°C	1.1 V	1.0 mA	4	**3.85**
70015999	KBPC2504‡	7	400 V	280 V	300 A	25.0 A @ T_C = 55°C	1.1 V	1.0 mA	4	**3.78**
70016000	KBPC2506‡	7	600 V	420 V	300 A	25.0 A @ T_C = 55°C	1.1 V	1.0 mA	4	**3.92**
70016001	KBPC2508‡	7	800 V	560 V	300 A	25.0 A @ T_C = 55°C	1.1 V	1.0 mA	4	**4.59**
70016002	KBPC35005‡	7	50 V	35 V	400 A	35.0 A @ T_C = 55°C	1.1 V	1.0 mA	4	**3.75**
70016003	KBPC3501‡	7	100 V	70 V	400 A	35.0 A @ T_C = 55°C	1.1 V	1.0 mA	4	**4.46**
70016004	KBPC3502‡	7	200 V	140 V	400 A	35.0 A @ T_C = 55°C	1.1 V	1.0 mA	4	**4.87**
70016028	MP3502*‡	8	200 V	140 V	400 A	35.0 A @ T_C = 55°C	1.1 V	0.5 mA	2	**4.26**
70015998	KBPC3504‡	7	400 V	280 V	400 A	35.0 A @ T_C = 55°C	1.1 V	1.0 mA	4	**4.13**
70016029	MP3504*‡	8	400 V	280 V	400 A	35.0 A @ T_C = 55°C	1.1 V	0.5 mA	2	**4.89**
70016005	KBPC3506‡	7	600 V	420 V	400 A	35.0 A @ T_C = 55°C	1.1 V	1.0 mA	4	**3.88**
70016030	MP3506*‡	8	600 V	420 V	400 A	35.0 A @ T_C = 55°C	1.1 V	0.5 mA	2	**5.00**
70016006	KBPC3508‡	7	800 V	560 V	400 A	35.0 A @ T_C = 55°C	1.1 V	1.0 mA	3	**5.22**
70016031	MP3508*‡	8	800 V	560 V	400 A	35.0 A @ T_C = 55°C	1.1 V	0.5 mA	2	**4.91**
70016007	KBPC3510‡	7	1000 V	700 V	400 A	35.0 A @ T_C = 55°C	1.1 V	1.0 mA	4	**3.84**
70016032	MP3510*‡	8	1000 V	700 V	400 A	35.0 A @ T_C = 55°C	1.1 V	0.5 mA	2	**3.63**
70016128	W06G	2	600 V	420 V	50 A	1.0 A @ T_A = 50°C	1.1 V	1.0 mA	4	**.41**
70016130	W10G	2	1000 V	700 V	50 A	1.5 A @ T_A = 50°C	1.1 V	1.0 mA	4	**.57**
70016146	KBL406	4	600 V	420 V	200 A	4.0 A @ T_C = 50°C	1.1 V	1.0 mA	4	**1.46**

Note: TSTG = –55 to +150°C. T_J = –55 to +125°C. *Molded plastic case with integrally mounted in bridge encapsulation. Wire leads (0.04 dia.) available on Fig. 5 and Fig. 7 devices by adding "W" to the end of the part number. ‡Figs. 6, 7, 8 — Heat sink required to maintain maximum Io rating.

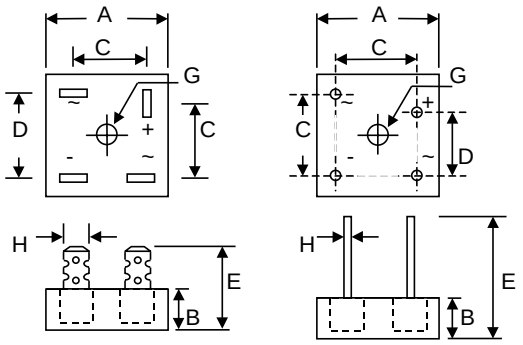
WTE
POWER SEMICONDUCTORS

KBPC15, 25, 35/W SERIES

15, 25, 35A HIGH CURRENT BRIDGE RECTIFIER

Features

- Diffused Junction
- Low Reverse Leakage Current
- Low Power Loss, High Efficiency
- Electrically Isolated Metal Case for Maximum Heat Dissipation
- Case to Terminal Isolation Voltage 2500V
- UL Recognized File # E157705



KBPC KBPC-W

Mechanical Data

- Case: Metal Case with Electrically Isolated Epoxy
- Terminals: Plated Leads Solderable per MIL-STD-202, Method 208
- Polarity: Symbols Marked on Case
- Mounting: Through Hole for #10 Screw
- Weight: KBPC 31.6 grams (approx.)
  KBPC-W 28.5 grams (approx.)
- Marking: Type Number

"W" Suffix Designates Wire Leads
No Suffix Designates Faston Terminals

	KBPC		KBPC-W	
Dim	**Min**	**Max**	**Min**	**Max**
A	28.40	28.70	28.40	28.70
B	10.97	11.23	10.97	11.23
C	15.70	16.70	17.10	19.10
D	17.50	18.50	10.90	11.90
E	22.86	25.40	30.50	—
G	Hole for #10 screw, 5.08Ø Nominal			
H	6.35 Typical		0.97Ø	1.07Ø
All Dimension in mm				

Maximum Ratings and Electrical Characteristics @T_A=25°C unless otherwise specified

Single Phase, half wave, 60Hz, resistive or inductive load.
For capacitive load, derate current by 20%.

Characteristics	Symbol	-00/W	-01/W	-02/W	-04/W	-06/W	-08/W	-10/W	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	800	1000	V
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	420	560	700	V
Average Rectifier Output Current @T_C = 60°C KBPC15 KBPC25 KBPC35	I_O	15 25 35							A
Non-Repetitive Peak Forward Surge Current 8.3ms single half sine-wave Superimposed on rated load (JEDEC Method) KBPC15 KBPC25 KBPC35	I_{FSM}	300 400 400							A
Forward Voltage Drop (per element) KBPC15 @I_F = 7.5A KBPC25 @I_F = 12.5A KBPC35 @I_F = 17.5A	V_{FM}	1.2							V
Peark Reverse Current @T_C = 25°C At Rated DC Blocking Voltage @T_C = 125°C	I_{RM}	10 1.0							μA mA
I^2t Rating for Fusing (t < 8.3ms) (Note 1) KBPC15 KBPC25 KBPC35	I^2t	373 373 664							A^2s

Maximum Ratings and Electrical Characteristics @T_A=25°C unless otherwise specified

Typical Junction Capacitance (per element) (Note 2)	C_j	300	pF
Typical Thermal Resistance Junction to Case (per element) (Note 3) KBPC15 KBPC25 KBPC35	$R_{\theta JC}$	6.3 3.8 2.7	K/W
RMS Isolation Voltage from Case to Lead	V_{ISO}	2500	V
Operating and Storage Temperature Range	T_j, T_{STG}	-65 to +150	°C

*** Glass passivated forms are available upon request.**

Note: 1. Measured at non-repetitive, for t > 1ms and < 8.3ms.
2. Measured at 1.0 MHz and applied reverse voltage of 4.0V D.C.
3. Thermal resistance junction to case mounted on heatsink.

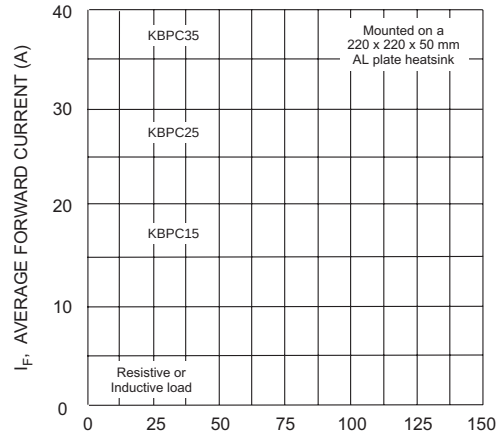


Fig. 1 Forward. Current Derating Curve

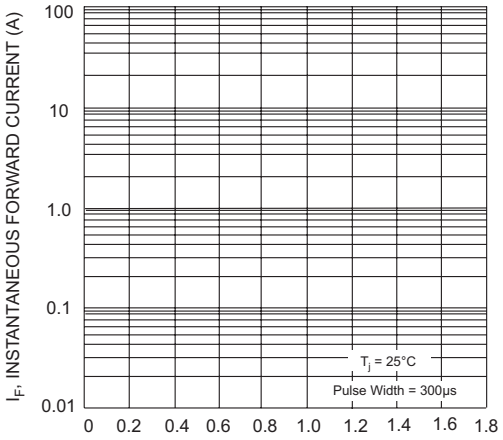


Fig. 2 Typical Forward Characteristics (per element)

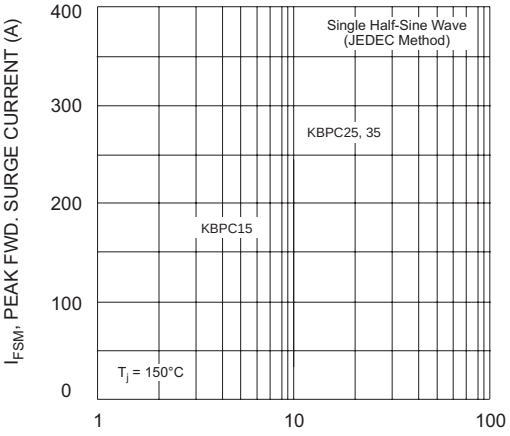


Fig. 3 Max Non-Repetitive Surge Current

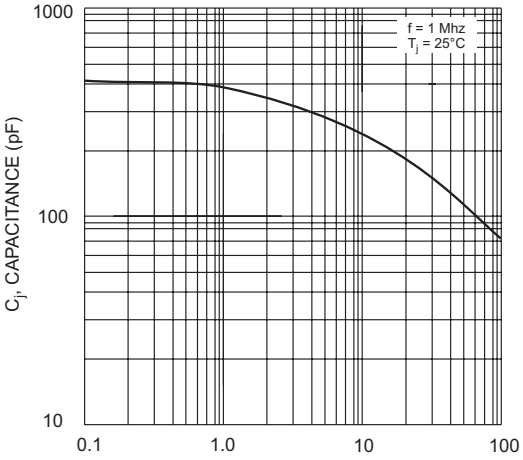


Fig. 4 Typical Junction Capacitance (per element)

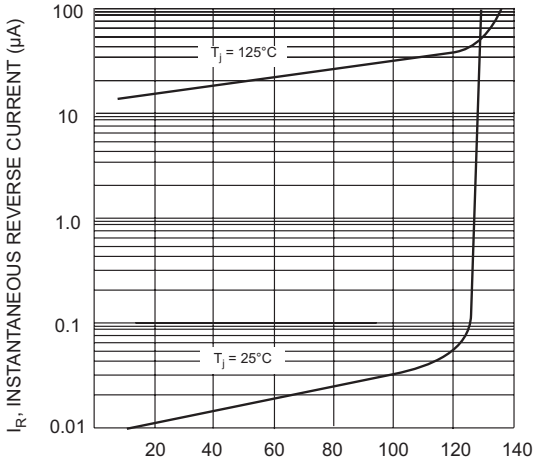


Fig. 5 Typical Reverse Characteristics (per element)

ORDERING INFORMATION

Product No.	Package Type	Shipping Quantity
KBPCxx00	Square Bridge	50 Units/Box
KBPCxx00W	Square Bridge	50 Units/Box
KBPCxx01	Square Bridge	50 Units/Box
KBPCxx01W	Square Bridge	50 Units/Box
KBPCxx02	Square Bridge	50 Units/Box
KBPCxx02W	Square Bridge	50 Units/Box
KBPCxx04	Square Bridge	50 Units/Box
KBPCxx04W	Square Bridge	50 Units/Box
KBPCxx06	Square Bridge	50 Units/Box
KBPCxx06W	Square Bridge	50 Units/Box
KBPCxx08	Square Bridge	50 Units/Box
KBPCxx08W	Square Bridge	50 Units/Box
KBPCxx10	Square Bridge	50 Units/Box
KBPCxx10W	Square Bridge	50 Units/Box

Shipping quantity given is for minimum packing quantity only. For minimum order quantity, please consult the Sales Department.

Won-Top Electronics Co., Ltd.
No. 44 Yu Kang North 3rd Road, Chine Chen Dist., Kaohsiung, Taiwan
Phone: 886-7-822-5408 or 886-7-822-5410
Fax: 886-7-822-5417
Email: sales@wontop.com
Internet: http://www.wontop.com

We power your everyday.

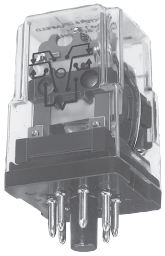
RELAY PRODUCTS

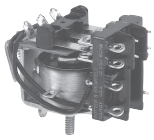
General Purpose
Panel/Plug-in Relays

Potter & Brumfield

KRPA Series Panel Plug-in Relay

- **5 to 10A current capability**
- **Contact arrangements of 1, 2 and 3 form C (CO)**
- **Octal type termination for quick installation**
- **Indicator lamp available on certain models**





Typical applications
Baggage handling, lighting, inspection equipment, marine.

Approvals

UL E22575; CSA LR15734
Technical data of approved types on request.

Contact Data

Contact arrangement	1 form C (CO), 2 form C (CO), 3 form C (CO)	
Rated voltage	240VAC	
Rated current	10A	
Contact material	Ag	AgCdO
Min. recommended contact load	100mA, 12VDC	300mA, 12VDC
Frequency of operation	360 ops./hour	360 ops./hour

Contact ratings

Type	Load	Cycles
UL 508		
KRPA, Ag		
	5A, 120VAC	$100x10^3$
	3A, 240VAC	$100x10^3$
	1/10HP, 120VAC	$1x10^3$
	1/6HP, 240VAC	$1x10^3$
KRPA, AgCdO		
	10A, 240VAC	$100x10^3$
	1/3HP, 120VAC	$1x10^3$
	1/2HP, 240VAC	$1x10^3$
KA, Ag		
	5A, 120VAC	
	3A, 240VAC	
	1/10HP, 120VAC	
	1/6HP, 240VAC	
KA, AgCdO		
	10A, 120VAC	
	6A, 240VAC	
	1/6HP, 120VAC	
	1/3HP, 240VAC	
Mechanical endurance	$10x10^6$ ops.	

Coil Data

Coil voltage range	6 to 220VDC 6 to 240VAC
Coil insulation system according UL	Class B

Coil versions, DC coil

Coil code	Rated voltage VDC	Operate voltage VDC	Coil resistance Ω±10%	Rated coil power W
6	6	4.5	32	1.15
12	12	9.0	120	1.2
24	24	18.0	472	1.25
48	48	36.0	1800	1.3
110	110	82.5	10000	1.2
–	220	Use 110V relay with 10KΩ, 5W resistor in series		

All figures are given for coil without preenergization, at ambient temperature +23°C.

Coil Data (continued)

Coil versions, AC coil

Coil code	Rated voltage VAC	Operate voltage VAC	Coil resistance Ω±15%	Rated coil power VA
6	6	5.1	6	2.01
12	12	10.2	24	2.02
24	24	20.4	85	2.02
20	120	102.0	2250	2.1
240	240	204.0	9110	2.1

All figures are given for coil without preenergization, at ambient temperature +23°C.

Insulation Data

Initial dielectric strength	
between open contacts	$1000V_{rms}$
between contact and coil	$1000V_{rms}$
between adjacent contacts	$1000V_{rms}$
Initial insulation resistance	
between insulated elements	KRPA: 1000MΩ KA: 100MΩ

Other Data

Material compliance:	EU RoHS/ELV, China RoHS, REACH, Halogen content refer to the Product Compliance Support Center at www.te.com/customersupport/rohssupportcenter
Ambient temperature	
DC coil	KRPA: -45ºC to 70ºC KA: -45ºC to 85ºC
AC coil	KRPA: -45ºC to 55ºC KA: -45ºC to 70ºC
Category of environmental protection	
IEC 61810	RTI - dust protected KRPA and RT0 - open style KA
Terminal type	KRPA: 8- or 11-pin octal-type plug KA: solder terminals
Weight	85g
Packaging/unit	tray/25 pcs., box/150pcs.

Accessories

For details see datasheet	Sockets and Accessories, KRPA Relays

Product Code	Description
27E891	Two pole DIN socket (use 20C318 clip)
27E892	Three pole DIN socket (use 20C318 clip)
27E122	Two pole track mount socket (use 20C318 clip)
27E123	Three pole track mount socket (use 20C318 clip)

11-2012, Rev. 1112
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RELAY PRODUCTS

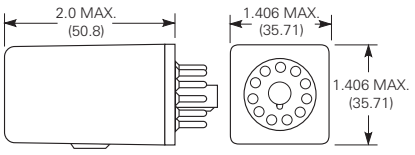
General Purpose
Panel/Plug-in Relays

Potter & Brumfield

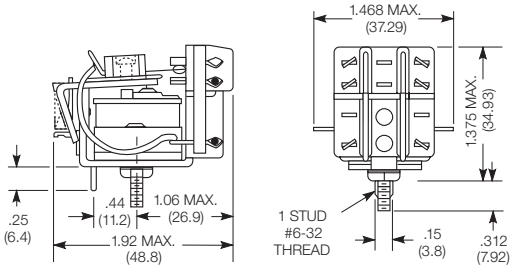
KRPA Series Panel Plug-in Relay (Continued)

Dimensions

KRPA

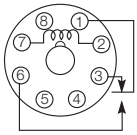


KA

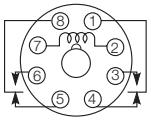


Terminal assignment

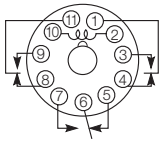
KRPA
1 form C



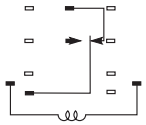
KRPA
2 form C



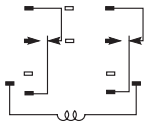
KRPA
3 form C



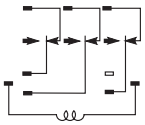
KA
1 form C



KA
2 form C



KA
3 form C



Product code structure

Typical product code **KRPA** **-5** **A** **Y** **-120**

Type
- **KRPA** Enclosed relay with octal-style plug
- **KA** Open style relay with solder terminals

Contact arrangement and rating
- **5** 1 form C (CO)
- **11** 2 form C (CO)
- **14** 3 form C (CO)

Coil Input
- **A** AC, 50/60Hz
- **D** DC

Contact material and indicator lamp option
- **Y** Ag, no indicator lamp
- **G** AgCdO, no indicator lamp
- **N** AgCdO, with indicator (Code N only available with relay type KRPA)

Options
- **Leave blank** no additional options
- **F** Au flashed contacts
- **P** Push to test button

(Options F and P only available with relay type KRPA)

Coil voltage

Coil code: please refer to coil versions table

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KRPA Series Panel Plug-in Relay (Continued)

Product Code	Arrangement	Contact Material	Coil	Option	Part Number
KA-5AG-120	1 form C, 1 CO	AgCdO	120VAC	Open style	7-1393099-1
KA-5AY-120		Ag			7-1393099-3
KA-5DG-6		AgCdO	6VDC		7-1393099-9
KA-5DG-12			12VDC		7-1393099-7
KA-5DG-110			110VDC		7-1393099-6
KA-11AG-120	2 form C, 2 CO		120VAC		3-1393099-6
KA-11AY-6		Ag	6VAC		4-1393099-1
KA-11AY-24			24VAC		4-1393099-0
KA-11AY-120			120VAC		3-1393099-9
KA-11DG-12		AgCdO	12VDC		4-1393099-3
KA-11DG-24			24VDC		4-1393099-5
KA-11DG-110			110VDC		4-1393099-2
KA-14AG-120	3 form C, 3 CO		120VAC		5-1393099-0
KA-14AY-120		Ag			5-1393099-4
KA-14DG-24		AgCdO	24VDC		5-1393099-7
KA-14DG-110			110VDC		5-1393099-5
KRPA-5AG-24	1 form C, 1 CO		24VAC	None	9-1393104-9
KRPA-5AG-120			120VAC		9-1393104-8
KRPA-5DG-6			6VDC		1393105-5
KRPA-5DG-12			12VDC		1393105-3
KRPA-5DG-24			24VDC		1393105-4
KRPA-5DY-12		Ag	12VDC		1393105-6
KRPA-5DY-24			24VDC		1393105-7
KRPA-11AG-6	2 form C, 2 CO	AgCdO	6VAC		2-1393104-8
KRPA-11AG-12			12VAC		2-1393104-4
KRPA-11AG-24			24VAC		1-1393105-2
KRPA-11AG-120			120VAC		2-1393104-5
KRPA-11AG-240			240VAC		2-1393104-7
KRPA-11AN-12			12VAC	Indicator	3-1393104-1
KRPA-11AN-24			24VAC		3-1393104-3
KRPA-11AN-120			120VAC		3-1393104-2
KRPA-11AN-240			240VAC		3-1393104-4
KRPA-11AY-6		Ag	6VAC	None	3-1393104-9
KRPA-11AY-12			12VAC		3-1393104-5
KRPA-11AY-24			24VAC		3-1393104-7
KRPA-11AY-120			120VAC		3-1393104-6
KRPA-11AY-240			240VAC		3-1393104-8
KRPA-11DG-6		AgCdO	6VDC		4-1393104-7
KRPA-11DG-12			12VDC		4-1393104-3
KRPA-11DG-24			24VDC		4-1393104-5
KRPA-11DG-48			48VDC		4-1393104-6
KRPA-11DG-110			110VDC		4-1393104-2
KRPA-11DG-125			125VDC		4-1393104-4
KRPA-11DG-24			24VDC		4-1393104-5
KRPA-11DG-48			48VDC		4-1393104-6
KRPA-11DN-12			12VDC	Indicator	5-1393104-0
KRPA-11DN-24			24VDC		5-1393104-1
KRPA-11DN-110			110VDC		4-1393104-9
KRPA-11DY-12		Ag	12VDC	None	5-1393104-6
KRPA-11DY-24			24VDC		5-1393104-7
KRPA-14AG-12	3 form C, 3 CO	AgCdO	12VAC		6-1393104-4
KRPA-14AG-24			24VAC		6-1393104-7
KRPA-14AG-120			120VAC		6-1393104-5
KRPA-14AG-240			240VAC		6-1393104-8
KRPA-14AN-24			24VAC	Indicator	7-1393104-4
KRPA-14AN-120			120VAC		7-1393104-3
KRPA-14AN-240			240VAC		7-1393104-5
KRPA-14AY-24		Ag	24VAC	None	7-1393104-8
KRPA-14AY-120			120VAC		7-1393104-7
KRPA-14AY-240			240VAC		7-1393104-9
KRPA-14DG-12		AgCdO	12VDC		8-1393104-2
KRPA-14DG-24			24VDC		8-1393104-4
KRPA-14DG-48			48VDC		8-1393104-5
KRPA-14DG-110			110VDC		8-1393104-1
KRPA-14DG-125			125VDC		8-1393104-3
KRPA-14DN-24			24VDC	Indicator	9-1393104-0
KRPA-14DY-24		Ag		None	9-1393104-3

11-2012, Rev. 1112
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TEMCo
INDUSTRIAL POWER SUPPLY

WORLDWIDE Electric Corp

WorldWide General Purpose Motor T1.5-18-56CB

Type:	General Purpose
Horsepower:	1.5
RPM:	1800
Rotation:	Reversible
Frame size:	56C
Enclosure:	TEFC
Mounting:	Face and foot
Connection box:	Side
Shaft diameter:	0.625
Shaft type:	Smooth shaft with 0.188 x 0.188 key
Shaft height (from base):	3.5 in
Overall length:	13.8 in
Overall height:	8.5 in
Bearing type:	Ball bearings
Frame material:	Rolled steel
Phase:	Single
kW:	1.119
Voltage:	115/208-230
Amps (full load):	7.6
Frequency (Hz):	60 Hz
Service factor:	1.15
Duty cycle:	Continuous-use rated
Full load efficiency:	71%
Integrated overload protection:	None
Base type:	Removable
Mounting hole pattern length:	5in, 3in
Mounting hole pattern width:	4.88 in
Face type:	C-Face
Bolt circle diameter (centerline):	3/8-16
Number of holes:	4
Integrated base:	Yes
Agency approvals:	CSA Approved, CE Marked.
Warranty:	1 Year

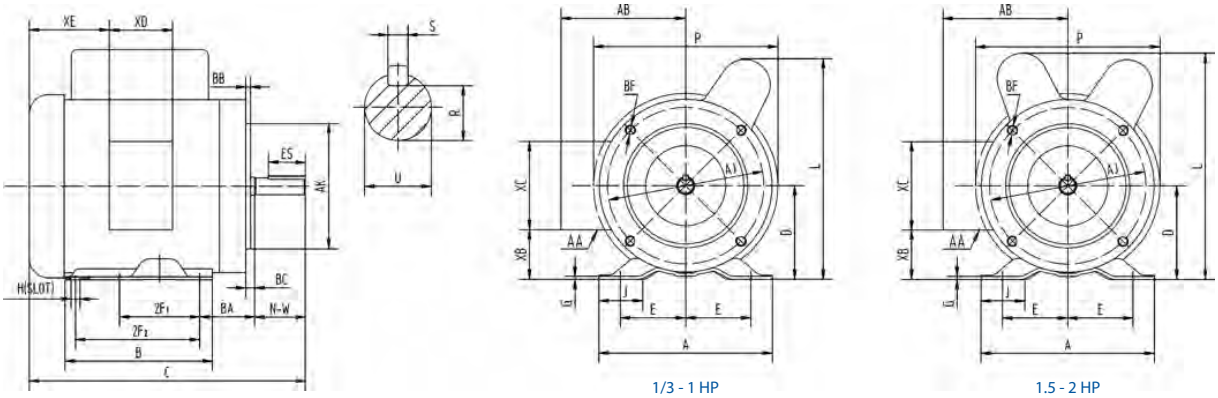
Company Headquarters: *TEMCo* – Tower Electric Motor Company 41474 Christy Street Fremont, CA 94538
Inside USA (877) 474-8209 **International** (510) 490-2187 **Fax** (510) 490-1507 www.temcoindustrialpower.com

WORLDWIDE FRACTIONAL HP MOTORS

General Purpose Motors

TEFC Enclosure ▪ C-Face ▪ Removable Base

Single-Phase ▪ 115/208-230 Volt



1/3 - 1 HP

1.5 - 2 HP

With Manual Overload

ALL DIMENSIONS IN INCHES

Model	E	2F1	2F2	H	BA	A	B	C	D	G	J	P	L	AB
T13-18-56CB-OL	2.44	3	5	0.34	2.75	6.5	6.5	12.2	3.5	0.12	1.73	6.9	8.07	5.35
T12-18-56CB-OL	2.44	3	5	0.34	2.75	6.5	6.5	12.2	3.5	0.12	1.73	6.9	8.07	5.35
T34-18-56CB-OL	2.44	3	5	0.34	2.75	6.5	6.5	12.8	3.5	0.12	1.73	6.9	8.07	5.35
T1-18-56CB-OL	2.44	3	5	0.34	2.75	6.5	6.5	13.4	3.5	0.12	1.73	6.9	8.07	5.35
T1.5-18-56CB-OL	2.44	3	5	0.34	2.75	6.5	6.5	14.09	3.5	0.12	1.73	6.9	8.5	5.35
T2-18-56CB-OL	2.44	3	5	0.34	2.75	6.5	6.5	14.88	3.5	0.12	1.73	6.9	8.5	5.35

Without Overload

ALL DIMENSIONS IN INCHES

Model	E	2F1	2F2	H	BA	A	B	C	D	G	J	P	L	AB
TJ13-36-56CB-NOL	2.44	3	5	0.34	2.75	6.5	6.5	12.2	3.5	0.12	1.73	6.9	8.07	5.35
T13-18-56CB	2.44	3	5	0.34	2.75	6.5	6.5	12.2	3.5	0.12	1.73	6.9	8.07	5.35
TJ12-36-56CB-NOL	2.44	3	5	0.34	2.75	6.5	6.5	12.2	3.5	0.12	1.73	6.9	8.07	5.35
T12-18-56CB	2.44	3	5	0.34	2.75	6.5	6.5	12.2	3.5	0.12	1.73	6.9	8.07	5.35
TJ34-36-56CB-NOL	2.44	3	5	0.34	2.75	6.5	6.5	12.2	3.5	0.12	1.73	6.9	8.07	5.35
T34-18-56CB	2.44	3	5	0.34	2.75	6.5	6.5	12.2	3.5	0.12	1.73	6.9	8.07	5.35
TJ1-36-56CB-NOL	2.44	3	5	0.34	2.75	6.5	6.5	12.2	3.5	0.12	1.73	6.9	8.07	5.35
T1-18-56CB	2.44	3	5	0.34	2.75	6.5	6.5	12.6	3.5	0.12	1.73	6.9	8.07	5.35
TJ1.5-36-56CB-NOL	2.44	3	5	0.34	2.75	6.5	6.5	13	3.5	0.12	1.73	6.9	8.5	5.35
T1.5-18-56CB	2.44	3	5	0.34	2.75	6.5	6.5	13.8	3.5	0.12	1.73	6.9	8.5	5.35
TJ2-18-56CB-NOL	2.44	3	5	0.34	2.75	6.5	6.5	13	3.5	0.12	1.73	6.9	8.5	5.35
T2-18-56CB	2.44	3	5	0.34	2.75	6.5	6.5	14.6	3.5	0.12	1.73	6.9	8.5	5.35

Dimensions shown in this catalog are for general use only.
For an exact drawing on a specific rating, please contact our sales office.

TEMCo TRANSFORMER DIVISION

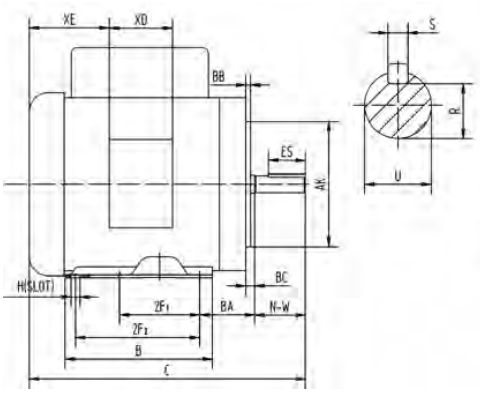
Headquarters: Fremont, CA USA | **International:** (510) 490-2187 | **Inside USA:** 877-474-8209
Fax: (510) 490-1507 | Visit us on the web at **www.temcoindustrialpower.com**

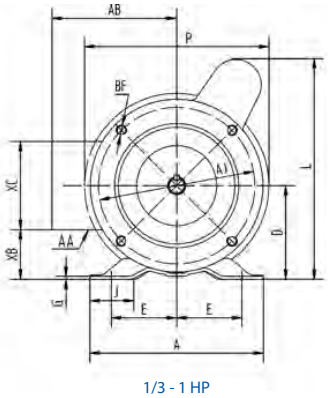
WORLDWIDE FRACTIONAL HP MOTORS

General Purpose Motors

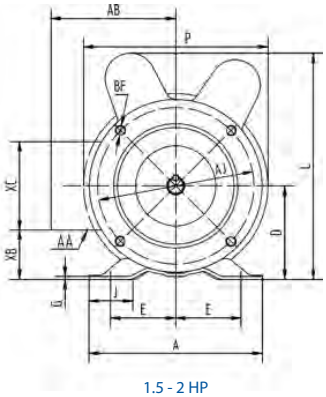
TEFC Enclosure ▪ C-Face ▪ Removable Base

Single-Phase ▪ 115/208-230 Volt





1/3 - 1 HP



1.5 - 2 HP

With Manual Overload

ALL DIMENSIONS IN INCHES

Model	S	ES	R	N-W	U	AA	BC	AK	AJ	BF	BB	XB	XC	XD	XE
T13-18-56CB-OL	0.188	1.41	0.517	1.88	0.625	1/2	0.19	4.5	5.875	3/8-16	0.16	1.65	3.7	3.23	2.85
T12-18-56CB-OL	0.188	1.41	0.517	1.88	0.625	1/2	0.19	4.5	5.875	3/8-16	0.16	1.65	3.7	3.23	2.85
T34-18-56CB-OL	0.188	1.41	0.517	1.88	0.625	1/2	0.19	4.5	5.875	3/8-16	0.16	1.65	3.7	3.23	2.85
T1-18-56CB-OL	0.188	1.41	0.517	1.88	0.625	1/2	0.19	4.5	5.875	3/8-16	0.16	1.65	3.7	3.23	2.85
T1.5-18-56CB-OL	0.188	1.41	0.517	1.88	0.625	1/2	0.19	4.5	5.875	3/8-16	0.16	1.65	3.7	3.23	2.85
T2-18-56CB-OL	0.188	1.41	0.517	1.88	0.625	1/2	0.19	4.5	5.875	3/8-16	0.16	1.65	3.7	3.23	2.85

Without Overload

ALL DIMENSIONS IN INCHES

Model	S	ES	R	N-W	U	AA	BC	AK	AJ	BF	BB	XB	XC	XD	XE
TJ13-36-56CB-NOL	0.188	1.41	0.517	1.88	0.625	1/2	0.19	4.5	5.875	3/8-16	0.16	1.65	3.7	3.23	2.85
T13-18-56CB	0.188	1.41	0.517	1.88	0.625	1/2	0.19	4.5	5.875	3/8-16	0.16	1.65	3.7	3.23	2.85
TJ12-36-56CB-NOL	0.188	1.41	0.517	1.88	0.625	1/2	0.19	4.5	5.875	3/8-16	0.16	1.65	3.7	3.23	2.85
T12-18-56CB	0.188	1.41	0.517	1.88	0.625	1/2	0.19	4.5	5.875	3/8-16	0.16	1.65	3.7	3.23	2.85
TJ34-36-56CB-NOL	0.188	1.41	0.517	1.88	0.625	1/2	0.19	4.5	5.875	3/8-16	0.16	1.65	3.7	3.23	2.85
T34-18-56CB	0.188	1.41	0.517	1.88	0.625	1/2	0.19	4.5	5.875	3/8-16	0.16	1.65	3.7	3.23	2.85
TJ1-36-56CB-NOL	0.188	1.41	0.517	1.88	0.625	1/2	0.19	4.5	5.875	3/8-16	0.16	1.65	3.7	3.23	2.85
T1-18-56CB	0.188	1.41	0.517	1.88	0.625	1/2	0.19	4.5	5.875	3/8-16	0.16	1.65	3.7	3.23	2.85
TJ1.5-36-56CB-NOL	0.188	1.41	0.517	1.88	0.625	1/2	0.19	4.5	5.875	3/8-16	0.16	1.65	3.7	3.23	2.85
T1.5-18-56CB	0.188	1.41	0.517	1.88	0.625	1/2	0.19	4.5	5.875	3/8-16	0.16	1.65	3.7	3.23	2.85
TJ2-18-56CB-NOL	0.188	1.41	0.517	1.88	0.625	1/2	0.19	4.5	5.875	3/8-16	0.16	1.65	3.7	3.23	2.85
T2-18-56CB	0.188	1.41	0.517	1.88	0.625	1/2	0.19	4.5	5.875	3/8-16	0.16	1.65	3.7	3.23	2.85

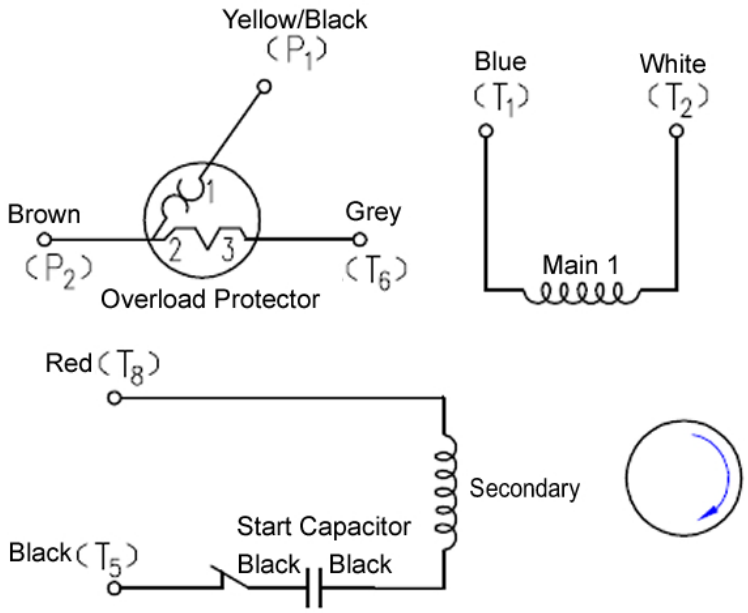
Dimensions shown in this catalog are for general use only.
For an exact drawing on a specific rating, please contact our sales office.

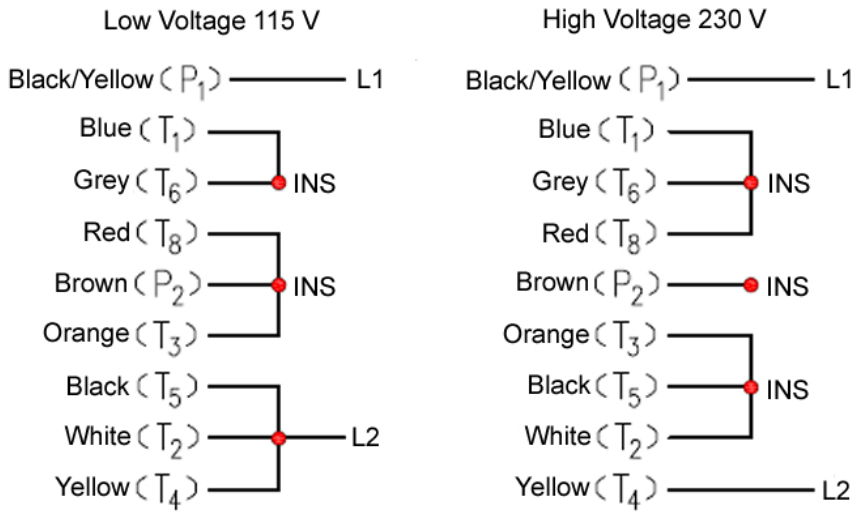
TEMCo
INDUSTRIAL POWER SUPPLY

WORLDWIDE Electric Corp

WorldWide Single Phase Motor Electrical Diagrams

TJ13~TJ1-36-56





TRIAD MAGNETICS

POWER TRANSFORMER
CHASSIS MOUNT :
QUICK-CONNECT WORLD SERIES ™

VPS24-1800

Electrical Specifications (@25C)

1. Maximum Power: 43VA
2. Primary - **Series:** 230VAC@50/60Hz; **Parallel:** 115VAC@50/60Hz
3. Secondary - **Series**[1]**:** 24.0V CT@ 1.8A; **Parallel**[2]**:** 12.0V @ 3.6A
4. Voltage Regulation: 25% TYP @ full load to no load
5. Temperature Rise: 30C TYP (45C MAX allowed)
6. Insulation Resistance: 100MΩ
7. Recommended Fuse[3]:
   - Series: Littelfuse p/n 313 2HXP, 2.0A 250V, slow blow, ¼ x 1 ¼ *or*,
     Cooper Bussmann p/n BKMDL-2, 2A 250V, ¼ x 1 ¼
   - Parallel: Littelfuse p/n 313 4 HXP, 4A 250V, slow blow, ¼ x 1 ¼ *or*,
     Cooper Bussmann p/n BKMDL-4, 4A 250V, ¼ x 1 ¼

Construction:

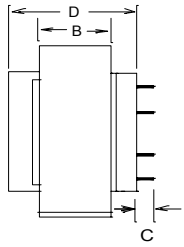
Dual bobbin construction with an insulated shroud, both made of a high temperature material that exceeds UL flammability requirements.

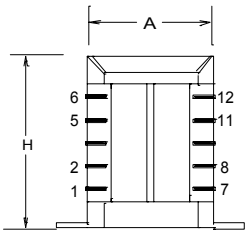
Safety:

These units are designed with 4000VAC isolation between the primary and secondary, and also, between each winding and the core.

Agency File:

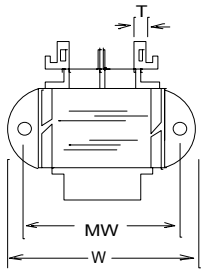
UL: File E53148, UL 5085-1 and 2 (formerly UL 506), General Purpose.
File E65390, UL 5085-1 and 3 (formerly UL1585), Class 2/3
UL 2097, Double Insulated
CSA: File LR 221330. C22.2 NO. 66, General Purpose.
TUV Certificate No.: R72103639, EN60950, Information Technology





A. Dimensions: Unit: In inches

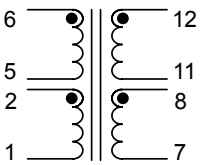
H	W	D	A	B	C	T	MW	ML
2-11/16	3-1/8	2	2-5/16	1-1/8	5/16	3/16	2-13/16	-



B. Mounting Hole Size: 3/16”
C. WT Lbs. : 1.6

Connections[4]:

Input: Series – 6 and 1, Jumper 5 to 2
Parallel – 6 and 1, Jumper 6 to 2 and 5 to 1
Output: Series – 12 and 7, Jumper 11 to 8
Parallel – 12 and 7, Jumper 12 to 8 and 11 to 7



SCHEMATIC

RoHS Compliance: As of manufacturing date February 2005, all standard products meet the requirements of 2011/65/EU, known as the RoHS initiative.

* Upon printing, this document is considered “uncontrolled”. Please contact Triad Magnetics’ website for the most current version.

[1] Non-Inherently limited. Class 2 not wet, Class 3 wet.
[2] Non-Inherently limited. Class 2.
[3] Fuse must be used on **secondary** as conditions of acceptability for UL Class2/3 operation.
[4] Primary and secondary windings are designed to be connected in series or parallel. Winding are not intended to be used independently.

Web: www.TriadMagnetics.com
Phone 951-277-0757
Fax 951-277-2757

460 Harley Knox Blvd.
Perris, California 92571

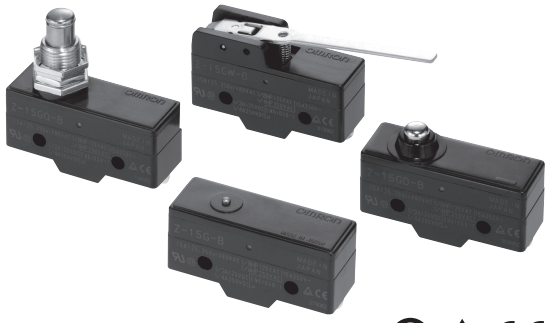
Publish Date: December 4, 2013

OMRON

General-purpose Basic Switch
Z

Best-selling Basic Switch Boasting High Precision and Wide Variety

- A large switching capacity of 15 A with high repeat accuracy.
- A wide range of variations in contact form for your selection: basic, split-contact and maintained-contact.
- A series of standard models for micro loads is available.
- A series of molded terminal-type models incorporating safety terminal protective cover is available.



Model Number Structure

Available types

- Basic models
  - General-purpose
  - Drip-proof
    - Without terminal protective cover
    - With terminal protective cover
    - Molded terminal
- Split-contact models
  - General-purpose
- Maintained-contact models
  - General-purpose

Basic Models

General-purpose

- A variety of actuators is available for a wide range of application.
- The contact mechanism of models for micro loads is a crossbar type with gold-alloy contacts, which ensures highly reliable operations for micro loads.
- Contact Gap:
  - H2: 0.20 mm (extra-high-sensitivity)
  - H: 0.25 mm (high-sensitivity, micro voltage current load)
  - G: 0.5 mm (standard)
  - E: 1.8 mm (high-capacity)
  - F: 1.0 mm (split-contact models)

Drip-proof

- These Switches use a rubber boot on the actuator and adhesive fill between the case and cover to increase resistance to drips.
- Models with drip-proof terminal protective covers and molded terminals with resin filling are also available.

Split-contact Models

- This type is identical in construction to the general-purpose basic switch except that it has two pairs of simultaneous acting contacts by splitting moving contacts.
- Since the moving contacts are connected to a common terminal, either parallel or series connection is possible.
- Highly reliable micro load switching is ensured if the model is used as a twin-contact switch.

Maintained-contact Models

- The maintained-contact type has a reset button at the bottom of the switch case, in addition to the pushbutton (plunger) located on the opposite side of the reset button. Use these buttons alternately.
- Since the Switch has greater pretravel than overtravel, it is suitable for use in reversible control circuits, manual reset circuits, safety limit circuits, and other circuits which are not preferable for automatic resetting. (For further details, refer to individual datasheets.)

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Ordering Information

Basic Models (General-purpose)

Actuator		Classification	Standard	High-sensitivity	Extra-high sensitivity	High-capacity	Micro load
		Contact gap	G (0.5 mm)	H (0.25 mm)	H2 (0.20 mm)	E (1.8 mm)	H (0.25 mm)
		Terminal *1	Model	Model	Model	Model	Model
Pin plunger			Z-15G	Z-15H	Z-15H2	Z-15E	Z-01H
			Z-15G-B	Z-15H-B	Z-15H2-B	Z-15E-B	Z-01H-B
Slim spring plunger			Z-15GS	Z-15HS	---	---	Z-01HS
			Z-15GS-B	Z-15HS-B			Z-01HS-B
Short spring plunger			Z-15GD	Z-15HD	---	Z-15ED	Z-01HD
			Z-15GD-B	Z-15HD-B		Z-15ED-B	Z-01HD-B
Panel mount plunger	Low OP		Z-15GQ3	---	---	---	---
			Z-15GQ3-B				
	Medium OP		Z-15GQ	Z-15HQ		Z-15EQ	Z-01HQ
			Z-15GQ-B	Z-15HQ-B		Z-15EQ-B	Z-01HQ-B
	High OP		Z-15GQ8	---		---	---
			Z-15GQ8-B				
Panel mount roller plunger			Z-15GQ22	Z-15HQ22	---	Z-15EQ22	---
			Z-15GQ22-B	Z-15HQ22-B		Z-15EQ22-B	
Panel mount cross roller plunger			Z-15GQ21	Z-15HQ21	---	Z-15EQ21	---
			Z-15GQ21-B	Z-15HQ21-B		Z-15EQ21-B	
Leaf spring			Z-15GL	---	---	---	---
			Z-15GL-B				
Roller leaf spring			Z-15GL2	---	---	---	---
			Z-15GL2-B				
Short hinge lever			Z-15GW21	---	---	---	---
			Z-15GW21-B				
Hinge lever	Low OP		Z-15GW	Z-15HW	---	---	---
			Z-15GW-B	Z-15HW-B			
	Medium OP		Z-15GW3	---			
			Z-15GW3-B				
	High OP		Z-15GW32				
			Z-15GW32-B				
Low-force hinge lever			Z-15GW4	Z-15HW24	---	---	---
			Z-15GW4-B	Z-15HW24-B			
Low- force wire hinge lever	Low OP		---	Z-15HW78	---	---	---
				Z-15HW78-B			
	High OP			Z-15HW52			
				Z-15HW52-B			
Short hinge roller lever			Z-15GW22	Z-15HW22	---	Z-15EW22	Z-01HW22
			Z-15GW22-B	Z-15HW22-B		Z-15EW22-B	Z-01HW22-B
Short hinge cross roller lever			Z-15GW49	---	---	---	---
			Z-15GW49-B				
Hinge roller lever	Standard		Z-15GW2	Z-15HW2	---	---	---
			Z-15GW2-B	Z-15HW2-B			
	Large roller		Z-15GW25	---		---	---
			Z-15GW25-B				

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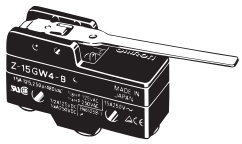
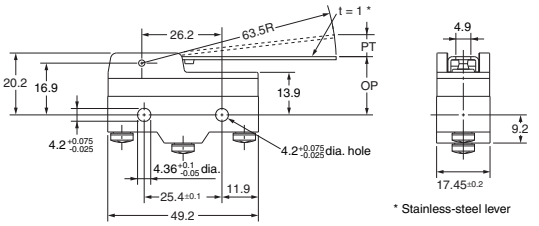
Note: 1. All drawings show the switches with screw terminals. For versions with solder terminals, remove the "-B" from the end of the part number.
2. Unless otherwise specified, all units are in millimeters and a tolerance of ± 0.4 mm applies to all dimensions.

Low-force Hinge Lever

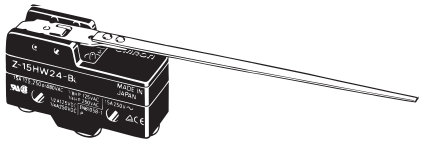
Z-15GW4-B

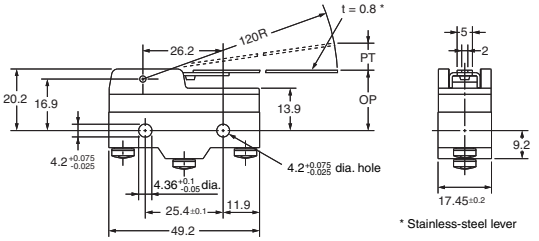




OF max.	28 gf
RF min.	3.5 gf
PT max.	10 mm
OT min.	5.6 mm
MD max.	1.27 mm
OP	19±0.8mm

Z-15HW24-B

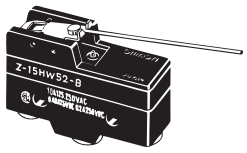




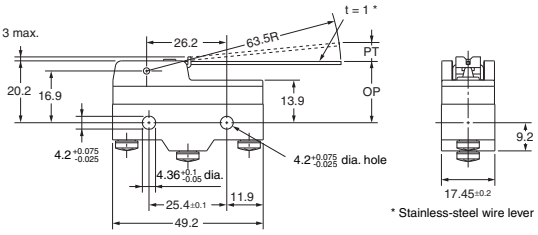
OF max.	6 gf
RF min.	0.5 gf
PT max.	19.8 mm
OT min.	10 mm
MD max.	2 mm
OP	19.8±1.6 mm

Low-force Wire Hinge Lever

Z-15HW52-B
Z-15HW78-B (Lever Length: 110R) *



* The external dimensions of the actuator vary.



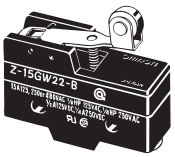
Model	**Z-15HW52-B**
OF max.	6 gf
RF min.	0.5 gf
PT max.	8.3 mm
OT min.	5.6 mm
MD max.	0.65 mm
OP	19±1 mm

Model	**Z-15HW78-B**
OF max.	4 gf
RF min.	0.3 gf
PT max.	10 mm
OT min.	6 mm
MD max.	3 mm
OP	20±1 mm

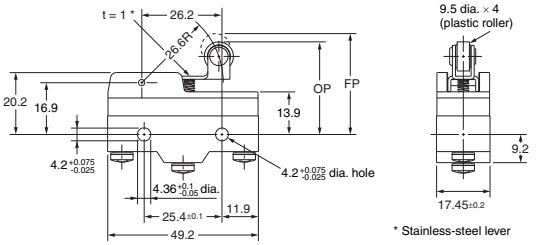
Note: AC electrical ratings: 10 A, 125/250 V.

Short Hinge Roller Lever

Z-15GW22-B **Z-01HW22-B**
Z-15HW22-B **Z-10FW22Y-B**
Z-15EW22-B
Z-15GW2-B * **Z-15HW2-B ***
Z-10FW2Y-B *



* The external dimensions of the actuator vary. (Lever Length: 48.5R)



Model	**Z-15GW22-B**	**Z-15HW22-B**	**Z-15EW22-B**	**Z-01HW22-B**	**Z-10FW22Y-B**	**Z-15GW2-B**	**Z-15HW2-B**	**Z-10FW2Y-B**
OFmax.	160 gf	150 gf	198 gf	160 gf	250 gf	100 gf	86 gf	130 gf
RF min.	42 gf	42 gf	42 gf	28 gf	35 gf	22 gf	22 gf	22 gf
OT min.	2.4 mm	2.4 mm	2.4 mm	2.4 mm	2.4 mm	4 mm	4 mm	4 mm
MD max.	0.5 mm	0.45 mm	1.3 mm	0.5 mm	1 mm	1.02 mm	0.6 mm	2 mm
FP max.	32.5 mm		35.1 mm	32.5 mm	34.8 mm	36.5 mm		37.4 mm
OP	30.2±0.4 mm		30.2±0.4 mm	30.2±0.4 mm	30.2±0.4 mm	30.2±0.8 mm		30.2±0.8 mm

Appendix B

Catalog pages

Power Transformers

VDE File: 18786-3390-0001
UL File: E53148
CSA File: 221330

Class B

Chassis Mount: Quick-Connect World Series™

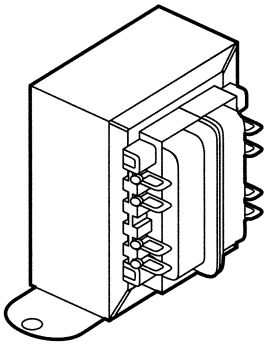


Figure A

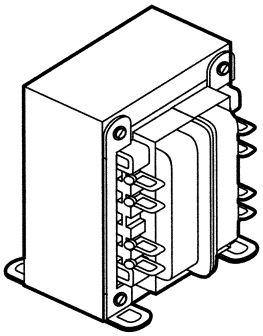


Figure B

:: Description

Triad chassis mount World Series transformers are designed to meet U.S. and International standards including CSA, IEC, VDE and UL requirements. The transformers consist of a dual bobbin design positioned inside an insulating shroud and constructed with UL approved high temperature material. This design eliminates the need for electrostatic shielding since there is minimal capacitance between coils when using a dual bobbin configuration. The primary and secondary are both electrically isolated from each other, and from the core itself. Chassis mount World Series transformers are available in sizes ranging from 25 VA to 175 VA, and are equipped with convenient "quick connect" terminations.

:: Specifications

Primary: 115/230 V, 50/60 Hz

:: World Series

Section	Type No.	VA	Secondary Series	Secondary Parallel	Dimensions H	W	D	A	B	C	T	Figure	Mounting MW	Mounting ML	Wt. Lbs.
	VPS10-2500	25	10.0V CT @ 2.5A	5.0V @ 5.0A	2 7/16	2 13/16	1 15/16	2	1 1/8	7/16	7/16	A	2 3/8	•	1.25
	VPS10-4300	43	10.0V CT @ 4.3A	5.0V @ 8.6A	2 11/16	3 1/8	2	2 5/16	1 1/8	7/16	7/16	A	2 13/16	•	1.60
A	VPS10-8000	80	10.0V CT @ 8.0A	5.0V @ 16.0A	3	2 1/2	2 5/16	•	1 3/8	7/16	7/16	B	2	2 1/4	2.80
	VPS10-13000	130	10.0V CT @ 13.0A	5.0V @ 26.0A	3 3/8	2 13/16	2 11/16	•	1 5/8	3/8	1/4	B	2 1/4	2 1/2	4.10
	VPS10-17500	175	10.0V CT @ 17.5A	5.0V @ 35.0A	3 3/4	3 1/8	2 13/16	•	1 5/8	3/8	1/4	B	2 1/2	2 1/2	5.50
	VPS12-2000	25	12.6V CT @ 2.0A	6.3V @ 4.0A	2 7/16	2 13/16	1 15/16	2	1 1/8	7/16	7/16	A	2 3/8	•	1.25
	VPS12-3400	43	12.6V CT @ 3.4A	6.3V @ 6.8A	2 11/16	3 1/8	2	2 5/16	1 1/8	7/16	7/16	A	2 13/16	•	1.60
B	VPS12-6300	80	12.6V CT @ 6.3A	6.3V @ 12.6A	3	2 1/2	2 5/16	•	1 3/8	7/16	7/16	B	2	2 1/4	2.80
	VPS12-10300	130	12.6V CT @ 10.3A	6.3V @ 20.6A	3 3/8	2 13/16	2 11/16	•	1 5/8	3/8	1/4	B	2 1/4	2 1/2	4.10
	VPS12-14000	175	12.6V CT @ 14.0A	6.3V @ 28.0A	3 3/4	3 1/8	2 13/16	•	1 5/8	3/8	1/4	B	2 1/2	2 1/2	5.50
	VPS16-1600	25	16.0V CT @ 1.6A	8.0V @ 3.2A	2 7/16	2 13/16	1 15/16	2	1 1/8	7/16	7/16	A	2 3/8	•	1.25
	VPS16-2700	43	16.0V CT @ 2.7A	8.0V @ 5.4A	2 11/16	3 1/8	2	2 5/16	1 1/8	7/16	7/16	A	2 13/16	•	1.60
C	VPS16-5000	80	16.0V CT @ 5.0A	8.0V @ 10.0A	3	2 1/2	2 5/16	•	1 3/8	7/16	7/16	B	2	2 1/4	2.80
	VPS16-8100	130	16.0V CT @ 8.1A	8.0V @ 16.2A	3 3/8	2 13/16	2 11/16	•	1 5/8	3/8	1/4	B	2 1/4	2 1/2	4.10
	VPS16-11000	175	16.0V CT @ 11.0A	8.0V @ 22.0A	3 3/4	3 1/8	2 13/16	•	1 5/8	3/8	1/4	B	2 1/2	2 1/2	5.50
	VPS20-1250	25	20.0V CT @ 1.25A	10.0V @ 2.5A	2 7/16	2 13/16	1 15/16	2	1 1/8	7/16	7/16	A	2 3/8	•	1.25
	VPS20-2200	43	20.0V CT @ 2.2A	10.0V @ 4.4A	2 11/16	3 1/8	2	2 5/16	1 1/8	7/16	7/16	A	2 13/16	•	1.60
D	VPS20-4000	80	20.0V CT @ 4.0A	10.0V @ 8.0A	3	2 1/2	2 5/16	•	1 3/8	7/16	7/16	B	2	2 1/4	2.80
	VPS20-6500	130	20.0V CT @ 6.5A	10.0V @ 13.0A	3 3/8	2 13/16	2 11/16	•	1 5/8	3/8	1/4	B	2 1/4	2 1/2	4.10
	VPS20-8800	175	20.0V CT @ 8.8A	10.0V @ 17.6A	3 3/4	3 1/8	2 13/16	•	1 5/8	3/8	1/4	B	2 1/2	2 1/2	5.50
	VPS24-1000	25	24.0V CT @ 1.0A	12.0V @ 2.0A	2 7/16	2 13/16	1 15/16	2	1 1/8	7/16	7/16	A	2 3/8	•	1.25
	VPS24-1800	43	24.0V CT @ 1.8A	12.0V @ 3.6A	2 11/16	3 1/8	2	2 5/16	1 1/8	7/16	7/16	A	2 13/16	•	1.60
E	VPS24-3300	80	24.0V CT @ 3.3A	12.0V @ 6.6A	3	2 1/2	2 5/16	•	1 3/8	7/16	7/16	B	2	2 1/4	2.80
	VPS24-5400	130	24.0V CT @ 5.4A	12.0V @ 10.8A	3 3/8	2 13/16	2 11/16	•	1 5/8	3/8	1/4	B	2 1/4	2 1/2	4.10
	VPS24-7300	175	24.0V CT @ 7.3A	12.0V @ 14.6A	3 3/4	3 1/8	2 13/16	•	1 5/8	3/8	1/4	B	2 1/2	2 1/2	5.50
	VPS28-900	25	28.0V CT @ 0.9A	14.0V @ 1.8A	2 7/16	2 13/16	1 15/16	2	1 1/8	7/16	7/16	A	2 3/8	•	1.25
	VPS28-1500	43	28.0V CT @ 1.5A	14.0V @ 3.0A	2 11/16	3 1/8	2	2 5/16	1 1/8	7/16	7/16	A	2 13/16	•	1.60
F	VPS28-2800	80	28.0V CT @ 2.8A	14.0V @ 5.6A	3	2 1/2	2 5/16	•	1 3/8	7/16	7/16	B	2	2 1/4	2.80
	VPS28-4600	130	28.0V CT @ 4.6A	14.0V @ 9.2A	3 3/8	2 13/16	2 11/16	•	1 5/8	3/8	1/4	B	2 1/4	2 1/2	4.10
	VPS28-6250	175	28.0V CT @ 6.25A	14.0V @ 12.5A	3 3/4	3 1/8	2 13/16	•	1 5/8	3/8	1/4	B	2 1/2	2 1/2	5.50
	VPS36-700	25	36.0V CT @ 0.7A	18.0V @ 1.4A	2 7/16	2 13/16	1 15/16	2	1 1/8	7/16	7/16	A	2 3/8	•	1.25
	VPS36-1200	43	36.0V CT @ 1.2A	18.0V @ 2.4A	2 11/16	3 1/8	2	2 5/16	1 1/8	7/16	7/16	A	2 13/16	•	1.60
G	VPS36-2200	80	36.0V CT @ 2.2A	18.0V @ 4.4A	3	2 1/2	2 5/16	•	1 3/8	7/16	7/16	B	2	2 1/4	2.80
	VPS36-3600	130	36.0V CT @ 3.6A	18.0V @ 7.2A	3 3/8	2 13/16	2 11/16	•	1 5/8	3/8	1/4	B	2 1/4	2 1/2	4.10
	VPS36-4800	175	36.0V CT @ 4.8A	18.0V @ 9.6A	3 3/4	3 1/8	2 13/16	•	1 5/8	3/8	1/4	B	2 1/2	2 1/2	5.50
H	VPS56-2300	80	36.0V CT @ 2.3A	28.0V @ 4.6A	3 3/8	2 7/8	3 1/16	2 7/8	1 1/2	3/8	1/4	B	2 1/4	2 1/2	4.2
	VPS230-110	25	230.0V CT @ 0.11A	115.0V @ 0.22A	2 7/16	2 13/16	1 15/16	2	1 1/8	7/16	7/16	A	2 3/8	•	1.25
	VPS230-190	43	230.0V CT @ 0.19A	115.0V @ 0.38A	2 11/16	3 1/8	2	2 5/16	1 1/8	7/16	7/16	A	2 13/16	•	1.60
I	VPS230-350	80	230.0V CT @ 0.35A	115.0V @ 0.7A	3	2 1/2	2 5/16	•	1 3/8	7/16	7/16	B	2	2 1/4	2.80
	VPS230-570	130	230.0V CT @ 0.57A	115.0V @ 1.14A	3 3/8	2 13/16	2 11/16	•	1 5/8	3/8	1/4	B	2 1/4	2 1/2	4.10
	VPS230-760	175	230.0V CT @ 0.76A	115.0V @ 1.52A	3 3/4	3 1/8	2 13/16	•	1 5/8	3/8	1/4	B	2 1/2	2 1/2	5.50

CT = Center Tap Mounting Hole Sizes: 25 VA, 43 VA = 3/16" 80 VA, 130 VA, 175 VA = 13/64 x 3/8"

:: Outline Dimensions

Technical Notes

1. Hi-pot tested at 4,000 VRMS.

2. Both primary and secondary coils may be connected as either series or parallel, but both must be used simultaneously.

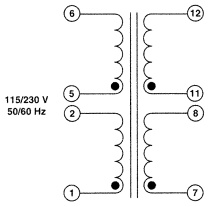


Figure A

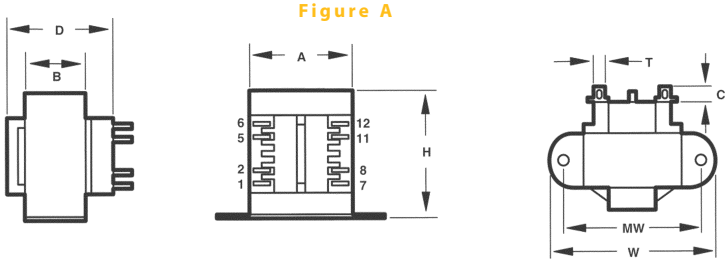
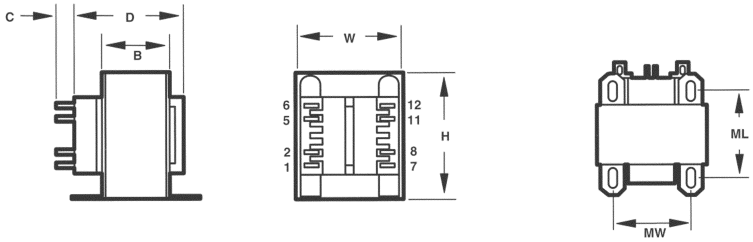


Figure B



Triad Magnetics is a global leader and trusted name in magnetics for more than 50 years.

COARSE TOOTH ROUGHING SINGLE END MILLS

MSC

Coarse Tooth Cobalt TiN, TiCN & TiAlN Coated Roughing End Mills

INTERSTATE HERTEL Niagara Cutter

Mill Dia. (In.)	Shk. Dia. (In.)	LOC (In.)	OAL (In.)	No. of Flutes	TiN Coated: Interstate Order #	TiN Coated: Interstate Price Ea.	TiN Coated: Hertel Order #	TiN Coated: Hertel Price Ea.	TiN Coated: Niagara Cutter List REM710 Order #	TiN Coated: Niagara Cutter List REM710 Price Ea.	TiCN Coated: Hertel Order #	TiCN Coated: Hertel Price Ea.	TiCN Coated: Niagara Cutter List REM710 Order #	TiCN Coated: Niagara Cutter List REM710 Price Ea.	TiAlN Coated: Hertel Order #	TiAlN Coated: Hertel Price Ea.
3/16	3/8	1/2	2 3/8	4	80262124	$29.54	[1]84511625	$35.59	45523289	$48.43	[1]84213842	$37.29	45517133	$50.78	62852678	$40.65
1/4	3/8	5/16	2 1/8	3	80260177	25.00	44839173	43.38			44839025	47.72			62852660	43.43
1/4	3/8	5/8	2 7/16	3	80260169	30.38										
1/4	3/8	5/8	2 7/16	4			06821979	35.96	45523305	48.43	87144606	37.67	45523347	50.78	62852637	54.38
1/4	3/8	7/8	2 11/16	3	80260185	29.37	44839165	48.51			44839017	53.36			62852603	51.35
1/4	3/8	1 1/8	2 13/16	3	80260193	29.37	44839157	33.83			44839009	37.23			62852629	51.35
1/4	3/8	1 1/4	3 1/16	4					*45523339	57.76			45517141	60.43	62852611	51.35
1/4	3/8	1 1/4	3 1/8	3			84512144	34.83			84213727	44.44				
1/4	3/8	1 3/8	3 1/8	3	80262157	56.96										
9/32	3/8	3/4	2 1/2	3	80262298	41.95										
5/16	3/8	7/16	2 3/16	3	80260219	39.38										
5/16	3/8	3/4	2 1/2	3	80260201	33.36										
5/16	3/8	3/4	2 1/2	4			06821987	35.96	45523370	48.43	87144622	37.67	45523412	50.78	62852579	34.84
5/16	3/8	1 1/8	2 13/16	3	80260235	51.28										
5/16	3/8	1 3/8	3 1/8	4									45517158	60.50		
5/16	3/8	1 3/8	3 3/16	4	80262306	40.10										
11/32	3/8	3/4	2 1/2	3	80262314	41.13										
3/8	3/8	7/16	2 3/16	4	80262413	39.38										
3/8	3/8	3/4	2 1/2	4	80260243	29.84	06821995	35.96	45523420	48.43	87144630	37.67	45523461	50.78	62852538	43.43
3/8	3/8	1 1/8	2 13/16	4	80260268	29.37	44839140	55.46			44838993	61.00			62852553	48.45
3/8	3/8	1 1/2	3 1/4	4			62913314	45.62	45523453	57.76	84213735	44.44	45517166	60.50	62852520	51.35
3/8	3/8	1 5/8	3 3/16	4	80262421	34.80	84511641	41.93								
13/32	3/8	1	2 11/16	4	80262447	58.61										
7/16	3/8	1	2 11/16	4	80260284	48.91	62913298	47.13	45523495	71.73	84213859	55.18	45517174	75.11	62852488	51.06
7/16	1/2	1 1/4	3 1/4	4			84511567	46.62								
15/32	1/2	1 1/4	3 1/4	4	80262504	59.17										
1/2	1/2	1/2	2 1/2	3	45403748	38.64	[4]06822225	46.54								
1/2	1/2	5/8	2 3/8	4	80260318	33.43	44839132	61.84			44838985	68.02			62852447	54.84
1/2	1/2	1	3	4	80260300	33.43	44839124	42.64			44838951	42.64	45541075	64.04	62852413	56.53
1/2	1/2	1 1/4	3 1/4	4	80260326	39.08	06822001	47.09	45523511	63.46	02499424	49.43	45523560	66.64	62852421	58.63
1/2	1/2	1 1/8	3 3/8	4	80260359	43.98	44839116	51.65			44838969	51.65	45541083	77.35	62852397	77.05
1/2	1/2	2	4	4	80260334	52.10	06822092	62.77	45523552	84.61	87144648	65.75	45517182	88.65	62852405	78.02
1/2	1/2	2 1/2	4 1/2	4	80260367	64.64							45541091	97.87		
1/2	1/2	3	5	4	50260348	76.45							45541109	110.56		
9/16	1/2	1 3/8	3 3/8	4	80262579	47.07	91192716	56.71			84511559	59.54	45517190	81.02	62852371	64.75
5/8	5/8	5/8	2 3/4	3	45403755	52.99	06822233	63.86			62914445	52.61			62852363	56.96
5/8	5/8	3/4	2 1/8	4	80260375	50.75							45541117	70.58		
5/8	5/8	1 1/4	3 3/8	4	80260383	53.02							45541125	73.31		
5/8	5/8	1 5/8	3 3/4	4	80260409	47.41	06822019	57.13	45523602	77.00	87144655	59.96	45523685	80.79	62852348	72.08
5/8	5/8	2 1/8	4 1/4	4	80260391	64.12										
5/8	5/8	2 1/2	4 3/8	4	80260417	61.22	06822100	73.76	*45523651	99.41	87144663	77.40	45517208	104.18	62852314	93.85
5/8	5/8	3 1/8	5 1/4	4	80260425	81.79							45541141	128.29		
11/16	5/8	1 5/8	3 3/4	4	80262595	82.10										
3/4	5/8	1 5/8	3 3/4	4	80260482	69.24							45517232	102.81		
3/4	3/4	3/4	3	4	80260458	56.01	06822241	67.48	45524808	92.03			45517224	96.26		
3/4	3/4	1 1/4	3 1/2	4	80260466	49.11	44839108	60.22			44838944	60.22	45541166	90.46	62852272	85.94
3/4	3/4	1 5/8	3 7/8	4	80260490	54.44	[2]06822027	65.61	45523719	88.44	[2]87144671	68.76	45523768	92.65		
3/4	3/4	2 1/2	4 3/4	4	80260474	63.52	44839090	74.05			44838936	74.05			62852801	113.15
3/4	3/4	3	5 1/4	4	80260508	71.25	06822126	85.86	45524782	115.70	87144689	89.94	45517216	121.22	62852819	113.19
3/4	3/4	4	6 1/4	4			84213669	111.83			84511526	141.26			62852843	135.85
3/4	3/4	4 1/8	6 3/8	4	80260516	101.71							45541208	161.05		
13/16	3/4	1 7/8	4 1/8	4	80262603	132.96										
7/8	3/4	1 1/8	3 3/8	5	80260524	82.80							*45541224	107.58		
7/8	3/4	1 7/8	4 1/8	5	80260565	78.15	06822035	94.15			87144713	98.59	45517240	132.85	62852215	111.72
7/8	3/4	3 1/2	5 3/4	5									45517257	161.68		
7/8	7/8	1 1/8	3 3/8	5	80262611	89.07							*45541240	127.02		
7/8	7/8	1 7/8	4 1/8	5	80260532	74.27	84213677	89.50			84213768	93.87	45517265	127.77	62852207	111.72
7/8	7/8	3 1/2	5 3/4	5	80260540	90.16	91192724	108.60			75987495	113.91	45517273	154.92	62852199	145.87
1	3/4	3/4	3	5									45517323	110.66		
1	3/4	1 1/8	3 3/8	6	80260581	84.59										
1	3/4	1 1/2	3 3/4	5	80260599	95.51			45525011	130.30			45517315	136.67		
1	3/4	1 7/8	4 1/8	5			06822043	97.16			62914353	110.24			62852181	117.91
1	3/4	2	4 1/4	5	80260623	84.88	91192732	102.26			62914346	113.94			62852165	123.04
1	3/4	3	5 1/4	5	80260607	125.52										
1	3/4	4	6 1/4	5	80260615	131.26										
1	1	1 1/8	3 3/8	5	80260656	126.52										
1	1	1 5/8	4 1/8	5	80260664	100.87										
1	1	2	4 1/2	5	80260649	81.93	06822050	98.72	45523966	133.05	87144721	103.45	45524055	139.41	84511401	103.45
1	1	3	5 1/2	5	80260672	103.83	84213701	125.09	45523982	170.29	84511542	131.17	45517281	178.56	62852140	166.26
1	1	4	6 1/2	5	80260680	111.13	06822134	133.89	45525003	180.44	87144739	140.16	45517299	188.91	84511419	140.16
1	1	6	8 1/2	5	80260730	150.14	91192740	180.89	45525029	246.24	75987511	189.58	45517307	258.08	62852124	242.64
1 1/8	1	2	4 1/2	6	80260706	115.88	06822068	139.60					45517331	199.50		
1 1/8	1	3 1/2	6	6	80260839	123.43	91193086	148.72								
1 1/4	3/4	3/4	3	6					*45524287	170.70			45517398	178.97		
1 1/4	3/4	1 1/8	3 3/8	6	80260896	130.31										
1 1/4	3/4	2	4 1/4	6	80260722	116.10	[3]91192757	139.87								
1 1/4	1 1/4	2	4 1/2	6	80260748	108.79	06822076	131.06	*45524394	236.30	87144754	137.32	45517349	185.11	84511427	137.32
1 1/4	1 1/4	3	5 1/2	6	80260763	143.15	06822118	172.48	*45524295	232.49	87144762	180.80				
1 1/4	1 1/4	4	6 1/2	6	80260771	159.31	75987537	191.93	45525169	261.27	87144770	203.11			84511435	203.11
1 1/4	1 1/4	6	8 1/2	6	80260912	227.52	91192773	274.13	45525185	373.18	87144788	290.05				
1 1/2	3/4	3/4	3	6					*45524402	178.75			*45517471	187.44		

[1] 3 Flute [2]OAL: 3¾" [3]OAL: 4½" [4] 4 Flute *Limited Supply

- Best for heavy cuts, deep slotting and pocketing applications
- Excellent in all steels and ferrous materials
- 2" Shanks have combination drive
- Can be run at heavier feed rates with less chatter and vibration

Surface Treatments:

TiN (Titanium Nitride)
- For general purpose use
- Extends tool life
- Reduces chipping
- Provides an ability to increase machining speeds by 10-20% vs. uncoated tools

TiCN (Titarium Carbonitride)
- For stainless steel, medium hard ferrous and nonferrous materials
- Extends tool life
- Has excellent lubricity and prevents "edge buildup"
- Provides excellent heat and wear resistance
- Provides an ability to increase machining speeds by 30-50% vs. uncoated tools

TiAN (Titarium Aluminum Nitride)
- For harder materials, high temperature and titanium alloys
- Excellent in cast and nodular irons
- For use at higher machining speeds
- At proper speeds, can be run in dry conditions
- Provides outstanding heat and wear resistance
- Provides an ability to increase machining speeds by 30-50% vs. TiCN coated tools

Continued on next page