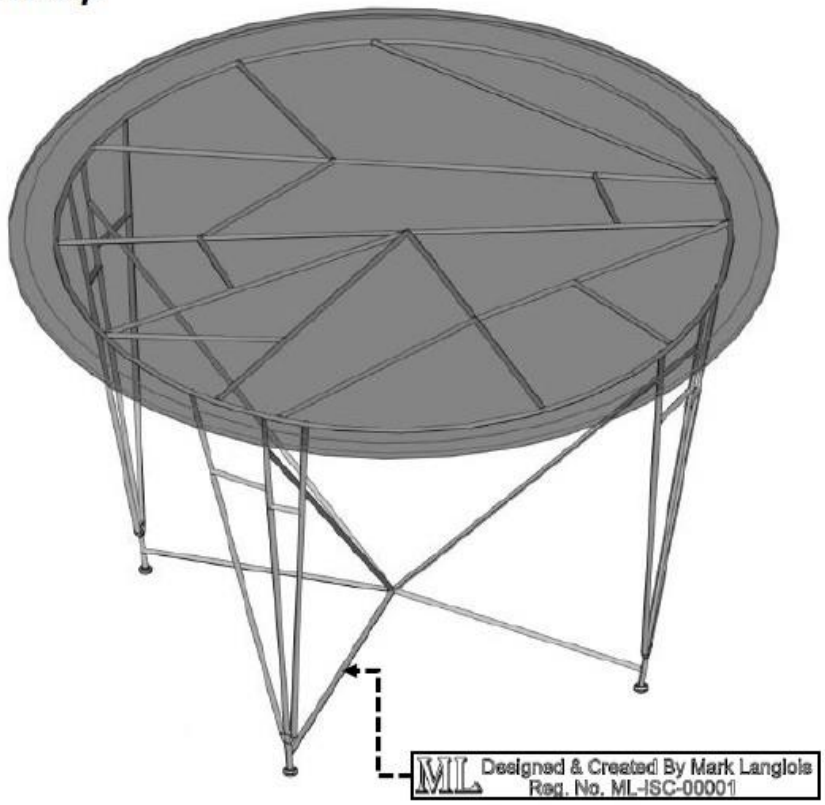

Ideation to Creation By Mark Langlois--May--2021
Fixture Build &
Fabrication Part II

Certification of Authentication and Registration Of Ownership

Free Form Geometric Patio Table in 3/8 Steel Bar
Original Design By Mark Langlois, Created By Mark Langlois

Purchased By *N/A*
Date Purchased *N/A*
Color *N/A*
Design Iteration Number 121775-1A
Registration Number ML-ISC-0 0 0 0 1



Registration Tag Location

Certificate of Registration

This Certificate issued under the seal of the Copyright Office in accordance with title 17, *United States Code*, attests that registration has been made for the work identified below. The information on this certificate has been made a part of the Copyright Office records.

Acting United States Register of Copyrights and Director

Registration Number
VAu 1-383-371
Effective Date of Registration:
August 12, 2019
Registration Decision Date:
February 12, 2020

About the man behind the design and creation of your table and author of this book, detailing its development and construction.

Name: Mark Bradford Langlois
Status: Married with Children, Grandchildren
Education: B.S. Liberal Arts, Central Michigan University
Career: Design, Engineering, Product Life Cycle Management, IT Consultant, Software Development
Music: J.J. Cale, Jackson Brown, Mark Knopfler, Snowy White, Jazz, Classical
Favorite Book: Catcher in the Rye, by J.D. Salinger
Drink: Oban Single Malt Scotch, Jack Daniels or whatever you have
Cigar: Rocky Patel Vintage 1990, 1992, Undercrown Maduro Robosto
Hobbies: Travel, Photography, Music, Art, Creative Design and Engineering

Acknowledgments:
A very special note of thanks to my wife Marianne, who has supported me in every way throughout this entire project.

To John and Edward Darnbrook, Oneida Tool Company. Thank you both for your avid interest, advice and continued support in the development of my project.

Book Completed: May 5th, 2021

Ideation to Creation, History and Background

I was a young college student attending Central Michigan University from 1975 to 1980. I was pursuing a Bachelor of Science Degree in Sociology with a Minor in Industrial Technology. While my degree was in Sociology, I also took many classes in Computer Science, Art and Industrial Technology.

My industrial technology classes were focused on manufacturing and hands on practical applications in casting, welding, machining, computer assisted design and manufacturing (CAD/CAM), manufacturing communications and in the new industrial applications associated with the emergence of simple pick and place robots.

During the semester associated with the hands on application of my industrial technology course work, my instructor had a set of defined projects we were to complete. In addition, we were required to complete one project of our own design and present it to the rest of the class.

My selected project was to create two tables made from 3/8 inch steel rod. I had no particular design in mind other than they were going to be 30 inches high, have a round top and made of welded construction.

The industrial technology lab, had only limited equipment; the steel I needed, a MIG Welder, and space that I had to share with other students. I had to bend the 40 inch diameter table top around a plywood form that I made by hand; clamp it and weld it. The result was a top that was not completely round and I had to work the metal hoop in as close to a circular shape as I could get. I spent the rest of the semester in the industrial technology lab every free minute I could get; creating and welding the free form design for the top and designing and welding the legs and cross members. I had two tables completed by the end of the semester and was very pleased with the results.

My instructors were also quite amazed with what I had been able to accomplish in a single semester along with all of my other assigned projects.

I gave the tables to my parents as a graduation present in 1980. They used them in their home for many years. My parents eventually moved into an apartment and I regained ownership of the tables I had made.

I have had these tables and used them for more than 30 years; both inside my home as a dining table, office desk, living room table and outside as patio tables. I enjoy them very much both from an aesthetic standpoint and in the way they are constructed; functional, solid and strong.

In late 2019, I was sitting at one of the tables I had made on the patio and it came to me that I had created these tables using my own creative energy using an ad hoc design approach; the tables had no established origin or documentation. The tables existed, but there was nothing to establish how or when they were made or that I was the individual that created them (other than historical fact). They really didn't exist in any other form other than some hard work and creative energy that came to pass in a small college lab in 1980, which now date these original creations to roughly 40 years ago.

I have spent the better part of 37 years working in the field of computer aided manufacturing, computer aided design, computer simulation, managing assembly structures and software development. In consideration of the existence of these tables without any actual design content, I decided to chart a path to formally define the design and creation of these tables and to capture the major steps in the process to produce them.

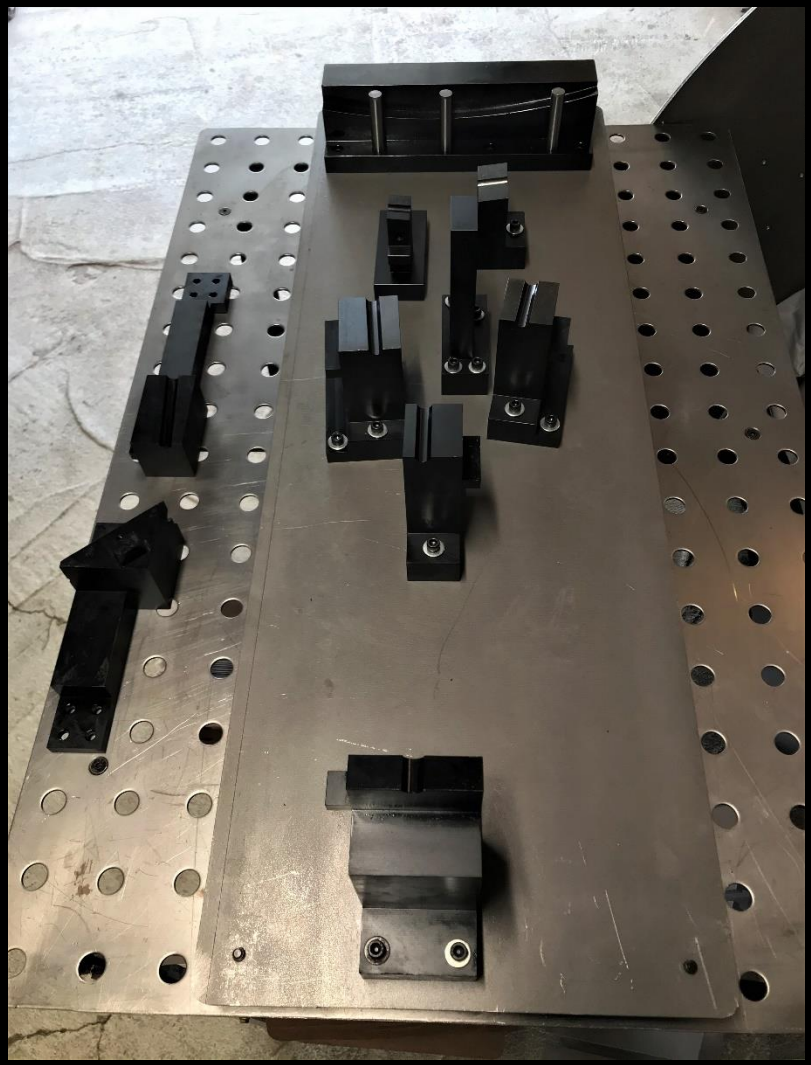
My vision was to provide some historical documentation in the transformation of what it takes to go from an idea or metaphysical muse, to the physical existence of that dream—"Ideation to Creation".

This is a shot of one of the original tables designed and made by me some 40 years prior. The table is a contemporary geometric design that creates an intentional 3D perspective looking down through the top. This table was the conceptual basis for the development of the new documented design that has been created. The elemental constructs of this design has been incorporated into the new table design.

Receiving And Inspecting Vendor Made Details: After the fixture details were CNC machined and delivered, I needed to inspect each one to make sure they were made according to the 3D design and drawings. The tooling details shown above were made for the table top and leg fixtures.



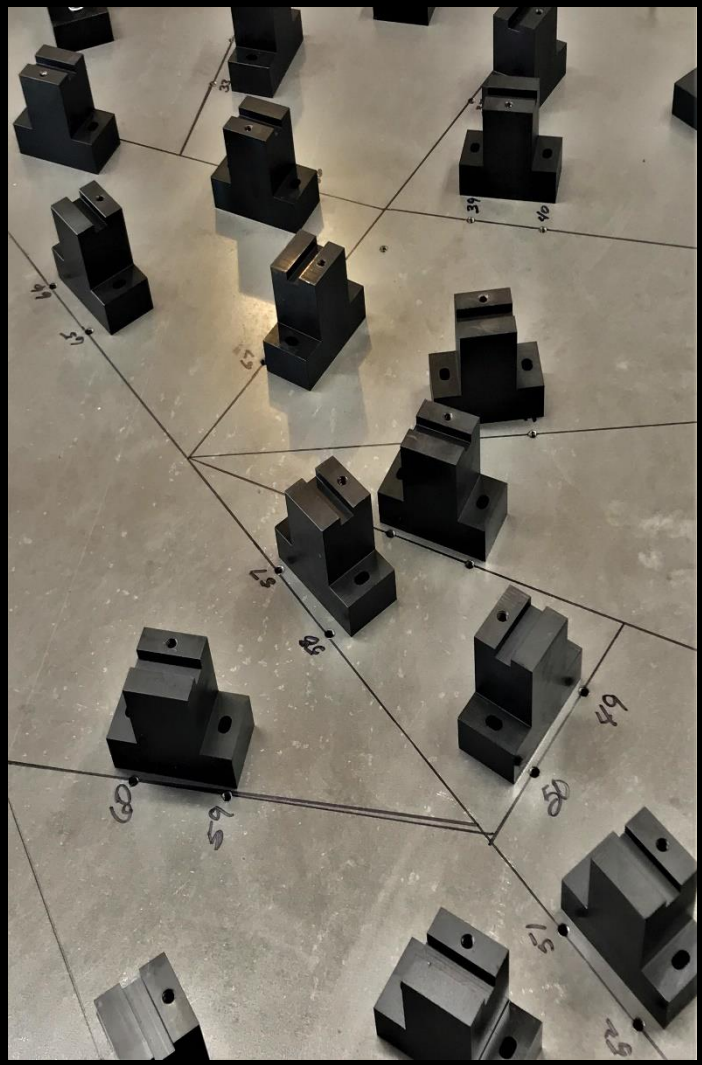
Vendor Made Base Plates And Ring Gauge: My base plate for the legs is on the left, the ring gauge in the center and the base plate for the table top on the right were all cut to size and holes made by a CNC laser cutting machine. The holes in the plate were then tapped for a 1/4-28 cap screw. The plates and the ring gauge are all 1/4 inch steel plate. The leg and top base plates will locate and position all of the fixtures details.



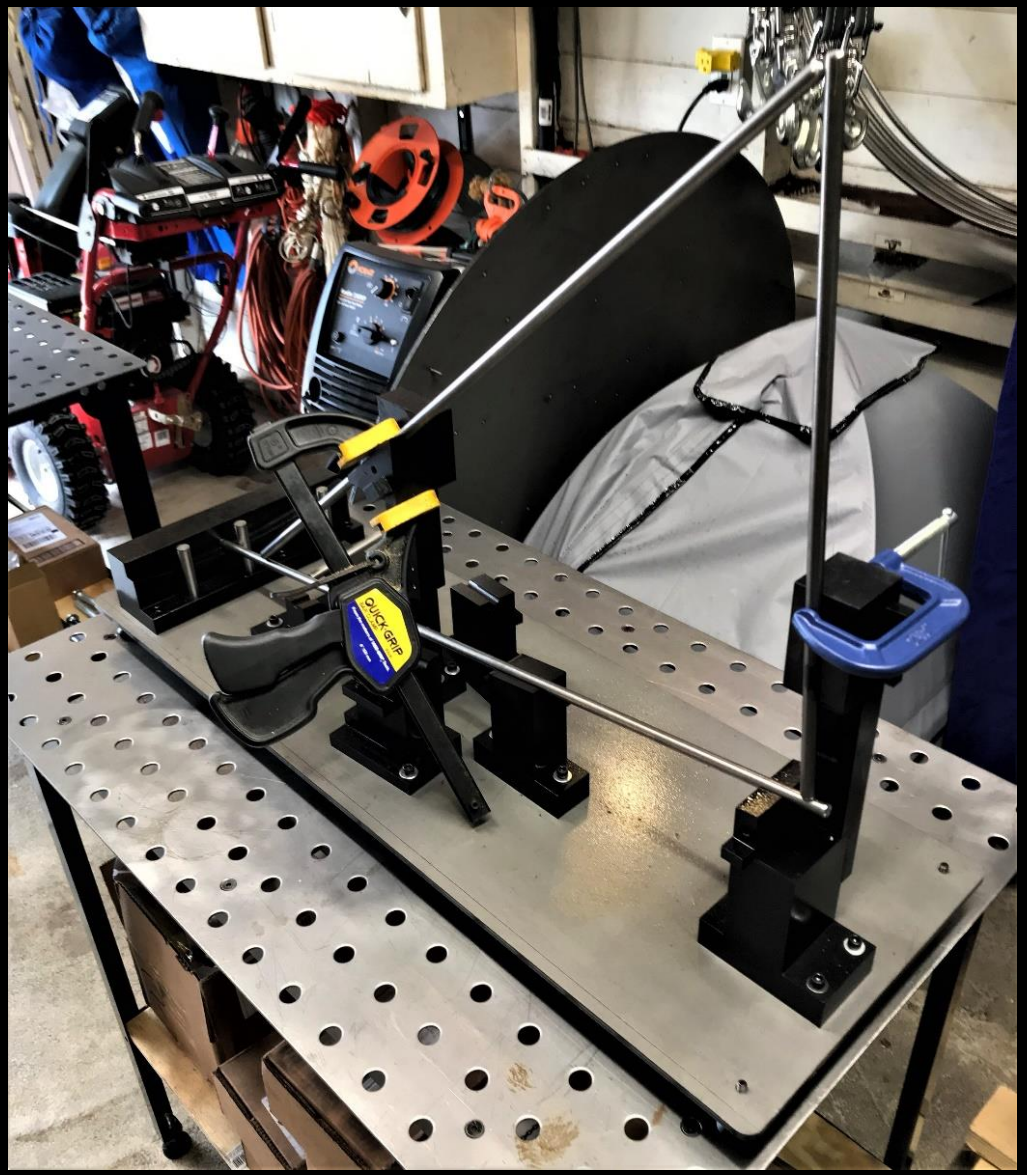
Assembling Leg Weld Fixture Blocks: After I inspected each of the weld fixture details, I cleaned each one and then took them to a vendor to have them coated in black oxide to help prevent rust. I installed leveling feet in the designated leg base plate mounting holes first and got the base plate level. Then, I assembled the fixture details for welding the legs on base plate. The location and position of the leg fixture details must still be qualified to position each of the steel rod segment as designed. I anticipate that minor adjustments will be required to locate each block precisely, relative to the fixed center leg positioning block.

Installing The Table Top Base Plate: Like the leg base plate, I installed the leveling feet in the mounting holes for the table top base plate first. Next, I used another base plate, 3/8 inches thick; the same diameter as the table top base plate but without holes, and located that on the top of two welding tables and got the plate level. Last, I need to position the table top base plate. The table top base plate weighs around 400 pounds. I needed to use a chain hoist to lift the plate up and onto the steel support plate, align the diameters and then get it level.

Assembling The Table Top Weld Fixtures-Weld Shoes: I assembled the 10 table top ring weld shoes on the table top base plate first. The radial locations are precise and are incorporated into the hole locations on the base plate. There is an adjustment allowance on the diameter for each weld shoe, perpendicular to the table top diameter; only in and out.



Assembling The Table Top Weld Fixtures-Interior Positioning Blocks: To start, I laid out the base plate using a sharpie to align the positioning block hole centers. The lines provide an approximate alignment for each steel rod segment that will be located and managed by the 24 interior positioning blocks. My design allows the positioning blocks to move perpendicular to their respective linear line, defining that segment only. Pictured on the left, is the approximate alignment drawn on the plate and the assigned hole number from the base plate chart. The shot on the right, shows the positioning blocks assembled on the base plate, along these initial layout lines.

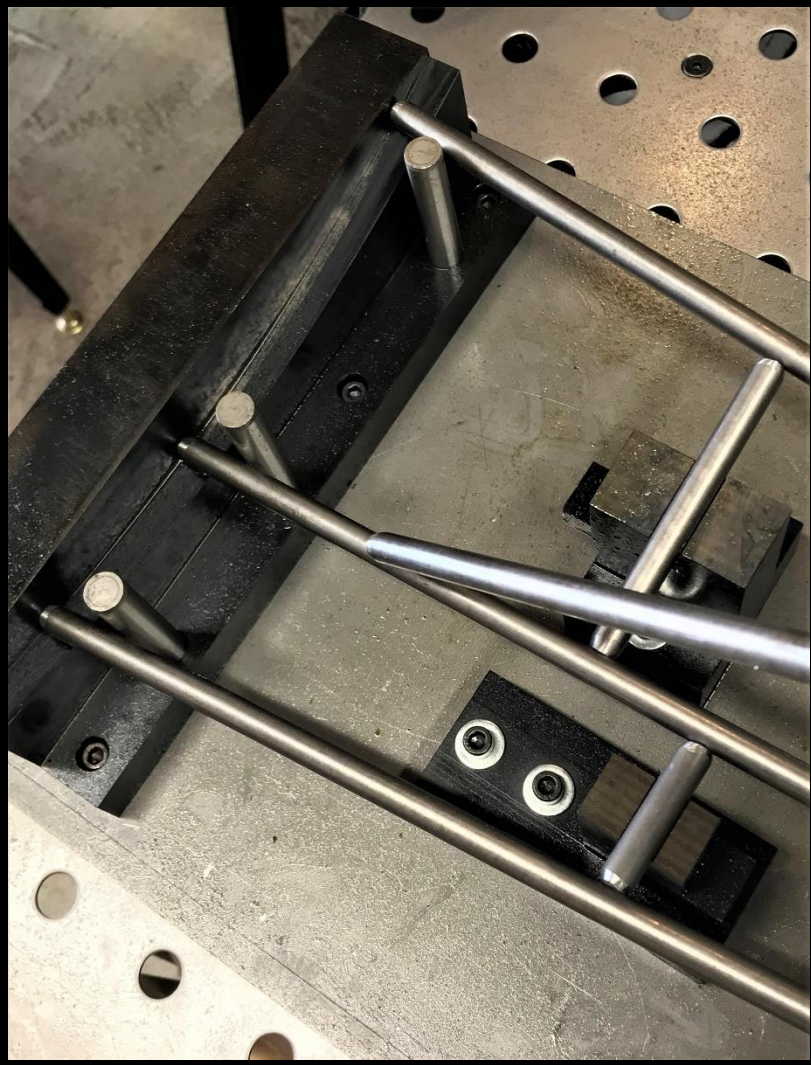


Qualifying The Leg Weld Fixture: Qualifying the leg weld fixture first involves aligning the leg center segment, top center brace and lower center brace to be in the same plane.

These pieces are the core components that all of the other rod segments will be positioned to.

The leg center components must also lie in the same plane when welded to the table top, 180 degrees apart.

It is important that I am able to consistently replicate these positions in the leg fixture.



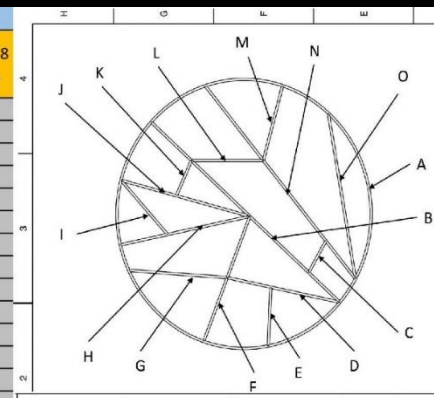
Next, the top diameter end stop block positions the center, right and left rod segments on the center diameter of the table top ring. The pins locate the rod segments in the correct angular position on the top diameter. The center, right and left positioning blocks provide the correct angle and height so the leg rod segments are joined at the correct location on the center leg rod segment. The center blocks are fixed locations and the right and left positioning blocks are allowed to move about an 1/8 of an inch perpendicular to the location angle for correct alignment.

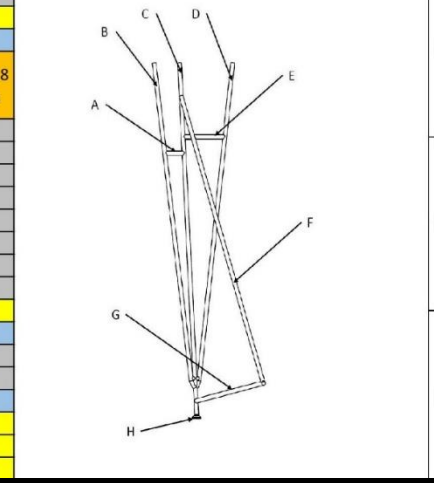
Patio Table Top Component Chart					
Label	Optimized Linear Length In inches	Optimized Fractional Size In Inches	Appr. Linear Length in Feet	Material Weight in lbs	Material 1018 Num Welds
A	156.0000	156.0 Inches	13.000	4.888	1
B	41.5000	41-1/2 Inches	3.458	1.300	4
C	5.3125	5-5/16 Inches	0.443	0.166	4
D	18.2500	18-1/4 Inches	1.521	0.572	4
E	8.7500	8-3/4 Inches	0.729	0.274	4
F	20.6250	20-5/8 Inches	1.719	0.646	4
G	16.0000	16.0 Inches	1.333	0.501	4
H	21.2500	21-1/4 Inches	1.771	0.666	4
I	11.0625	11-1/16 Inches	0.922	0.347	4
J	21.5000	21-1/2 Inches	1.792	0.674	4
K	5.6875	5-11/16 Inches	0.474	0.178	4
L	11.7500	11-3/4 Inches	0.979	0.368	4
M	11.5000	11-1/2 Inches	0.958	0.360	4
N	38.2500	38-1/4 Inches	3.188	1.199	4
O	24.9375	24-15/16 Inches	2.078	0.781	4
Totals	412.375		34.365	12.921	57

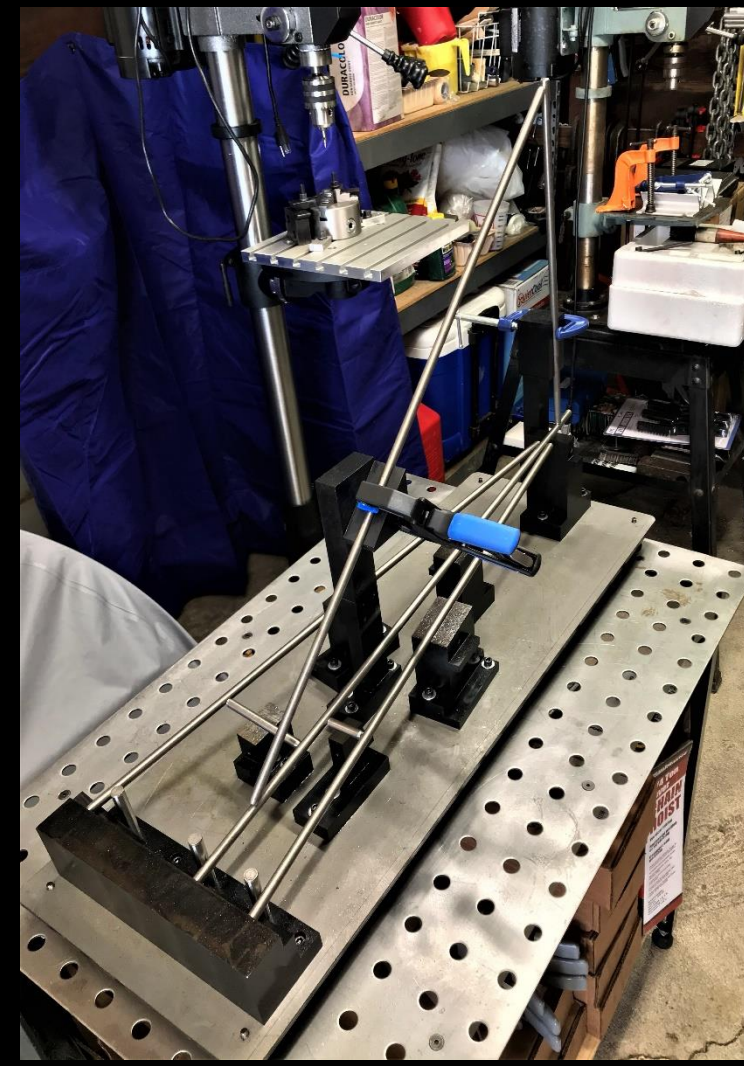
Patio Table Legs (4) Component Chart 1 Leg					
Label	Optimized Linear Length In inches	Optimized Fractional Size In Inches	Appr. Linear Length in Feet	Material Weight in lbs	Material 1018 Num Welds
A	1.6875	1-11/16 inches	0.141	0.053	4
B	27.1875	27-3/16 Inches	2.266	0.852	4
C	30.0000	30.0 Inches	2.500	0.940	4
D	27.4375	27-7/16 Inches	2.286	0.860	4
E	3.7500	3-3/4 Inches	0.313	0.118	4
F	30.3750	30-3/8 Inches	2.531	0.952	4
G	16.6250	16-5/8 Inches	1.385	0.521	4
H	0.0394	N/A	0.003	0.001	0
Totals	137.102		11.425	4.296	112

Total Approx. Patio Table Base & Top--Linear Length and Weight					
A	Linear Length ft.		80.065		
B	Table Weight lbs		30.105		

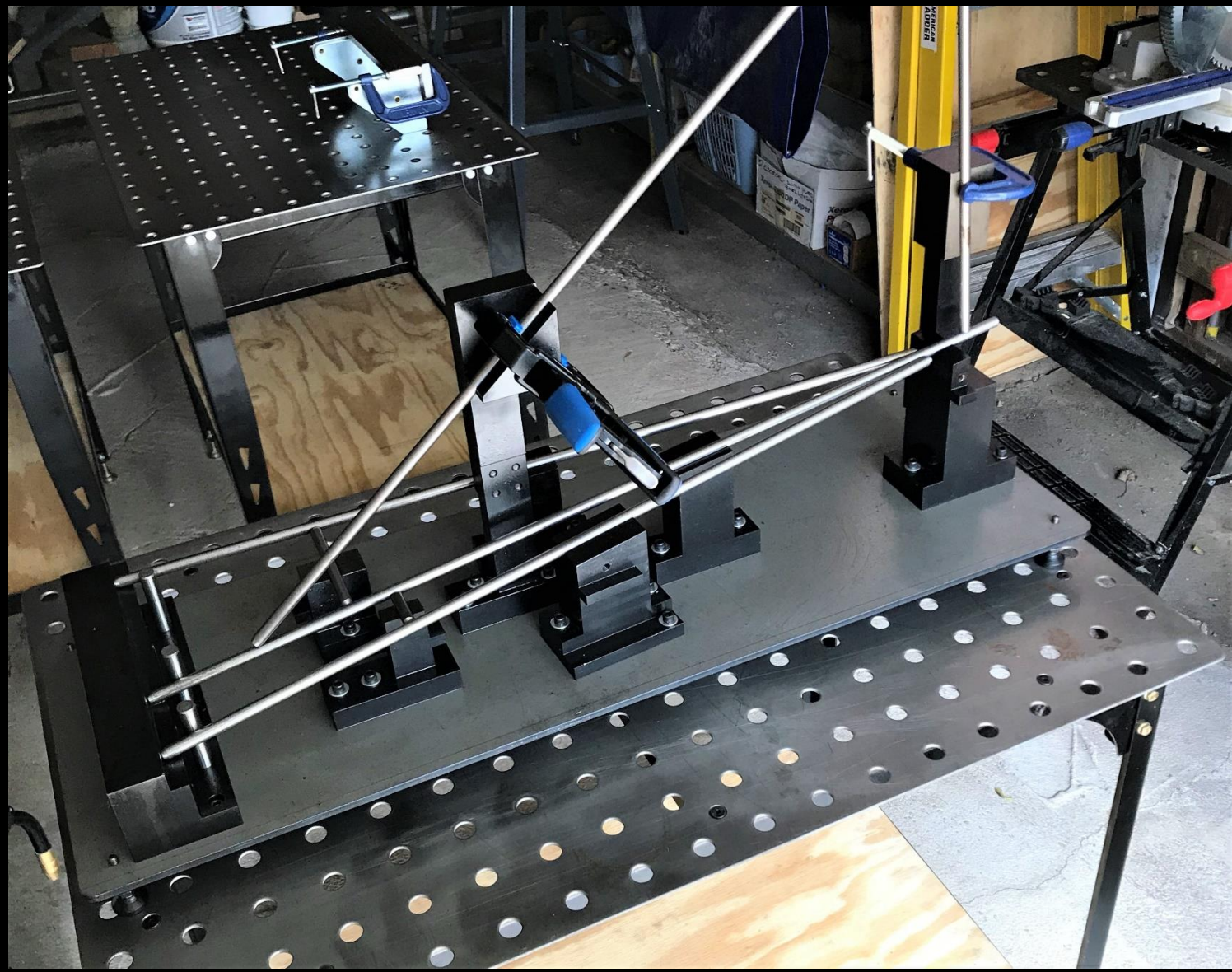
Total Welds, Top, Legs, Leg to Table Top, Center Bars To Center Bars					
A	Weld Legs to Top				12
B	Weld Center Bars To Center Bars				8
Totals	Total Number of Welds				189



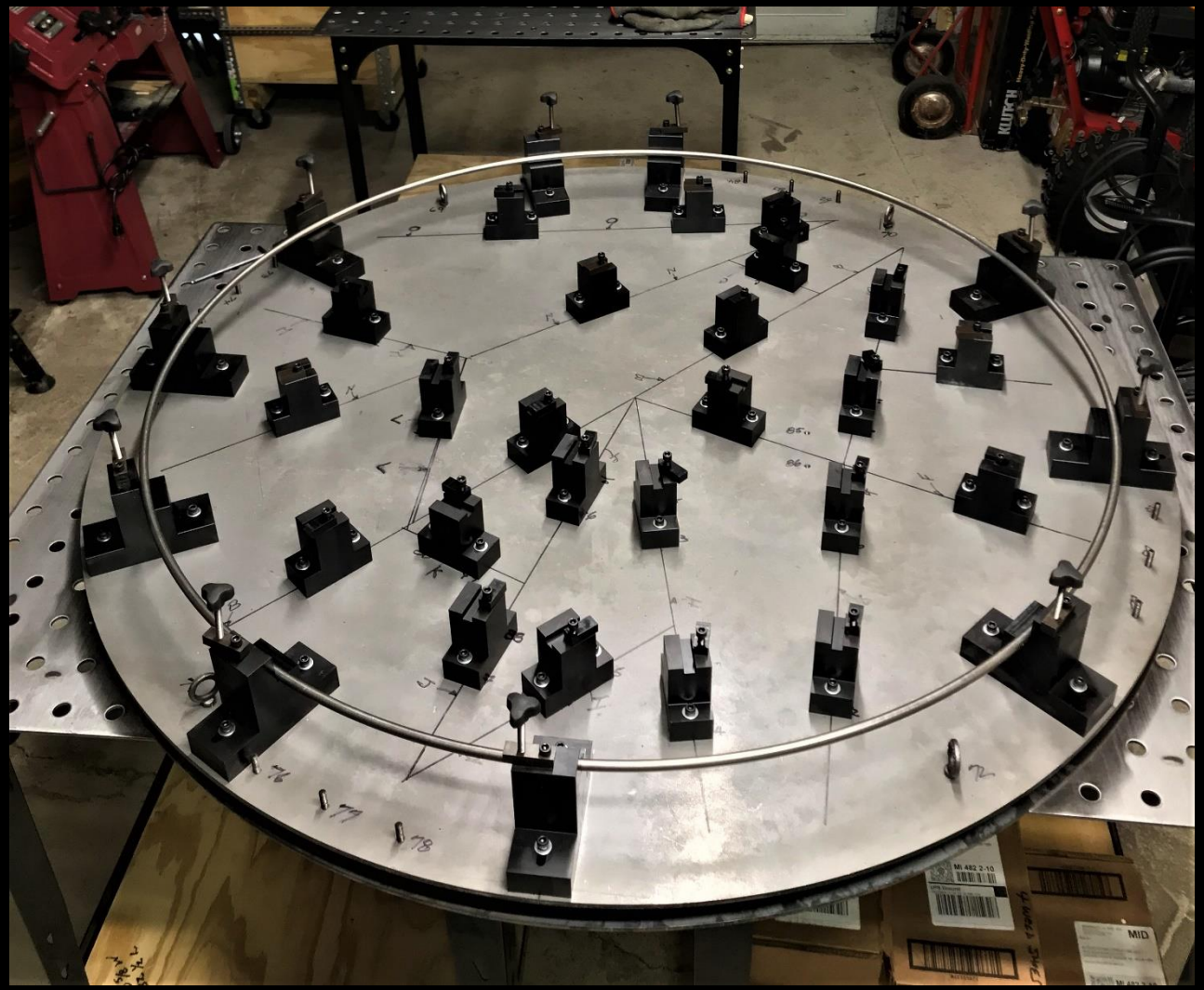




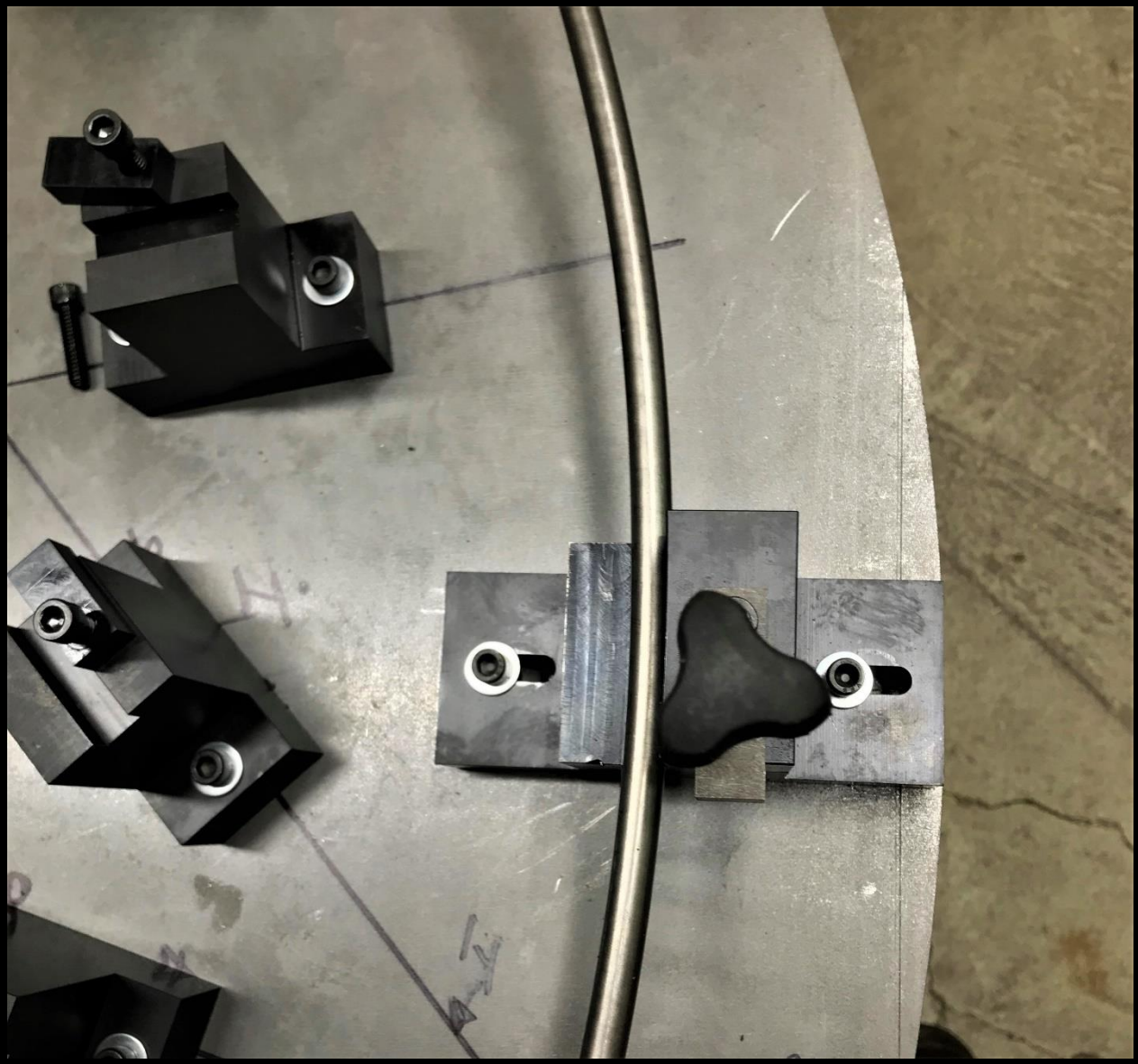
Lastly, qualifying the fixture requires capturing the actual linear length of each rod segment to be placed in each positioning block. The linear lengths that I initially captured with the 3D solid model are only good for reference. In the 3D solid model, the linear rod segments intersect so that they can be united into a single solid model. In reality, the steel rod segments can only be in contact with its neighboring piece. Each rod segment placed in the fixture must be cut and pencil ground for a custom fit. The rod segment is then measured, and that length, is the qualified length. I updated the component chart spreadsheet for each rod segment with its qualified length.



The weld fixture and rod segment lengths have been qualified to weld the table legs. However, I did not have a vendor make the fixture clamps for the leg positioning blocks. I decided to make these clamps myself and I will cover that process shortly.



Qualifying The Table Top Ring: Earlier in the book, I mentioned that the table top ring is a purchased component from a vendor. It was roll formed and butt welded. I have hand finished the weld areas on each of the table top rings and they are ready for locating in the fixture. The table top ring is supported and positioned by the 10 weld shoes on the weld base plate. The ring is clamped into positon with a screw clamp. The table top ring diameter tolerance per the vender is 1/8 inch, so I had to be able to adjust the weld shoes normal to the diameter (in and out only).

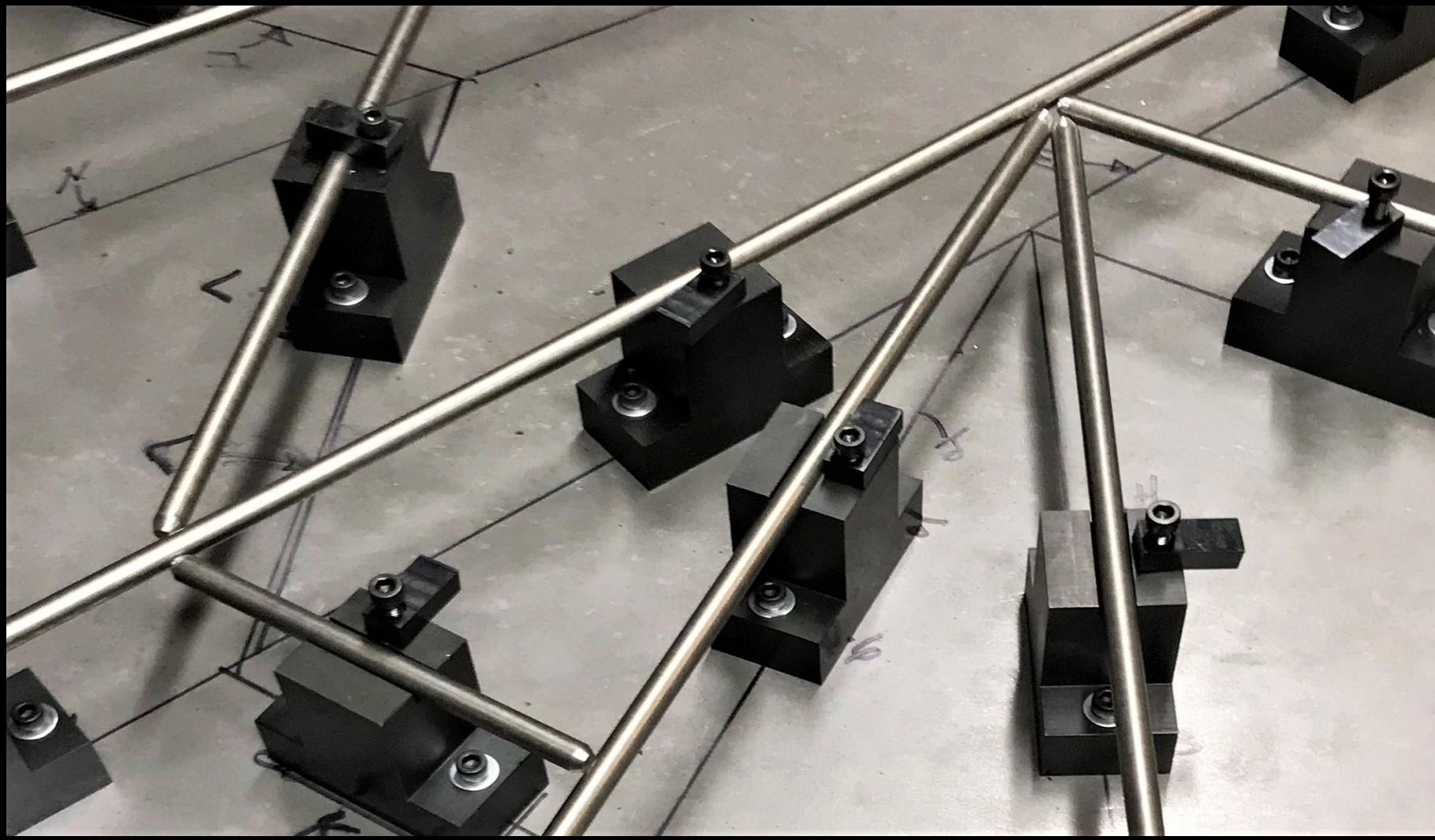


The table top ring diameter is machined into the face of each of the weld shoes to provided accurate positioning (the ring and fixtures diameters were very uniform) and positive contact for work holding the table top.

The table top ring rests on a machined face of the weld shoe elevated off the base plate.

The positioning blocks that locate the interior rod segments need to match this same plane.

Qualifying Table Top Interior Positioning Blocks: Qualifying the table top rod segments requires me to align two or more blocks holding a rod segment along the same vector. The blocks are allowed to move perpendicular to the line defined in the base plate by the hole locations. These adjustments are made in conjunction with evaluating and qualifying the linear lengths of each interior rod segment in the table top. These qualified lengths are measured for each interior rod segment and updated on the spreadsheet, just like the leg rod segments.



The actual linear lengths of each rod segment are very important. In replicating the table top and legs, I will be cutting steel based on the size indicated on the spreadsheet for the designated component. For example, if I am cutting steel for the center leg and I am making 10 tables, I need to cut 40 pieces of 3/8 steel bar the same length. Replicating the qualified dimensions allows me to pencil grind the weld relief into the rod segment with minimal time spent on sizing the component. Nonetheless, every piece loaded into either of these two weld fixtures must be custom ground and fit into position.

The Table Top And Leg Weld Fixtures Are Now Qualified: In the background of this shot, you can see my updated spreadsheet hanging from the cabinet. Now that I have captured all of the qualified lengths for each of the table's component rod segments, its time to cut a lot of 3/8 steel rod to make these tables.

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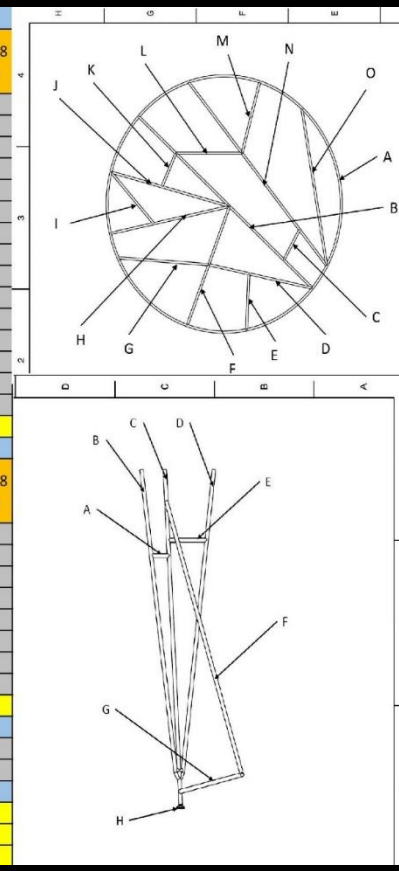
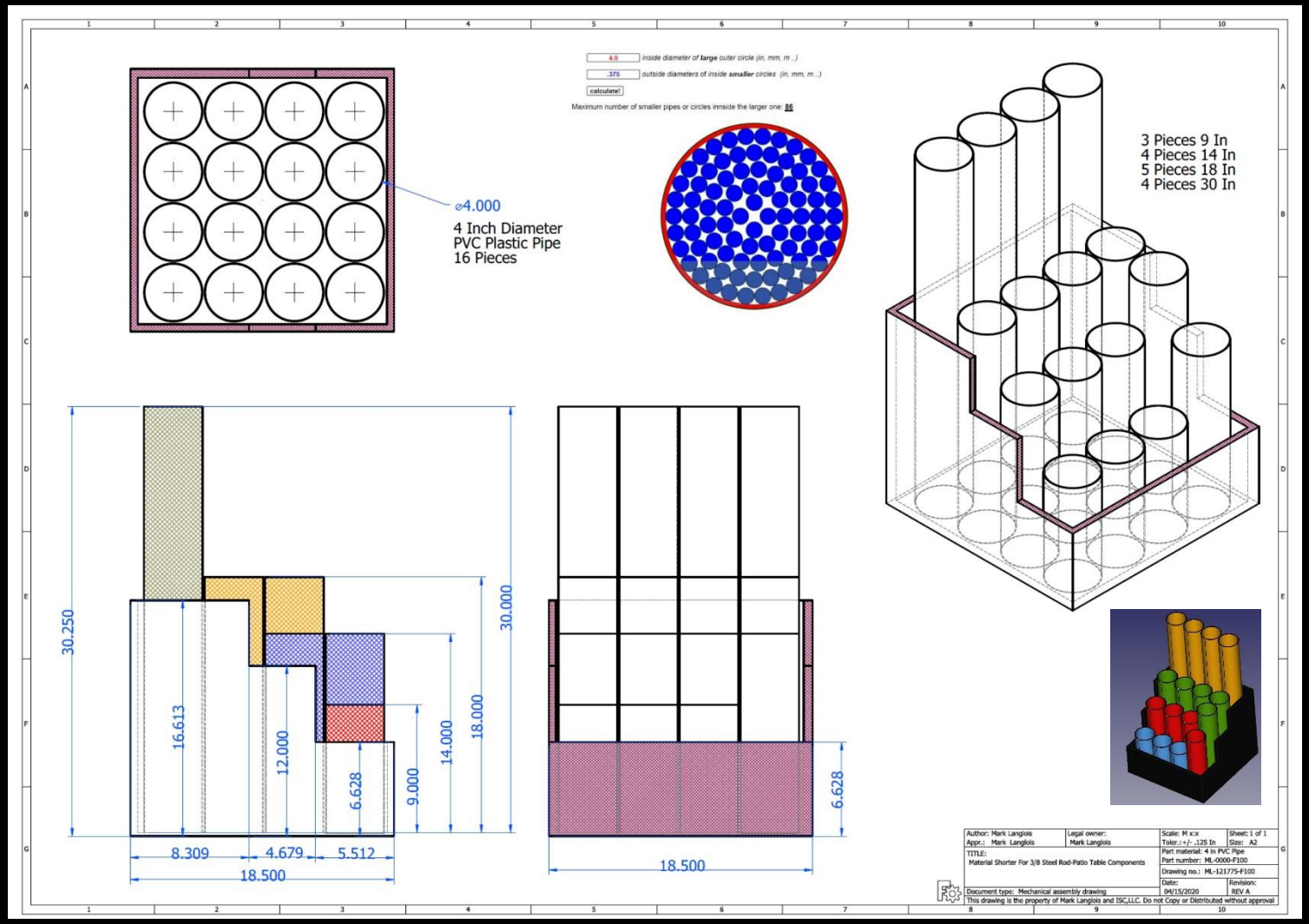
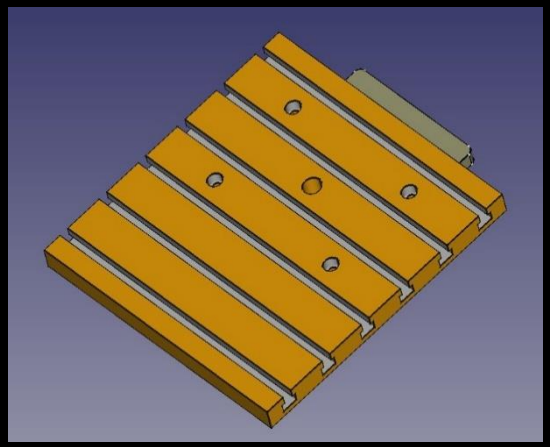


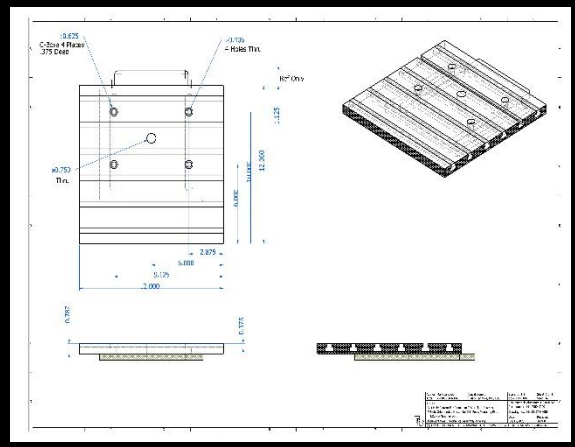
Cutting Qualified Steel Rod Segments To Length: In my table, there are 14 steel rod segments that make up the table top interior design and 28 steel rod segments that make up the 4 legs (7 steel rod segments for each leg). The spreadsheet sums the linear lengths of each of these components. From the total, I can calculate how much steel I will need to make a single table. Having purchased and finished the table top rings, each table requires 67 linear feet of steel to make. I chose to make 10 tables initially. This equates to a purchase order of 56 bars of 3/8" steel rod, 12 feet long. Total number of individual pieces to cut to the qualified length is 420.

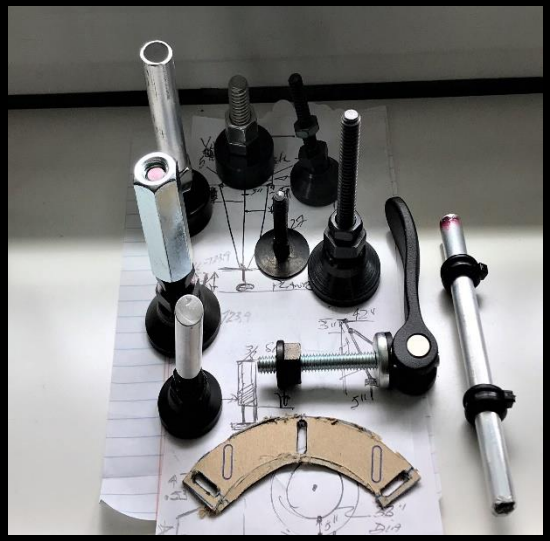


Material Handling And Organization: Because I am cutting 420 pieces of steel and the quantity and qualified length is specific to each component, I will need some organizational tools to assist me in keeping the same components grouped together as well as a way to identify each component. Prior to ordering the 3/8” steel rod to make the tables, I designed an organizer to hold each steel rod segment required to make the top interior design and each leg. In addition, a picture showing the location of where the component is in the design, along with its spreadsheet label and qualified length is on each tube. There will be over 300 pounds of steel in this organizer when all of the steel is cut.

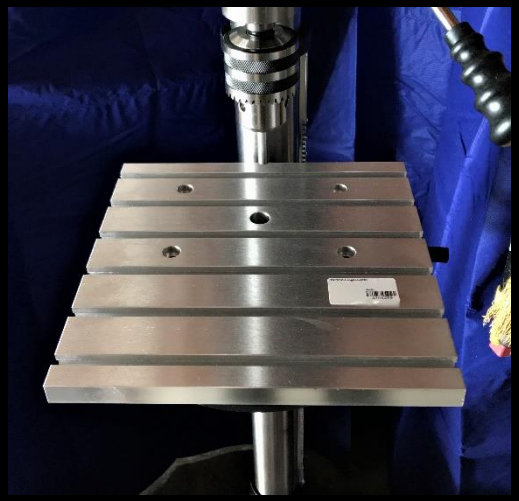
Cutting Steel: Each of the 420 steel rod components were cut on my band saw (left) to its qualified length. I measured each component again after completing the cut and placed it in the proper location in the part organizer. In spite of my gauging each piece, there will be some minor variations in size; these bars are not cut to a machined tolerance. In addition, there will be a small burr on each end of the bar to sand off before it gets custom fit into its place in the weld positioning blocks. Each tube has a picture of the specific part, its location and size. The organizer is also fitted with wheels so I can roll it around and get it out of the way.







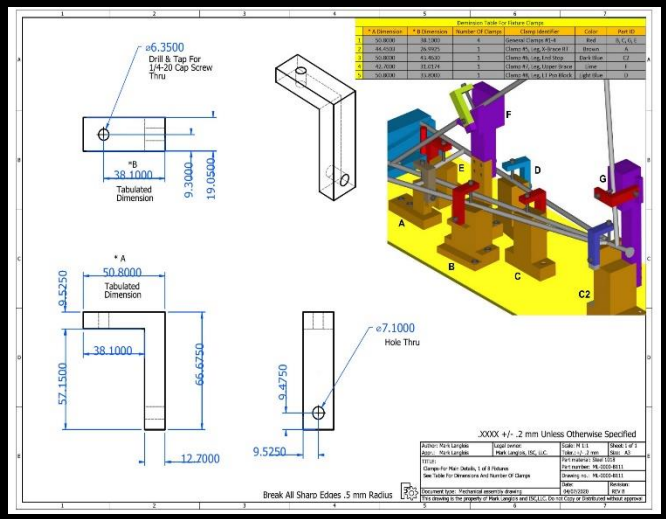
Drilling And Tapping The Center Leg: A considerable amount of thought, prototyping and communication with vendors went into the development of how to mount the leveling feet for the table center leg. One of my major concerns was finding a leveling foot that had at least 15 degrees of articulation; the center leg is already consuming 7 of the 15 degrees of articulation just to lay flat, due to the inboard angle. I wanted the center legs to be able to adjust at least 1 inch in height. My options were to use a sleeve or drill and tap the center leg. I chose to drill and tap the center leg for aesthetic appearance and also weld considerations. To make this work, I needed to acquire a new drill press, a three jaw chuck, design a tee slot plate for the drill press and get some work holding components.

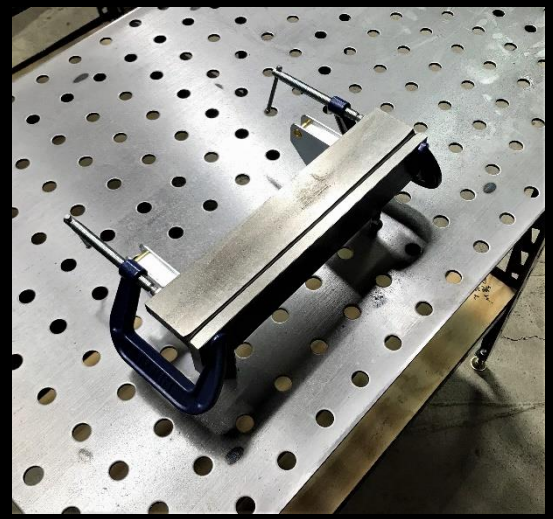


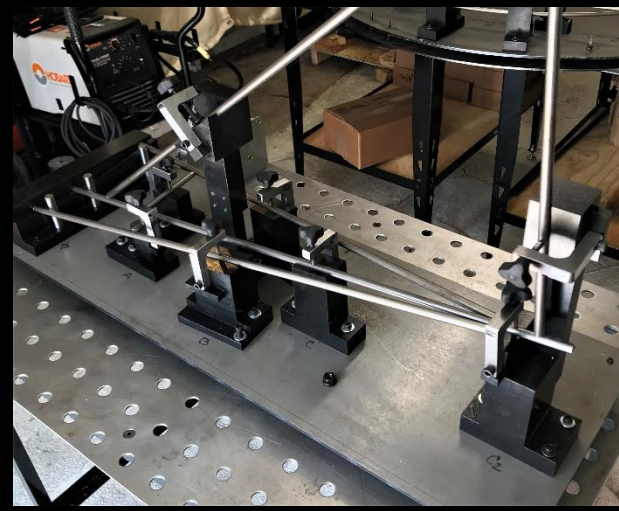




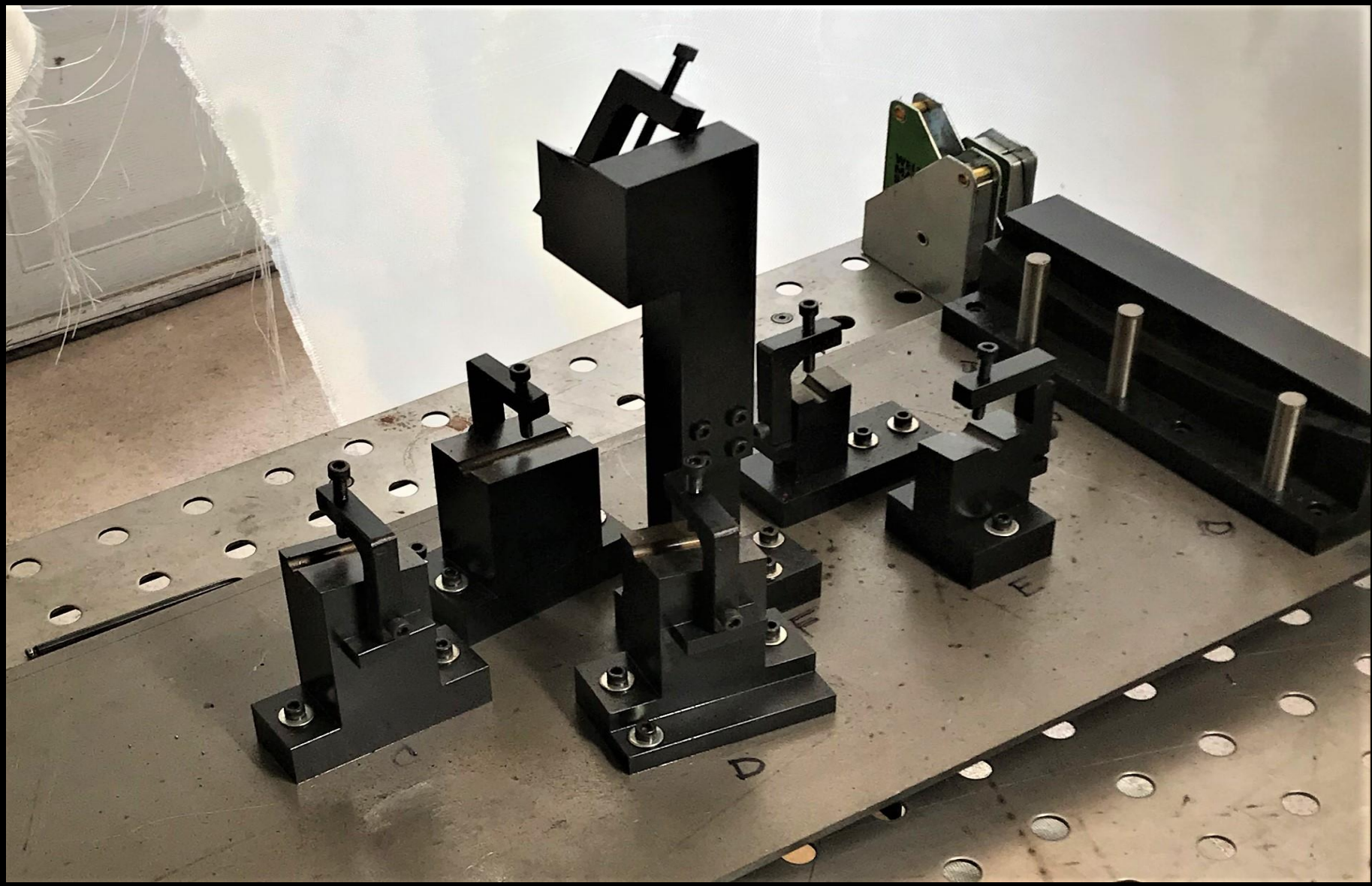
I mounted the tee slot table on the drill press with the thru holes aligned. The three jaw chuck was mounted and aligned with the center of the drill press spindle and clamped down. I needed the new floor standing drill press to allow the 30 inch long center leg to load from underneath the drill press table and pass up through the chuck center hole. I used a magnetic torpedo level as a stop gauge to locate the center rod height in the chuck. Each center leg rod was center drilled, then tap drilled. Following that, I lowered the drill press table and hand tapped each leg . I tested each tapped hole to make sure the it was deep enough for the 1-1/4 inch leveling foot thread.







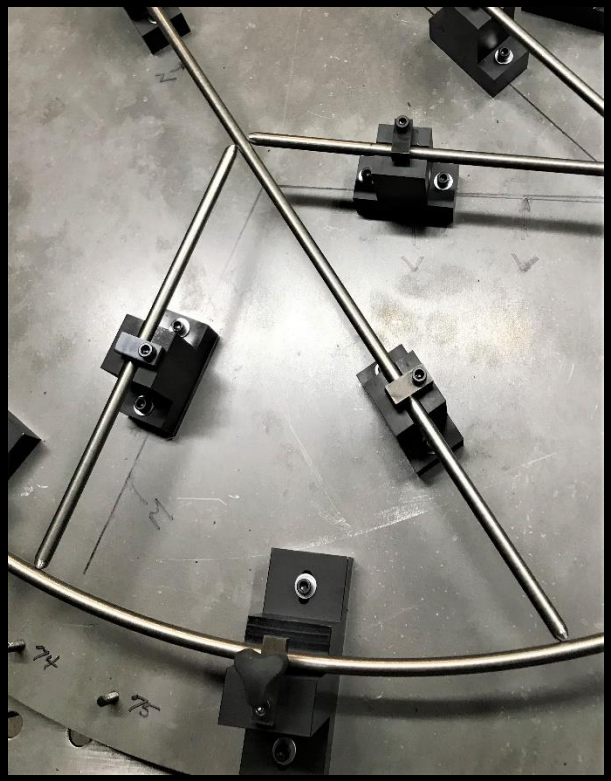
Making The Leg Fixture Clamps: I didn't have the leg fixture clamps CNC machined with the positioning blocks, to save money. I made them myself using two pieces of 3/8 steel plate. First, I angle ground weld relief on both sides of the plate and welded them together. Then, I cut the weldment on the bandsaw according to the clamp drawing dimensions. Next, I positioned each clamp in a compound vice on the drill press to drill the thru hole on the bottom for a 1/4-20 cap screw and the other hole on the top; drilled and tapped for a 1/4-20 screw. There are 8 clamps in the leg fixture to secure the rod segments.



Completed Leg Fixture Clamps: Like the fixture positioning blocks, I had all of the leg fixture clamps coated in black oxide to prevent rust as well.

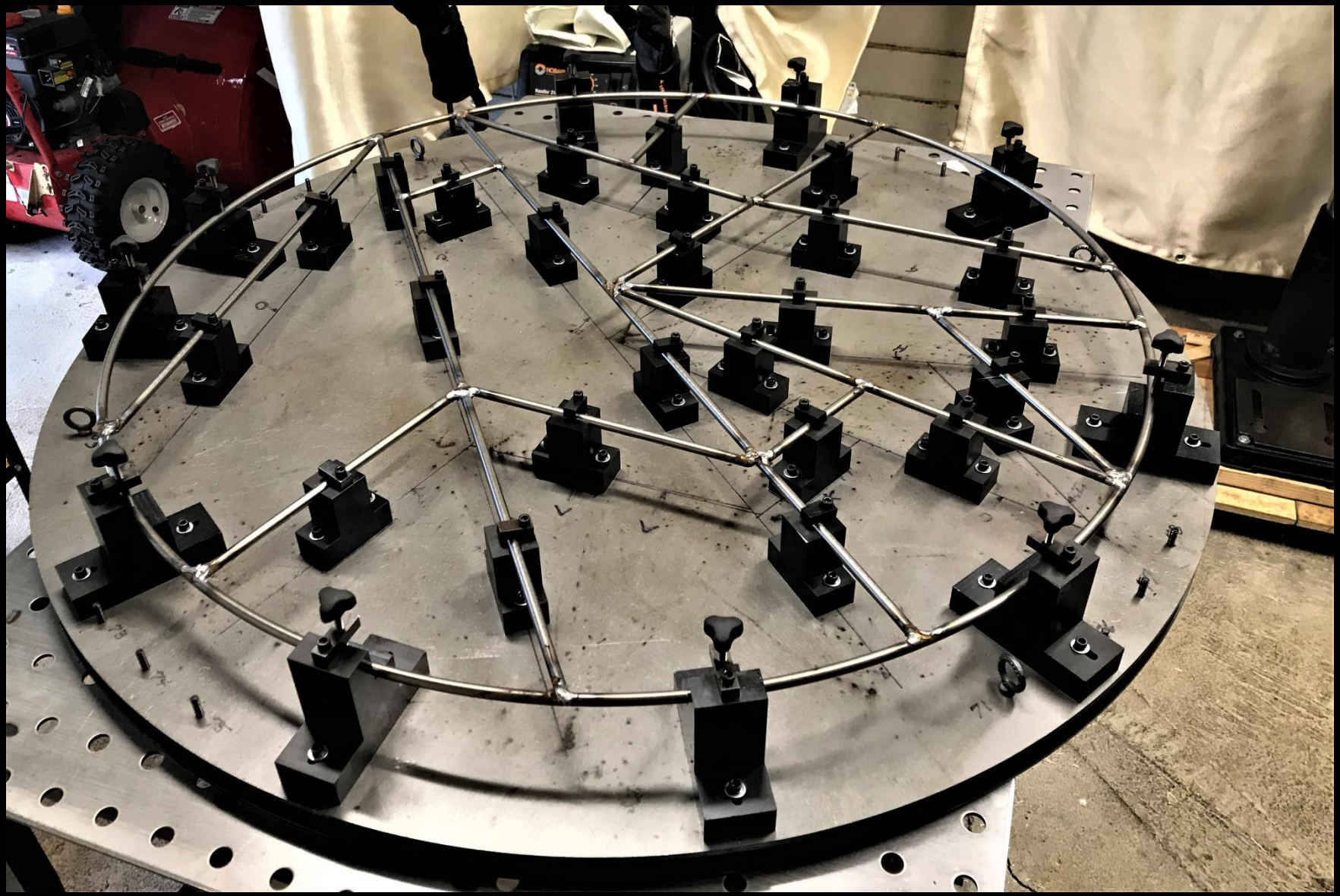
A & B Side Welding: Each steel rod component welded in the construction of the table requires welding both the front and back sides. The 3/8” round steel rod when welded on the "A" side fills in the weld area around only half of the diameter of the bar. In the picture on left, the “A” side weld is complete. Flipping the welded sample over shows what remains on the "B" side on the right. The "B" side must be welded for two reasons; for strength and integrity of the welded component and because the tables "B" side will be a visible show surface on many parts of the table. Both the A & B sides must be welded and finished.

Pencil Grinding The Rod Segments For Welding: Each end of the steel rod segments that make up the interior design on the table top and in the construction of each leg requires, "pencil grinding“; a relief between the bars before welding. The “pencil grind” at each end of the rod segment allows the weld to flow into the spaces between the intersecting bars. This space filled with weld creates additional surface contact on the steel bar and adds weld mass, creating a strong weld bond. Because each rod segment is "pencil ground", the weld must fill in all of the gaps around the relief areas. After I have finished welding a rod segment, the pencil ground relief areas should not be visible.



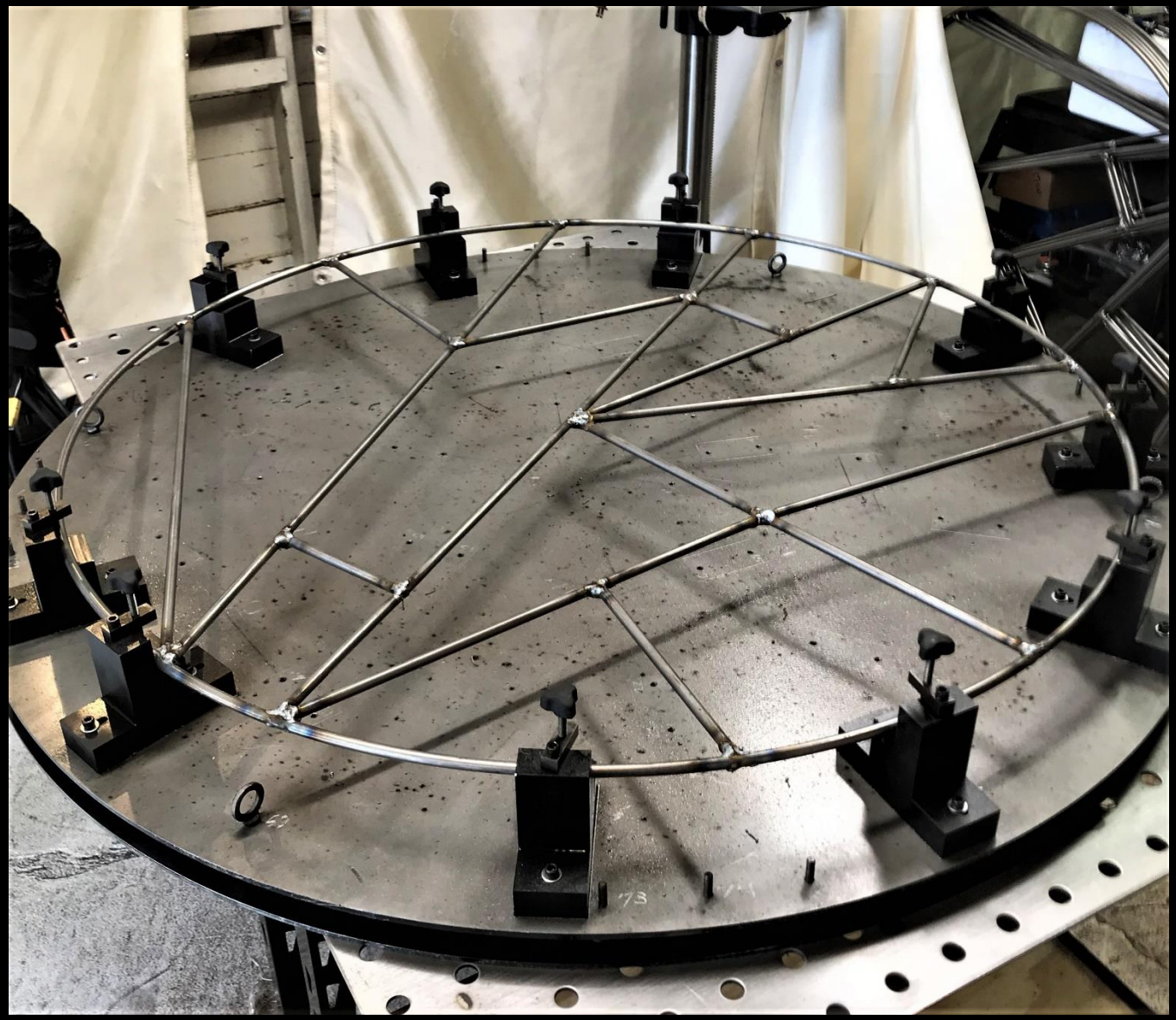
Creating Weld Transitions: In the solid model of my table design, the steel rod segments intersected each other so they could become a single solid model. If the top and legs were made of cast steel, it might be possible to incorporate the blend transitions between each rod segment intersection. However, because the table is welded, these blend transitions do not exist. When I am welding the individual rod segments, it is not enough to simply weld the components together and cover the “pencil grind”, I must also weld the components to deposit enough weld material to create and finish a smooth, natural looking transition between the components. I found it to be a challenge to create and control these component weld transitions for finish.

Welding The "A" & "B" Side Table Top Interior Design: After I custom fit each rod segment into its designated position for the interior design, it's time to weld the table top "A" side.



Welding The "A" & "B" Side Table Top Interior Design: I have completed the first “A” side welds for table top 1. I must repeat this process for each of the remaining 9 table top “A” side rings. Each rod segment is positioned in the correct location, custom fit to size, pencil ground, clamped in the fixture and welded.

Welding The "A" & "B" Side Table Top Interior Design: I have now completed welding the “A” side interior rod segments for all 10 table top rings.



Welding The "A" & "B" Side Table Top Interior Design: To weld the "B" side of the table top, I must remove all of the interior positioning blocks. They cannot be on the base plate because all of the welded rod segments are in a different position when the top is turned over to the “B” side. All I need to do, is clamp the table top ring to hold it in place and weld each table top segment on the "B" side.

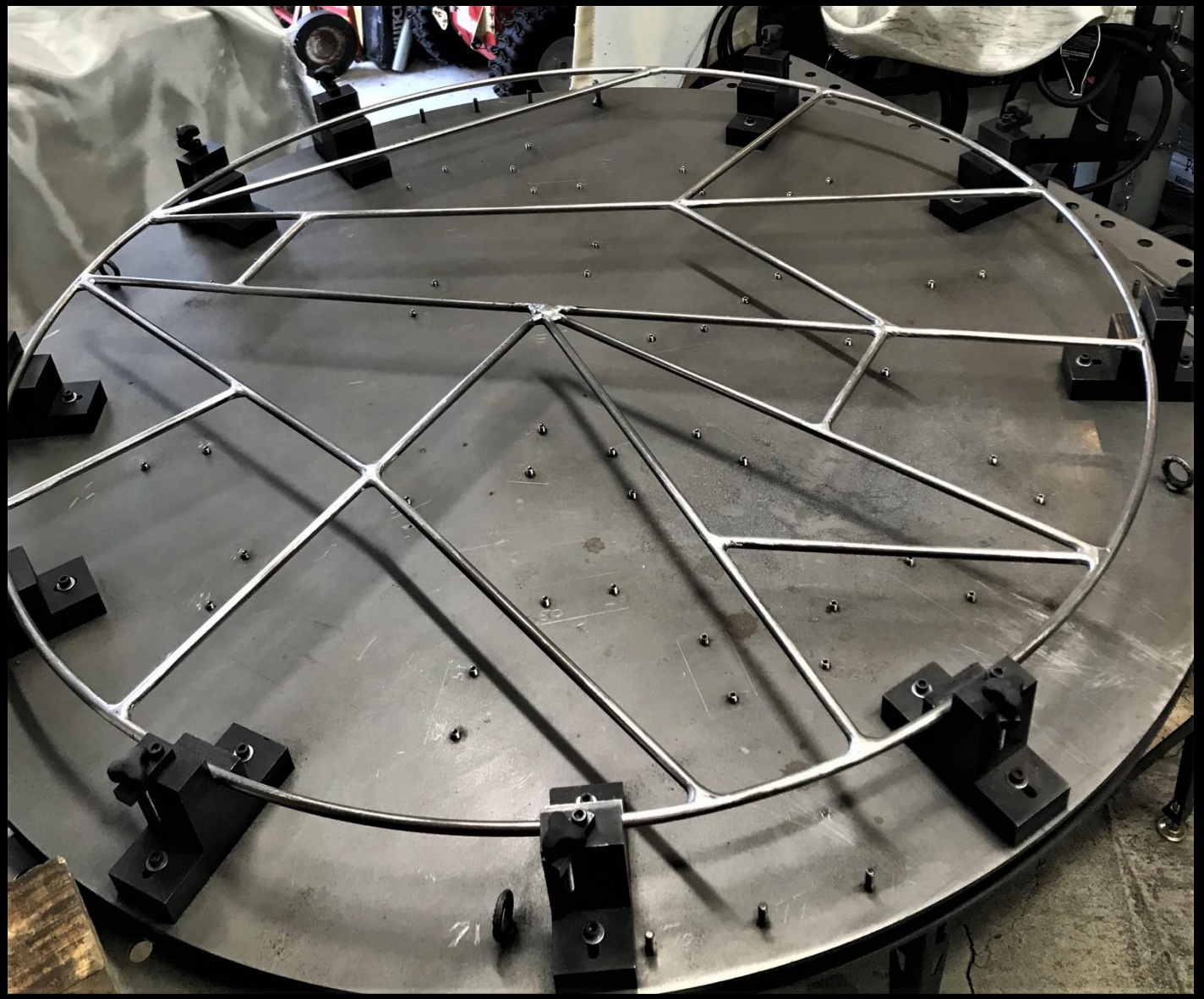
Creating Semi-Finished Transitions On The Welded Tops: I have finished welding the table top interior design on both the "A" and "B" sides. My next task is to rough grind each individual weld and then hand file them to create a smooth, natural looking transition, between each intersection on both the "A" and "B" sides of the table top.





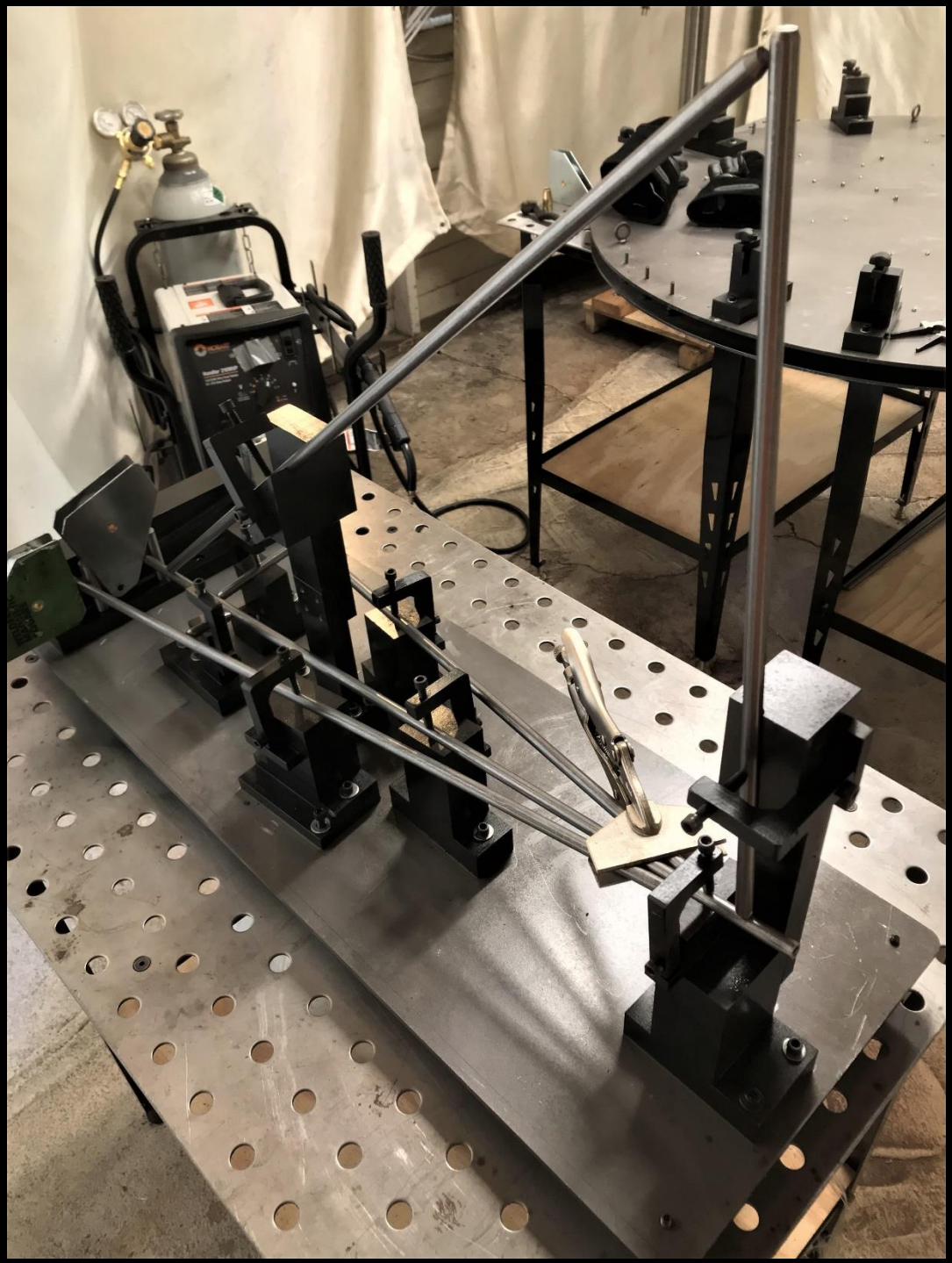



Creating Semi-Finished Transitions On The Welded Tops: The most labor intensive process in the construction of these tables is developing the weld transitions. Power tools can only get me so far in the process and the rest of the transition must be hand filed. Each pass I make with the grinder or file removes weld material from the joint. The trick is to leave as much weld in the joint as possible and still create a transition that looks natural and flows as part of the design.



Creating Semi-Finished Transitions On The Welded Tops: The weld shoes on the base plate serve as a work holding device while I am developing the weld transitions. I can rotate the table top ring and grind or file the intersections without it moving. In the shot above, I have all of the semi finished transitions completed, with the exception of the one in the center. It takes me approximately 40 man hours to complete the "A" & "B" side transitions for one top.

Creating Semi-Finished Transitions On The Welded Tops: I have completed semi-finishing the welds for the “A” and “B” sides on table top 1. Only 9 more to go.

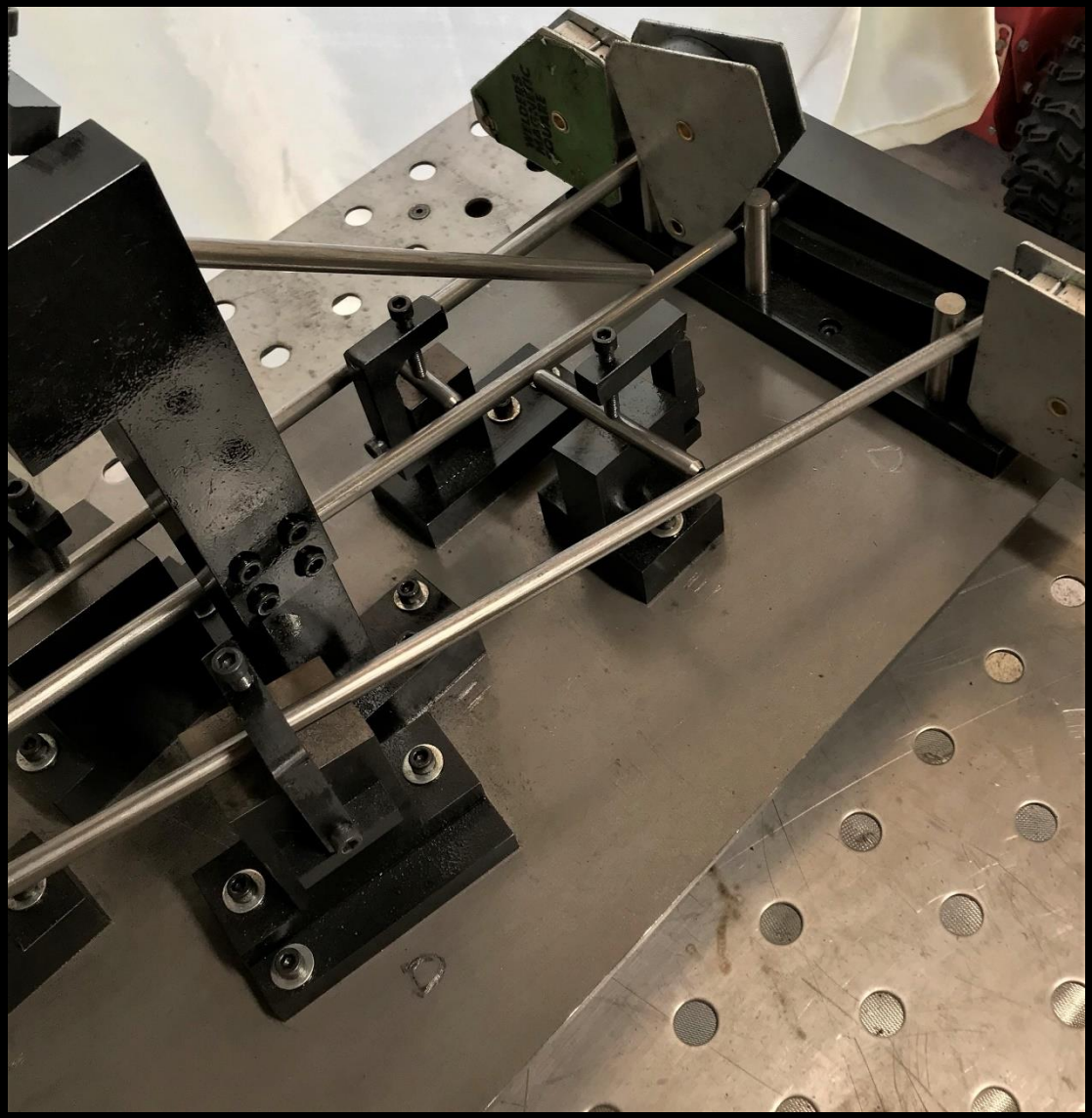


Welding "A" Side Legs: I found that welding the legs is a much more involved process than welding the table top. There are only 7 steel rod segments, however they are positioned in close proximity to each other.

The center rod segment has a tapped hole in the same location where the lower center brace must be welded. The tapped hole creates a thin wall of steel where the rest of the rod segments are solid. I don't want to melt through this thin wall when I weld the lower center brace.

The legs also need to be welded in a specific order so that the angles and heights remain in place. I need to make sure that the center rod segment is in plane with the upper and lower center braces when I weld them.

Just like the table tops, I must “pencil grind” and custom fit each of the leg rod segments in the fixture. Forty leg components need to be made (280 pieces) to mate with the 10 table tops.



Welding "A" Side Legs: The first components I am welding are the two cross braces that tie the right and left leg rod segments to the center rod segment.

The magnetic welding squares attached to the radial stop block are clamping the right, left and center rods to the dowel pins.

The two cross braces must fit exactly so they don't push the leg components off the pins when I clamp them into the fixture.

Welding the cross braces first will keep right left and center rod segments positioned at the correct spacing on the radial diameter.

Welding "A" side Legs: The next component I am welding is the upper center brace to the leg center rod segment.

I used a magnetic square to align the upper center brace to the center line of the center rod segment. The outside diameters of each rod will be tangent to the face of the square.

The square is aligned to the center rod and the upper center brace follows. These welding magnets are quite strong and very handy to work with.

I must tack weld the upper brace to the center rod first, remove the magnet, and then finish this "A" side weld.

My other goal here, is not to weld the magnet to either of the rod segments. It’s a tight fit in this spot.

Welding "A" Side Legs: Welding the lower center brace to the center rod segment is my next weld to make.

This weld is made where the 1/4-20 tapped hole is located, at the end of the center rod.

Welding these components creates a lot of heat and it may impact (shrink) the internal threads in the center bar.

I must be careful not to melt the thin wall of this part of the bar creating a hole or getting weld on the internal threads when welding this lower center brace.

I will have to run a tap back into each of these threaded holes after welding both the "A" & "B" sides, to clean out and smooth any thread distortion.

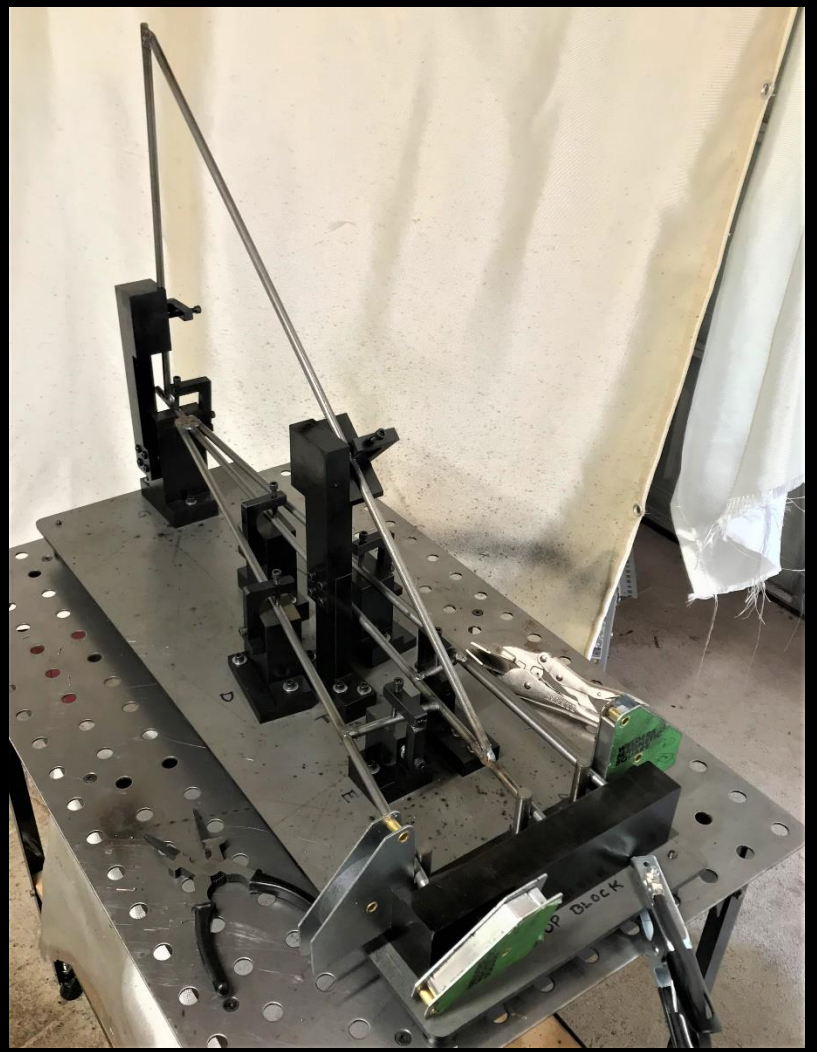
Welding "A" Side Legs: Next, I am welding the ends of right and left rod segments to the center rod segment.

I used a magnetic square to align the upper center brace in a previous weld. In this case, I am using a sheet metal vice grip which has a wide, straight, flat face to clamp all three bars.

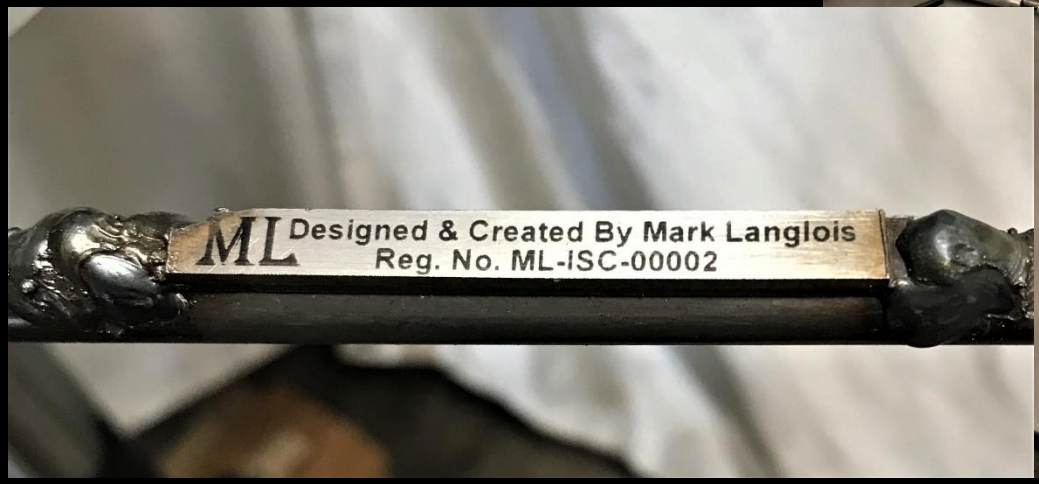
This clamp attaches to the top and bottom outside diameters of all three rods, keeping the right and left rod segments on the center line with the center rod segment.

I tack welded all three rods in position first, removed the vice grip clamp, and finished welding the rods.

There is a considerable amount of weld that goes into joining these three components at this junction.



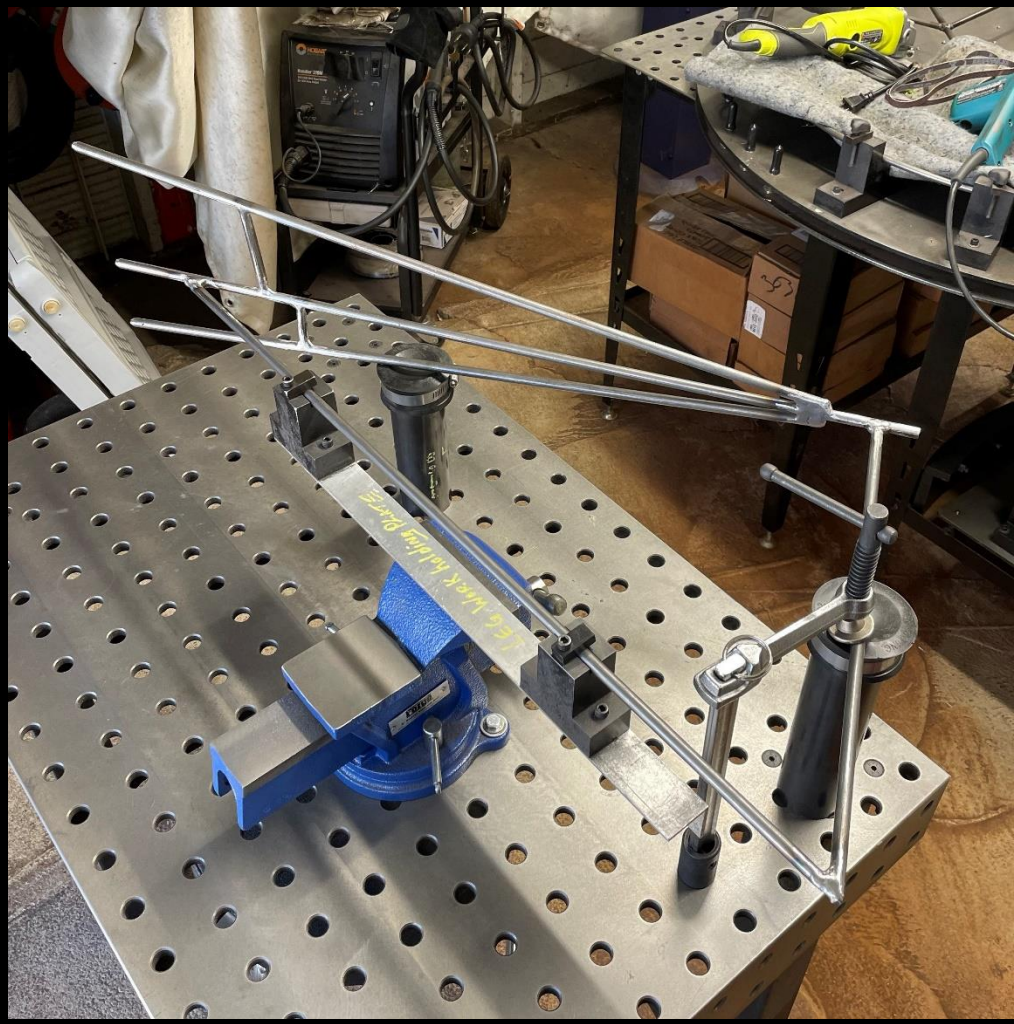
Welding "A" Side Legs: My last weld in creating the leg component is joining the upper and lower cross braces that meet at the table's center. The sheet metal vice grip clamp I used on previous page was also used here to align both the upper and lower rods on center. The rods were tack welded, the clamp removed and finish welded. There are 8 welds on the "A" side to complete the leg component from the 7 rod segments.



Welding "A" Side Legs: I have completed the "A" side welds on the first leg component and it has been removed from the fixture. On one of the table's 4 leg components, I need to weld my signature plate on the underside of the lower cross brace. This signature plate is a laser etched stainless steel bar with my name on it as the designer and creator, along with its registration number. The signature plate provides identification and authentication for each table made.

Welding "B" Side Legs: Welding the "B" side of the leg component was a much easier task then welding the "A" side, now that the leg is a solid component. I was able to leverage the weld fixture used for the '"A" welds as a work holding device by clamping the upper cross brace to the upper cross brace positioning block and locating the legs on the base of the radial stop block. Completing the "B" side welds on the outside of the leg went rather quickly. I used the white fire blanket to cover the fixture to keep weld and weld splatter off the components underneath.

Welding "B" Side Legs: I have finished welding 16 leg components thus far. There are 8 legs on the base plate and another 8 hanging up in the background on the left. Pictured on the right, I have 10 welded table tops hanging on the wall; four of the 10 tops are semi-finished. My plan is to semi-finish 8 legs and weld them to 2 of the semi-finished tops. I want to take 2 of the tables through to completion first, so that I can resolve any technical issues that may come up in the assembly and finish process before starting any more.



Semi-Finish "A" & "B" Side Legs: Semi-Finishing the leg components is a bit of a challenge. I had to come up with a way to hold the leg down firmly without bending any of the rod segments. I repurposed a couple of my interior positioning blocks and attached them to piece of 2” aluminum angle bar. I clamped that into a vice. Then cut steel tubes different sizes and put rubber caps on the top to support the work. This allowed me to swing the leg into different positions and access the interior welds. Still, developing the weld transition areas on the legs is more difficult and time consuming. It took me roughly 16 hours to semi-finish one of the leg components; grinding, sanding and hand filing.

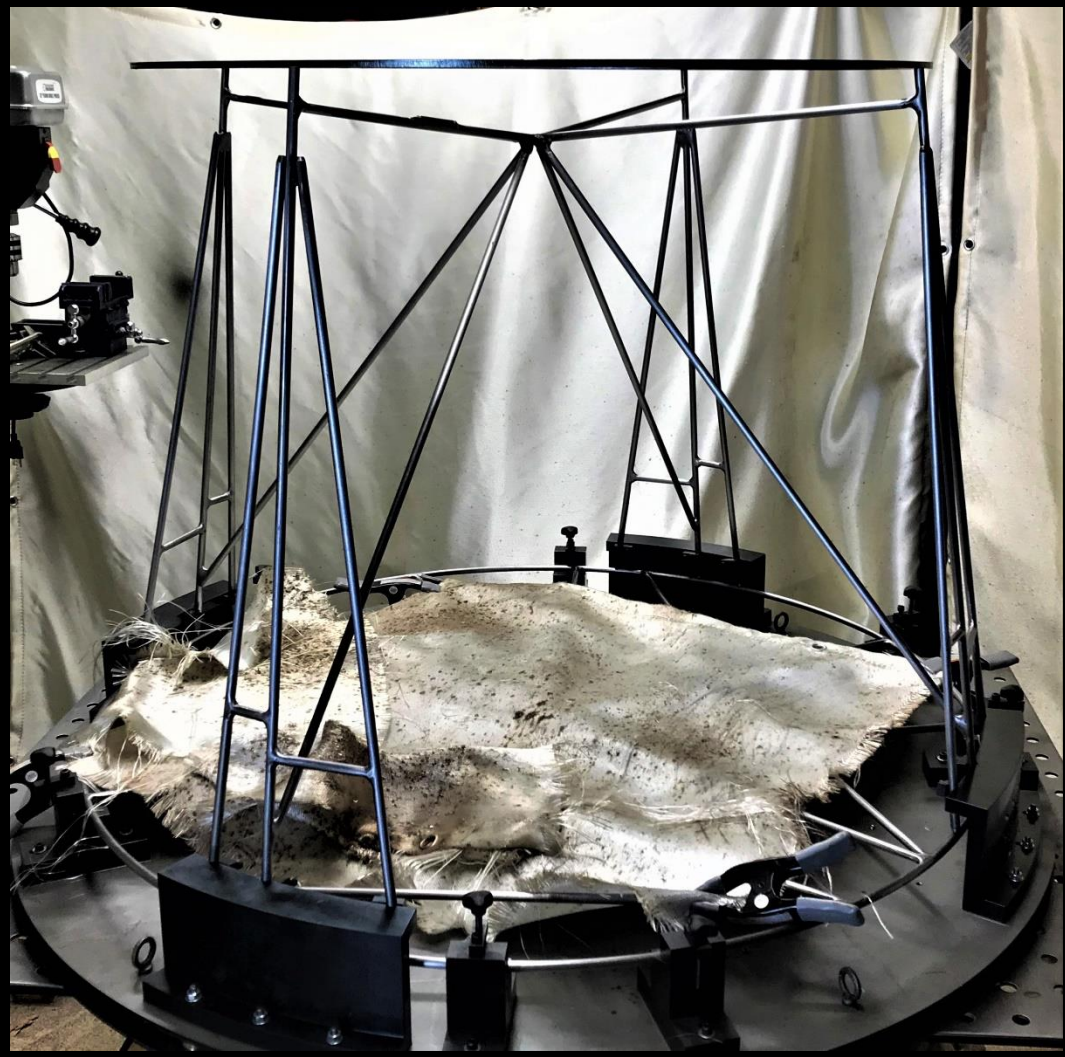
Semi-Finish "A" & "B" Side Legs: In the shot on the left, I have a set of 4 legs semi-finished, ready to weld to table ring #1. I am working on the other 4 legs for table ring #2. The ends of the upper and lower cross braces that will meet in the table's center are not semi-finished; they are ground smooth, and free of dirt and weld splatter. The leg center braces are all welded together after they are qualified in the assembly positioning blocks and finished after the table top welds are complete.

Qualifying Table Assembly Locating Blocks: To weld the legs to the table top ring, I have to install and qualify the assembly locating blocks. I designed the assembly locating blocks to use the threaded studs from the leveling feet; the assembly block hole locations and spacing are the same. The assembly locating blocks mount on these studs and can move in and out on the table ring diameter. The assembly blocks position the top of the leg components on the centerline of the table top ring diameter.

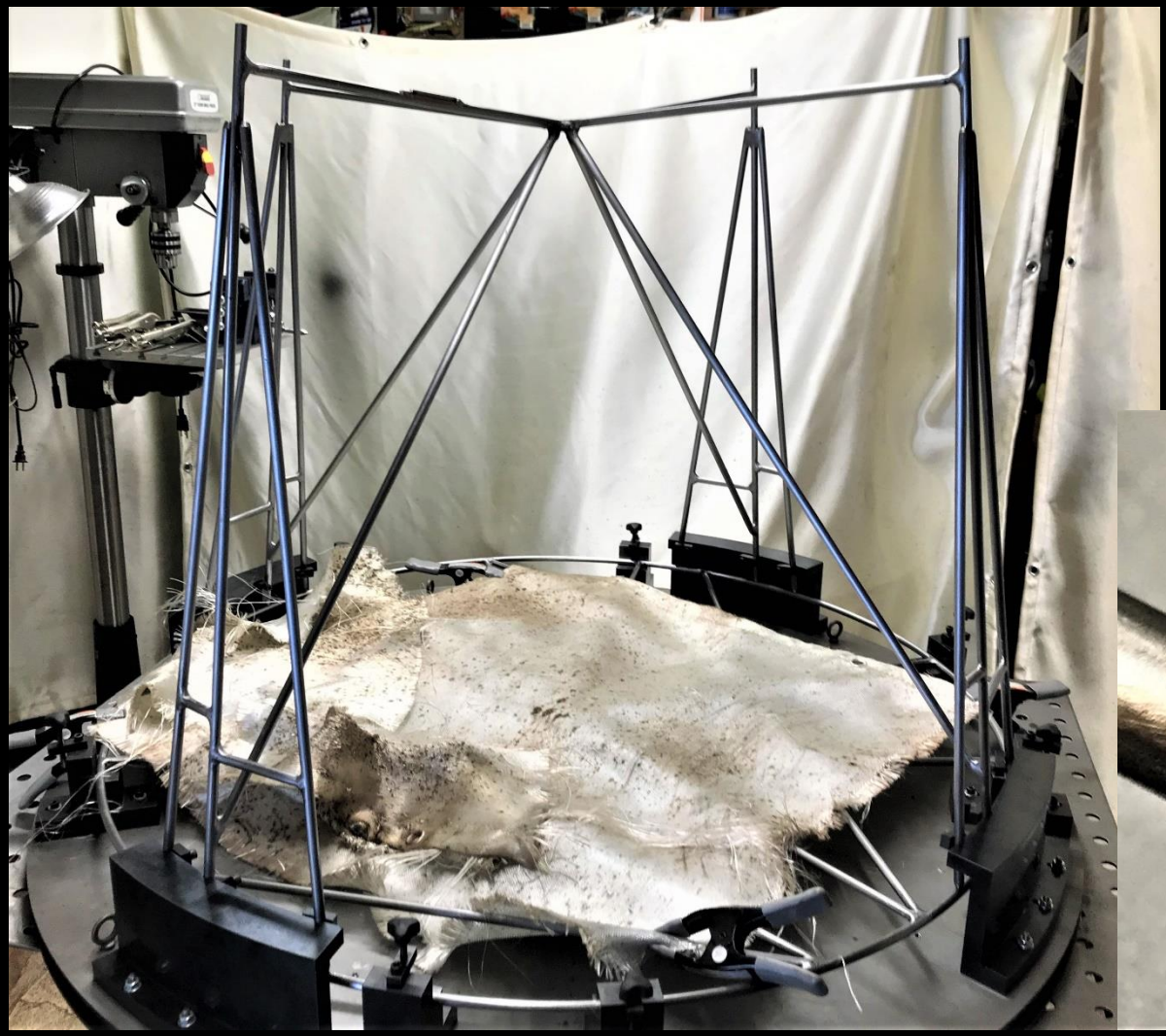
Qualifying Table Assembly Locating Blocks: After installing the assembly locating blocks, the table top ring diameter is clamped by the base plate weld shoes. The legs are then positioned in the assembly locating blocks and qualified so that the right, center and left, rod segments of each leg sit on the centerline of the table top ring. The assembly locating block clamps can be tightened or loosened so that each rod segment is aligned with the table top ring centerline.

Qualifying Table Assembly Locating Blocks: I used the assembly gauge ring to help me position the legs at the required inboard angle of 7 degrees. The position of the center cross braces will be clamped and evaluated with the ring gauge several times. In addition, I will measure each of the vertical leg heights from the base plate and take cross measurements between the legs to assist me in getting the legs into position.

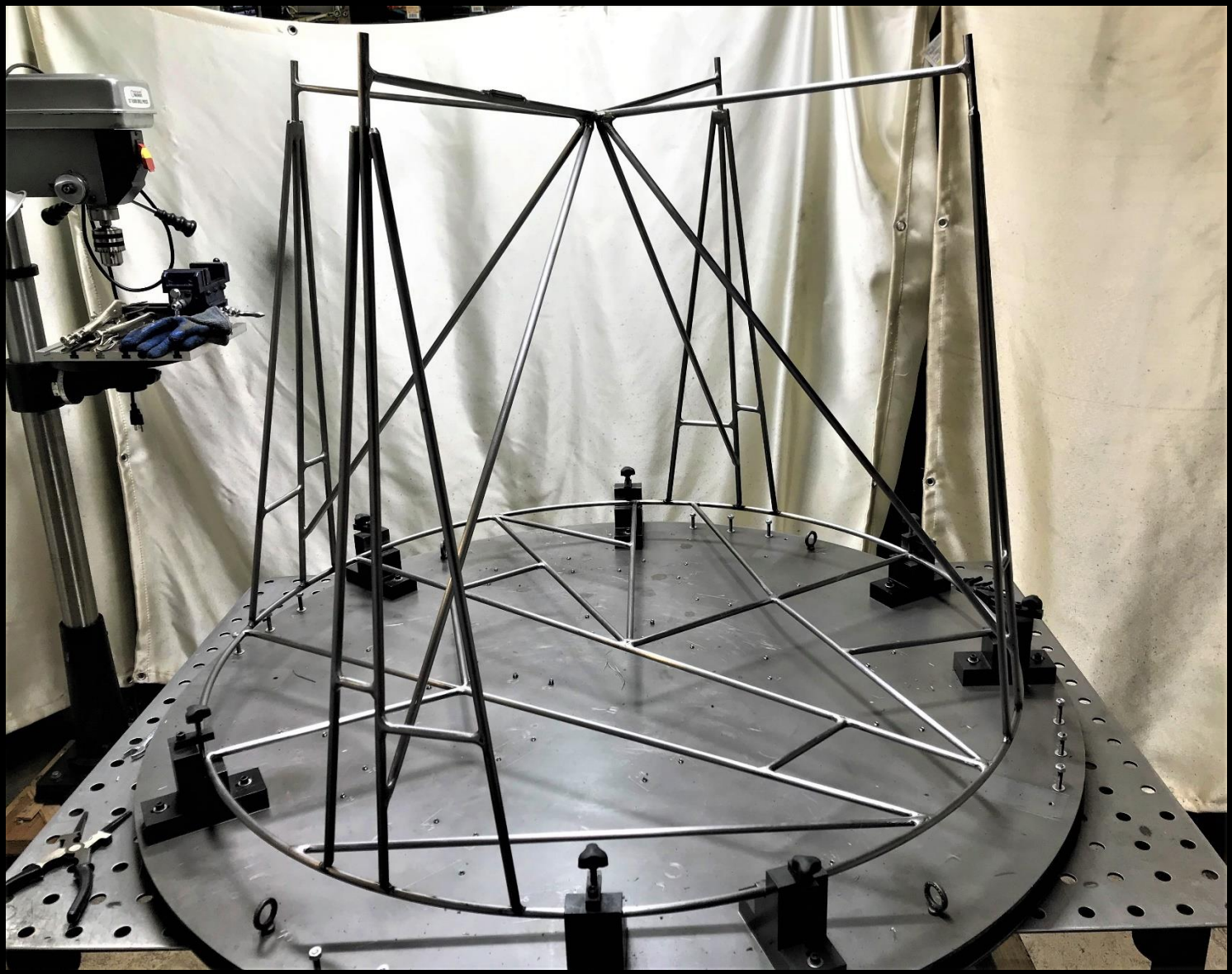
Qualifying Table Assembly Locating Blocks: Positioning and clamping the center cross braces is an important step in aligning all of the leg components to the table top. The center cross braces will be the first components that I tack weld. Once the center braces are tack welded, I can make the minor adjustments required to align the top of the legs to the table top ring. The assembly locating blocks did an excellent job in keeping the leg end segments on the center line of the table top ring.



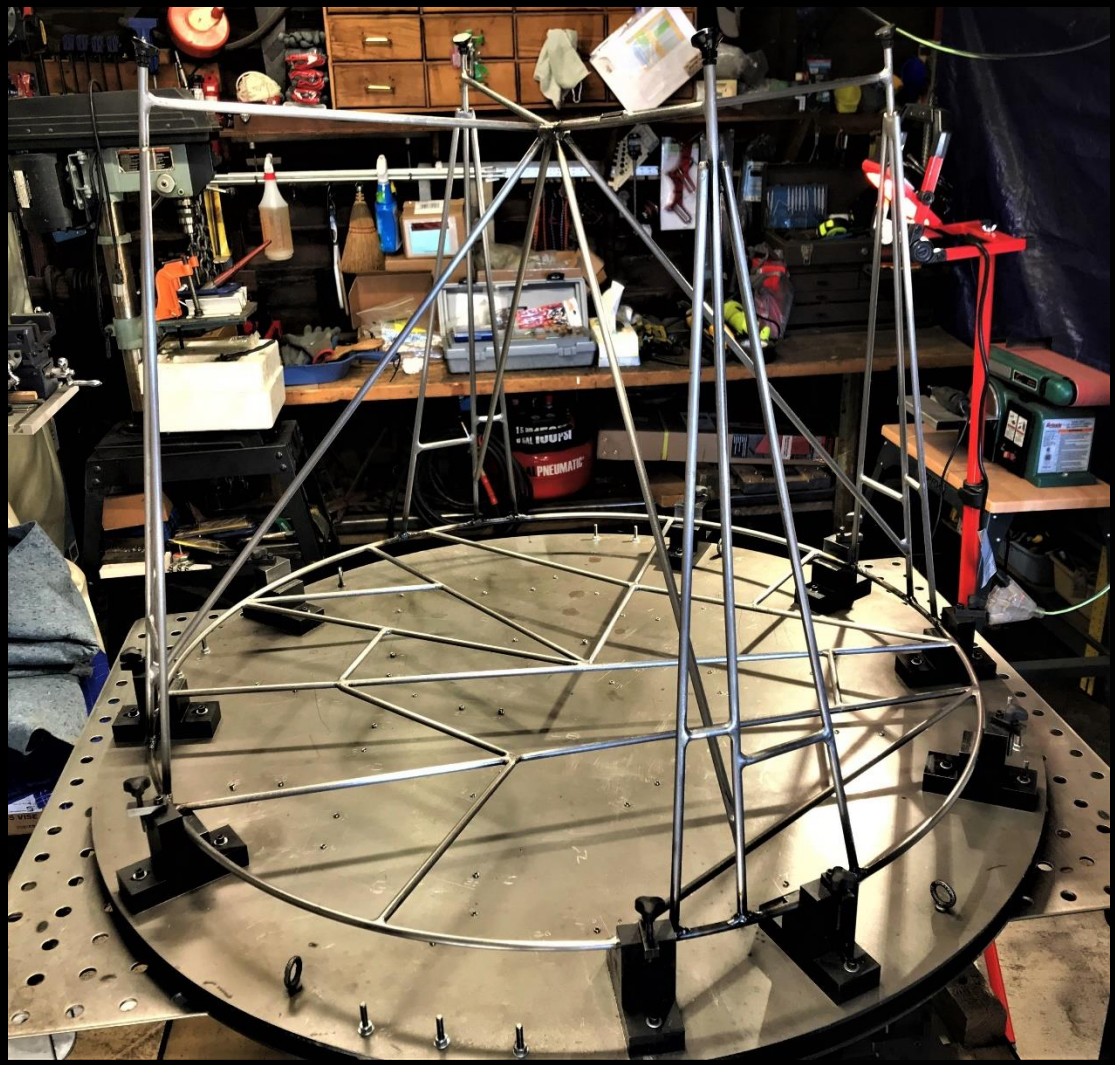
Tack Welding Legs To The Table Top Ring: The cross braces are tack welded in the center and on the bottom of where the center braces meet while clamped with the sheet metal vice grips. I removed the clamps and then added some additional radial welds between each of the adjoining cross braces. After tack welding the center cross braces, I used the ring gauge to check on the relative position of each leg.



Tack Welding Legs To The Table Top Ring: After tack welding the 4 center braces, I can now tack weld the rod segments to the table top ring. The legs are tack welded so they are held in place on the table top ring center line. The assembly locating blocks do not allow me enough room to complete welding the legs to the top. The assembly locating blocks must be removed from the base plate and the welds finished on the "A" & "B" sides clamped in the weld shoes. The picture, above right, shows the top of the leg rod segment tack welded to the table top ring. All of the leg rod segments will have similar welds. However small these welds appear, the legs will not move.



Finish Welding "A" & "B" Side Legs To The Table Top Ring: I have all of the legs tack welded to the table top ring and I have removed the assembly locating blocks. The base plate weld shoes will serve as the work holding device so I can finish welding the cross center braces and the "A" and "B" side welds for the legs to the table top ring. The leg "A" side welds are on the outside diameter, the "B" side welds are on the inside diameter.



Finish Welding "A" & "B" Side Legs To The Table Top Ring: The "A" & "B" side welds for each of the leg rod segments are now complete. Pictured bottom right, shows the finished leg segment welds. The legs segments are "over welded" to allow for the creation of a smooth, radial transition, back into the table top ring. The center cross braces are also finish welded (top right). I put a considerable amount of weld into this area to provide the necessary torsional strength and rigidity.

Finish Welding "A" & "B" Side Legs To The Table Top Ring: With the completion of the "A" & "B" side welds, I must now managed and handle the table as a single piece. I have installed the leveling feet in the center rod tapped holes as well. The table is level and strong and I am very happy with the performance of the fixtures and tooling in locating and positioning the table components. I will repeat the assembly process for table 2.

Finish Welding "A" & "B" Side Legs To The Table Top Ring: After installing the assembly locating blocks again, I repeated the process to weld the second set of legs to table #2. Tack welding first and then finish weld. Now, I have two tables with rough welding complete. The welds now have to be ground and hand filed to create smooth transitions into the table top ring.

I have completed welding the assembly of legs to the table top for tables ISC-00001 and ISC-00002. The assembly welds now need to be ground and hand filed to create smooth radial transitions where they meet.

Semi-Finish "A" & "B" Side Assembly Welds: The table is now one single welded piece. This requires some creative adaptation in how I hold and finish the rough welds on the table top ring. The center cross brace "group welds" also have to be ground and finished. It takes me approximately 55 man hours to develop the welds into smooth transitions after one table top assembly. However, I am not working 8 hours a day on them, so it might take me a couple of weeks to semi-finish the weld transitions.

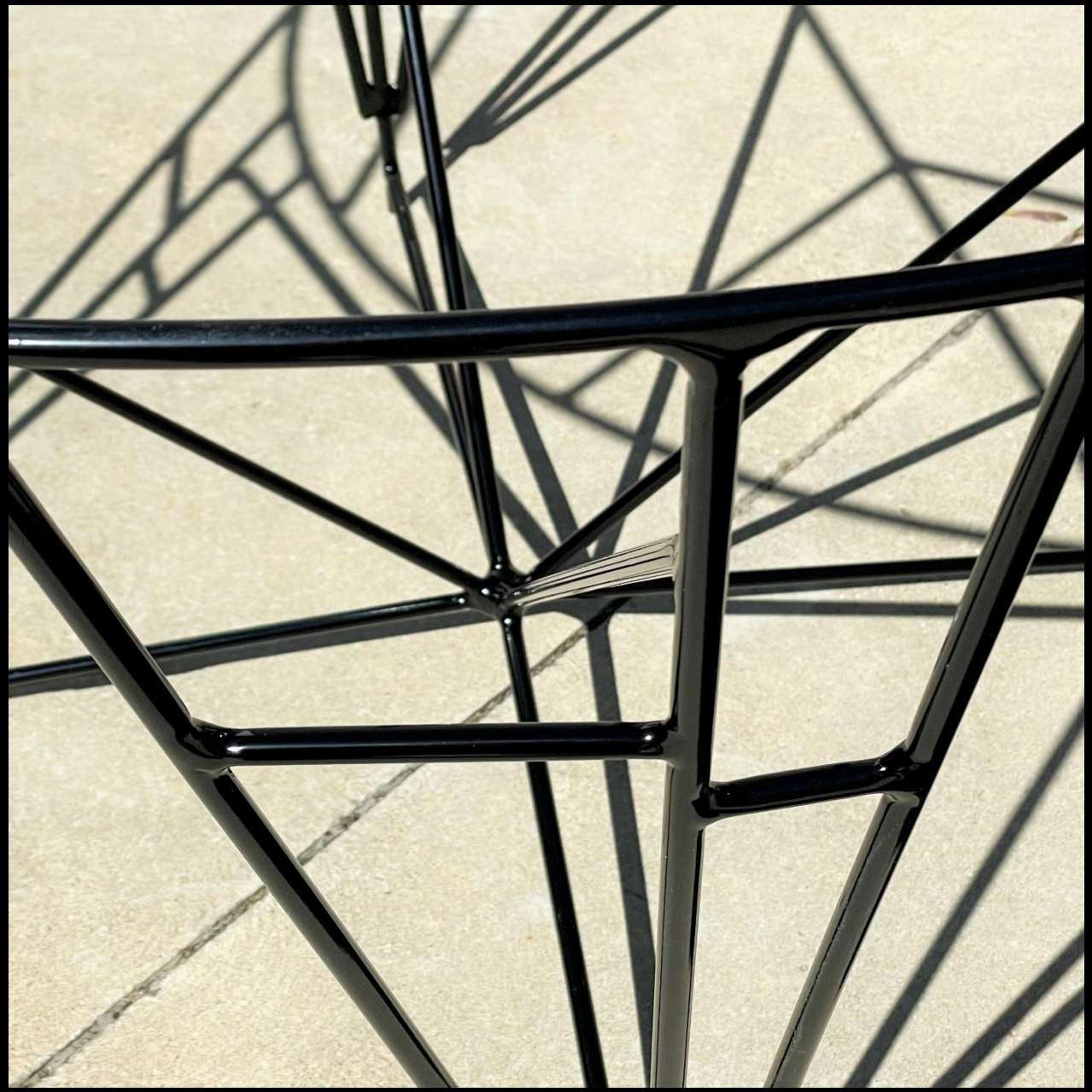
Semi-Finish "A" & "B" Side Assembly Welds: This is my table ISC-00001. It is the first table that I have welded and semi-finished. I must also get table ISC-00002 in the same condition. The next step in the finishing process is to powder coat both tables. Powder coating is a process that uses an electrical charge on the metal surface to be coated. Powdered paint when sprayed on the metal will adhere to all of the surfaces evenly. The coating is then baked in an oven at approximately 400 degrees to create a very smooth, strong and durable coating over the entire surface.

Sandblast Tables For Powder Coating: The first step in the powder coating finishing process for my tables, is to sandblast them to remove any dirt, oil, weld discoloration and loose metal fragments. The sand or media blasting process also creates a texture on the metal surface that allows the powdered paint to better adhere to it. My once shiny metal tables are now a dull gray color after sandblasting. The sandblasting was performed by my powder coating vendor as part of the powder coating process.

Powder Coating Tables ISC-00001 & ISC-00002: Next, I need to choose a powder coating color to apply to my tables; that can be a challenge. There are thousands of colors to choose from and custom colors can be mixed to create your own unique color. In this case, the color choice for coating both of the tables was Gloss Black. The sample shown above is for reference only.

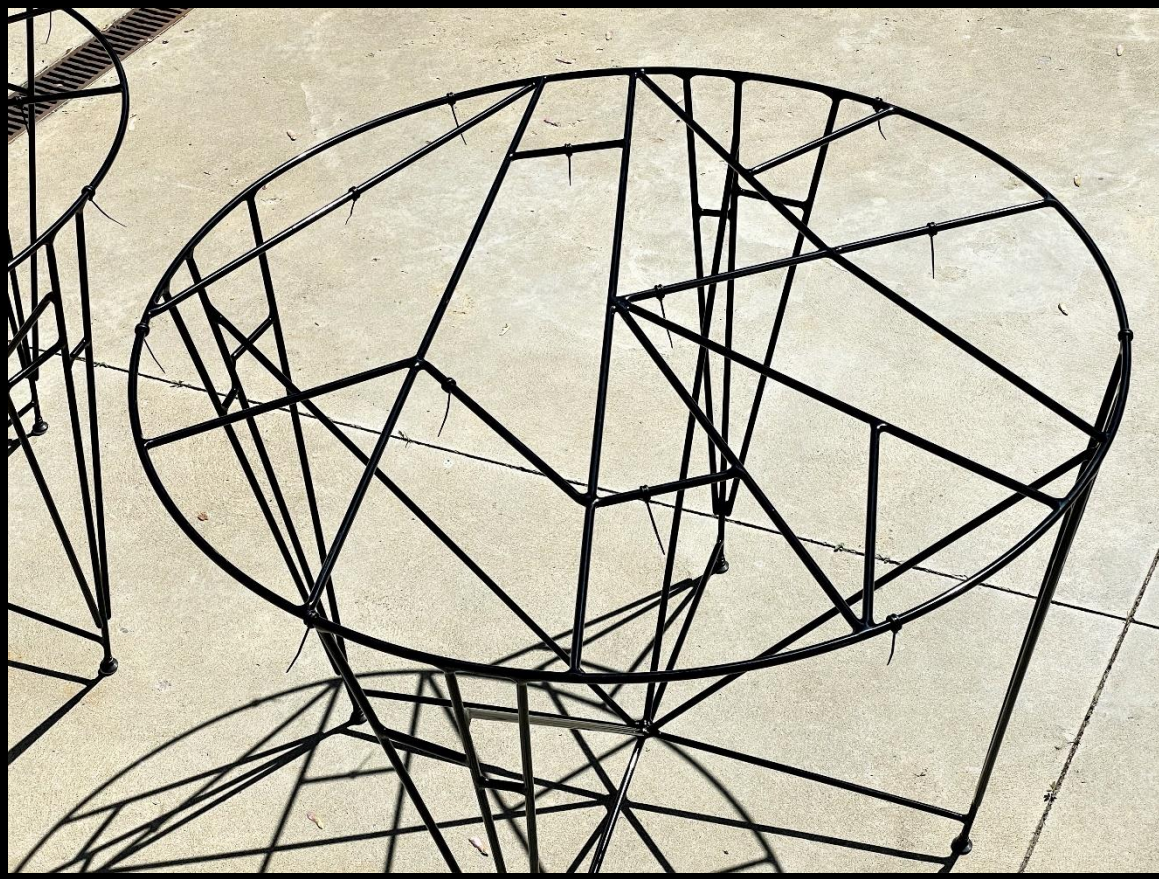
Powder Coating Tables ISC-00001 & ISC-00002: Time to powder coat. I have delivered my two tables to the powder coating vendor to get coated and baked in the oven.

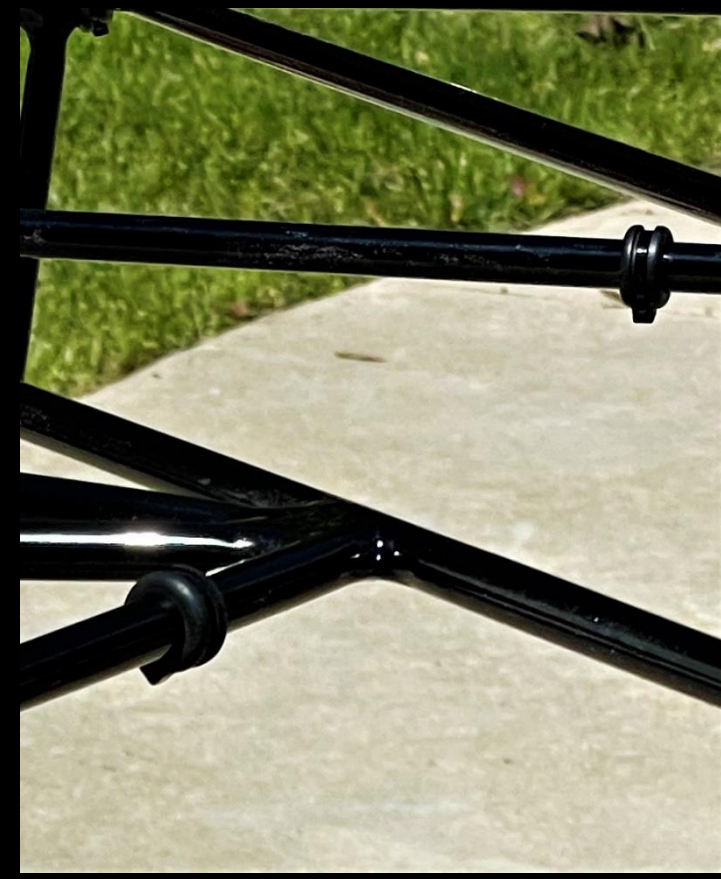
Powder Coated Tables ISC-00001 & ISC-00002: Powder coating is complete. My tables have been powder coated in the gloss black color that was selected.



Powder Coated Tables ISC-00001 & ISC-00002: The coated table finish and texture is smooth, very high gloss in color and coated in a uniform thickness of approximately 5mm.

Tables ISC-00001 & ISC-00002 Install Leveling Feet (Pads Optional): Now that the tables are powder coated, I can re-install the table's leveling feet into the leg center rod. The Leveling feet swivel on a ball, allowing 10-15 degrees of articulation and up to 1 inch of height adjustment. The leveling feet are made of steel. If the table is going be placed on hardwood flooring or tile, I will apply a felt pad to the bottom of the feet to prevent any damage to the floor and it can be moved easily.





Tables ISC-00001 & ISC-00002, Install Table Grommets: The plate glass I ordered that will sit on the table top is a 1/2 inch thick, 48 inches in diameter and weights 80 lbs. The glass top cannot sit directly on the powder coated steel; it needs a flexible cushion and something to keep it from sliding around. I decided to use rubber grommets with an outside diameter large enough to provide adequate cushion for the plate glass top and an inside diameter that fits the steel rod. The grommets are cut so they open and are strategically placed on the outside diameter of the table top ring and on the rods in the interior. The grommets by design, have a groove in the center. The groove allowed me to use a thin but strong zip tie to hold them in place. I found this approach to work very well to cushion the glass and keep it in place, while keeping the glass top off the steel surface.

Table ISC-00001 Complete

Table Construction Details:	
Material: 1018	3/8, 1018 Cold Rolled Steel, 57-12 ft. Bars
Steel Bar, Total Linear length, 1 Table	80 Linear Feet
Circular Ring, Top 42 Inches Diameter	13 Linear Feet
Top & Components	64 Linear Feet
Single Leg	11.5 Linear Feet
4 legs	45.7 Linear Feet
Table Top Construction	15 Steel Components
Leg Construction (1 Leg)	7 Steel Components
Center Leg Construction	1 Leveling foot, Tapped Hole, ¼ -20 Thread
Top, Number of Welds	57 (1 Butt Weld For Circular Ring)
1 Leg, Number of Welds	28
4 Legs Number of Welds	112
Mating welds, Legs To Top	20
Total Number Of Table Welds (A & B Sides)	189
Top Diameter	42 Inches
Top Diameter With Glass	48 Inches
Table Height	30 Inches
Table Leg Angle	7 Degrees Inboard From Vertical
Table Weight	30 lbs.
Glass (1/2 Inch Beveled Plate Glass)	82 lbs.
Weld Base Plate, ¼ A36 Steel Plate (Top)	48 Inches Diameter
Weld Base Plate (Top)	86 ¼ -28 Tapped Holes
Weld Shoes & Clamps, 1018 Steel (Top)	10
Weld Positioning Blocks & Clamps, 1018 Steel (Top)	24
Weld Base Plate, ¼ A36 Steel Plate (Legs)	12 X 24 Inches
Weld Base Plate (Legs)	26 ¼ -28 Tapped Holes
Weld Base Plate, Positioning Blocks & Clamps (legs)	10
Assembly Weld Blocks & Clamps, 1018 Steel	4
Assembly Ring Gauge, ¼ A36 Steel Plate	1
Weld Method, MIG Welding, Gas Shielded, Wire Feed	.035 Wire, Gas: Argon 75% / CO2 25%
Approx. Man Hours To Weld, Grind, Finish 1 Table	320