Instruction Manual for 7617
Quick Hoops™ Elliptical High Tunnel Bender

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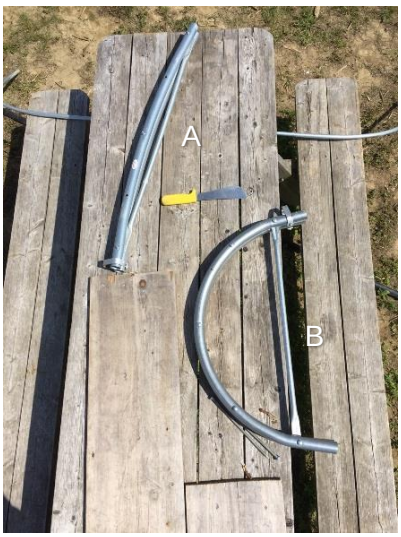
Overview:

This bender allows you to make spacious 24’ wide tunnels at any desired length using 3 pieces of 1 3/8” diameter chain-link fence top rail bent into long-radius hoops and connected to form 24’ wide bows, then placed atop high ground posts created with 1 5/8” diameter 8' chain link line posts. These structures are designed **for use only in areas with little or no snow load**, or alternately as three-season structures in any location by removing the main sheet of greenhouse film before snowfall occurs.



Contents

This bender set includes two separate jigs. One for the long radius across the top of the hoops (A), and one for where the hoops meet the ground posts (B). This second jig is actually our 3' wide Quick Hoops Low Tunnel Bender, which can be used to make 3’ wide by 4.5’ tall low tunnel hoops out of ½” EMT like the ones shown to the right.

The set also includes required mounting hardware for both jigs and a lever bar for the long radius bender.

Materials:

An Excel spreadsheet calculator has been developed to allow you to custom design a tunnel to meet your own operational and financial needs. It may be downloaded from the product page for the **7617 Quick Hoops™ Elliptical High Tunnel Bender** or from the **Growers Library** on our website.

Simply input the values in the different option boxes on the upper left and the spreadsheet will automatically tell you the following:

- How many of each component you will need
- Suggest where you can purchase them
- Give you a square footage calculation
- Estimated total cost calculation
- Cost per square foot

It will allow you to quickly see cost estimates for different tunnel options and allow you to quickly determine which ones meet your needs and your budget.

Johnny's Selected Seeds

Quick Hoops™ Fixed Traditional 24 ft. Wide Elliptical High Tunnel Calculator

Fill in the items in red below and the calculator will do the rest.

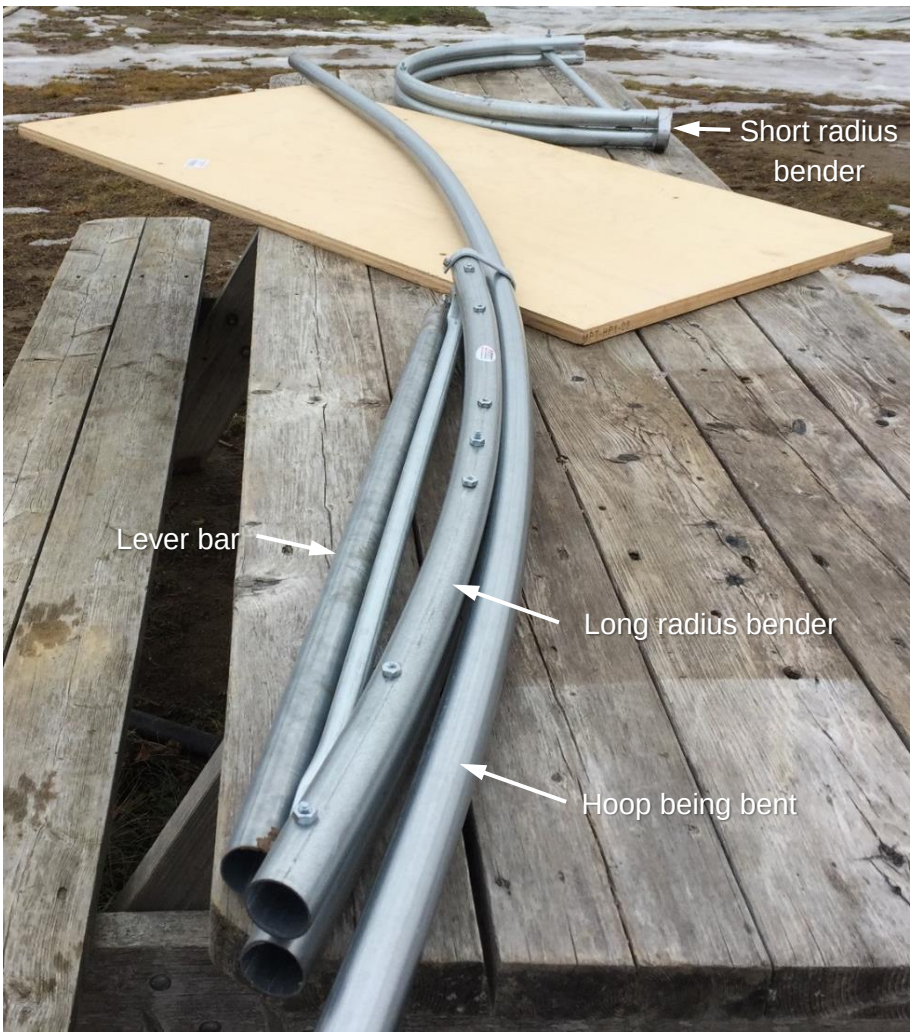
Dimensions, Spec's				Square Feet	2400
Length	100	feet	Enter length here. Must be divisible by spacing.	Cost / Sq. Ft.	$2.21
Spacing	4	feet	Enter spacing here.		
# Segments	25				
# Bows	26				

1	# Low cost scissor doors
1	# End walls with doors (per our instructions)
	No end walls (do not calculate them)
2	# of Purlins (optional)
x	Handcrank auto-stop roll-up sides
	No roll-up sides at all (shorter tunnels only)
x	Weed barrier at base of tunnel walls
	No weed barrier

Qty	Unit	Part#	Vendor	Description	Price	Ext
Special Tools					**Subtotal:**	**$152.00**
1	each	7617	Johnny's Selected Seeds	Quick Hoops **Elliptical** High Tunnel Bender	$119.00	$119.00
1	each	9482	Johnny's Selected Seeds	Ground Post Driver	$33.00	$33.00
Frame Components					**Subtotal:**	**$1,721.43**
78	each	181697	Home Depot	10 ft lengths of 1-3/8 in. top rail for hoops	$9.37	$730.86
31	each	181697	Home Depot	10 ft lengths of 1-3/8 in. top rail for ridge pole and purlins	$9.37	$290.47
4	each	181697	Home Depot	10 ft lengths of 1-3/8 in. top rail for angle braces	$9.37	$37.48
52	each	623105	Home Depot	8 ft lengths of 1-5/8 in. line post for ground posts	$12.35	$642.20
3	each	2405	www.boltdepot.com	#10 x 3/4 in. hex-head self-tapping screws, box of 100	$3.82	$11.46
4	each	BB13	www.chainlinkfittings.com	1 3/8 in. brace bands	$0.35	$1.40
12	each	BB15	www.chainlinkfittings.com	1 5/8 in. brace bands	$0.39	$4.68
16	each	CB51614	www.chainlinkfittings.com	5/16 in. x 1.25 in. carriage bolt with nut	$0.18	$2.88
Hipboards					**Subtotal:**	**$319.29**
18	each	253944	Home Depot	5/4 in. x 6 in. x 16 ft. deck boards	$16.27	$284.73
108	each	2777	www.boltdepot.com	5/16 in. x 3 in. carriage bolts	$0.21	$22.68
108	each	2977	www.boltdepot.com	5/16 in. flat washers	$0.06	$6.48
108	each	2649	www.boltdepot.com	5/16 in. hex nuts	$0.05	$5.40
Baseboards					**Subtotal:**	**$451.61**
22	each	253944	Home Depot	5/4 in. x 6 in. x 16 ft. deck boards	$16.27	$349.81
52	each	12529	www.boltdepot.com	5/16 in. x 7 in. J-bolt with hex nuts	$1.38	$71.76
76	each	2777	www.boltdepot.com	5/16 in. x 3 in. carriage bolts	$0.21	$15.96
128	each	2977	www.boltdepot.com	5/16 in. flat washers	$0.06	$7.68
128	each	2649	www.boltdepot.com	5/16 in. hex nuts	$0.05	$6.40
2	each	320858	Home Depot	6 ft lengths of 1-5/8 in. line post for stabilizing posts	$14.48	$28.96
Covering					**Subtotal:**	**$1,618.34**
1	each	7499	Johnny's Selected Seeds	Tufflite IV Greenhouse Film, 40 x 150 ft.	$589.00	$589.00
119	each	7040	Johnny's Selected Seeds	4 ft. lengths of Poly Latch Wire	$1.95	$232.05
51	each	7041	Johnny's Selected Seeds	8 ft. lengths of Poly Latch Channel	$10.15	$517.65
6	each	2525	www.boltdepot.com	#10 x 3/4 in. Phillips-head self-tapping screws, box of 100	$3.44	$20.64
1	each	9724	Johnny's Selected Seeds	Pro 5 Weed Barrier Landscape Fabric, 4 ft x 250 ft.	$193.00	$193.00
1	each	9723	Johnny's Selected Seeds	Anchoring Pins Fabric Staples, box of 500	$66.00	$66.00
Scissor Door(s)					**Subtotal:**	**$77.38**
1	each	2691	www.boltdepot.com	3/8 in. wing nut	$0.19	$0.19
1	each	2978	www.boltdepot.com	3/8 in. flat washers	$0.07	$0.07
1	each	329628	Home Depot	1-3/8 in. Kennel Clamp Set	$5.48	$5.48
3	each	2690	www.boltdepot.com	5/16 in. wing nut	$0.14	$0.42
2	each	BB13	www.chainlinkfittings.com	1-3/8 in. brace bands	$0.35	$0.70
2	each	CB51614	www.chainlinkfittings.com	5/16 in. x 1 1/4 in. carriage bolt and nut	$0.18	$0.36
4	each	ERC1313	www.chainlinkfittings.com	1 3/8 in. x 1 3/8 in. Rail End T-Clamp	$1.13	$4.52
5	each	181697	Home Depot	10 ft length of 1-3/8 in. fence top rail for scissor doors	$9.37	$46.85
4	each	2777	www.boltdepot.com	5/16 in. x 3 in. carriage bolts	$0.21	$0.84
6	each	2779	www.boltdepot.com	5/16 in. x 3.5 in. carriage bolts	$0.23	$1.38
1	each	654000	Home Depot	5/16 in. x 4 in. carriage bolt (fully threaded)	$0.46	$0.46
1	each	2648	www.boltdepot.com	5/16 in. hex nuts	$0.05	$0.05
1	each	654167	Home Depot	3/8 in. x 6 in. carriage bolt (fully threaded)	$1.10	$1.10
2	each	7035	Johnny's Selected Seeds	Snap Clamps for 1-3/8 in. Top-Rail, 10 pack	$7.48	$14.96
End Wall(s) with Doors					**Subtotal:**	**$306.26**
4	each	2777	www.boltdepot.com	5/16 in. x 3 in. carriage bolts	$0.21	$0.84
6	each	2779	www.boltdepot.com	5/16 in. x 3.5 in. carriage bolts	$0.23	$1.38
2	each	2784	www.boltdepot.com	5/16 in. x 6 in. carriage bolt	$0.39	$0.78
6	each	1065	www.boltdepot.com	5/16 in. x 4 in. lag bolt	$0.39	$2.34
12	each	2649	www.boltdepot.com	5/16 hex nuts	$0.05	$0.60
12	each	2977	www.boltdepot.com	5/16 in. flat washers	$0.06	$0.72
12	each	161667	Home Depot	2 in. x 4 in. x 12 ft. spruce, pine, or fir lumber	$5.99	$71.88
4	each	161659	Home Depot	2 in. x 4 in. x 10 ft. spruce, pine, or fir lumber	$5.05	$20.20
6	each	161640	Home Depot	2 in. x 4 in. x 8 ft. spruce, pine, or fir lumber	$3.55	$21.30
1	each	914681	Home Depot	1 in. x 4 in. x 8 ft. spruce, pine, or fir lumber	$4.58	$4.58
1	each	479652	Home Depot	1.25 in. drywall screws, 1 lb. box	$6.47	$6.47
3	each	333431	Home Depot	20-Gauge 1-1/4 in. x 9 in. Strap Ties	$0.84	$2.52
1	each	134380	Home Depot	#10 x 3 in. Phillips Bugle-Head Wood Screws, 1 lb. box	$7.98	$7.98
2	each	301878333	Home Depot	5/16 in. x 6 in. Heavy Duty Wood Screws, pkg of 10	$10.99	$21.98
2	each	335216	Home Depot	18-Gauge 3-1/4 in. Gusset Angle Corner Braces	$0.98	$1.96
1	each	320858	Home Depot	6 ft length of 1-5/8 in. line post for baseboard posts	$10.98	$10.98
8	each	208229	Home Depot	2 in. x 4 in. 20-Gauge Framing Brackets	$0.60	$4.80
8	each	461393	Home Depot	6 in. x 6 in. 14-Gauge L Straps	$3.97	$31.76
4	each	711786	Home Depot	4 in. Door Hinges	$2.98	$11.92
1	each	9604	Johnny's Selected Seeds	Coiled #9 Support Wire - 60'	$33.00	$33.00
2	each	292141	Home Depot	3/32 in.-1/8 in. Cable Clamps, pack of 4	$1.98	$3.96
2	each	117741	Home Depot	1/4 in. x 7-3/4 in. Zinc-Plated Turnbuckles with Hook & Eye	$1.93	$3.86
2	each	240664	Home Depot	6 in. Zinc Plated Heavy Duty Barrel Bolt	$7.87	$15.74
1	each	879282	Home Depot	8 in. Wooden Shims, bundle of 12	$1.82	$1.82
1	each	671223	Home Depot	3/8 in. x 36 in. Zinc-plated Threaded Rod	$2.87	$2.87
4	each	7242	www.boltdepot.com	3/8 in. nylock nuts	$0.08	$0.32
2	each	2978	www.boltdepot.com	3/8 in. flat washer	$0.07	$0.14
2	each	9673.500	Johnny's Selected Seeds	Small Hand Tool Replacement Handles	$10.20	$20.40
Roll-up Sides					**Subtotal:**	**$648.33**
21	each	181697	Home Depot	10 ft length of 1-3/8 in. top rail for roll-up sides	$9.37	$196.77
2	each	203114	Home Depot	10 ft length of 3/4 in. top rail for Sidewall Hand Crank	$4.20	$8.40
2	each	7033	Johnny's Selected Seeds	Sidewall Hand Crank	$159.00	$318.00
10	each	7035	Johnny's Selected Seeds	Snap Clamps for 1-3/8 in. Top-Rail, 10 pack	$5.89	$58.90
1	each	1	www.parachute-cord.com	1000 ft. spool of white parachute cord for lacing	$42.95	$42.95
3	each	727401	Home Depot	#4 zinc plated steel screw eyes, pack of 25	$7.77	$23.31
All prices are estimates. Prices will vary and do not include shipping costs or tax.					**Total Cost**	**$5,295**

Click on part# to link to product's web page. Vendors and part#'s for pipe and other accessories are provided for your convenience only.
We have no affiliation with these companies, other than purchasing these supplies from them and finding their prices competitive.

Mounting the Bender Jigs:

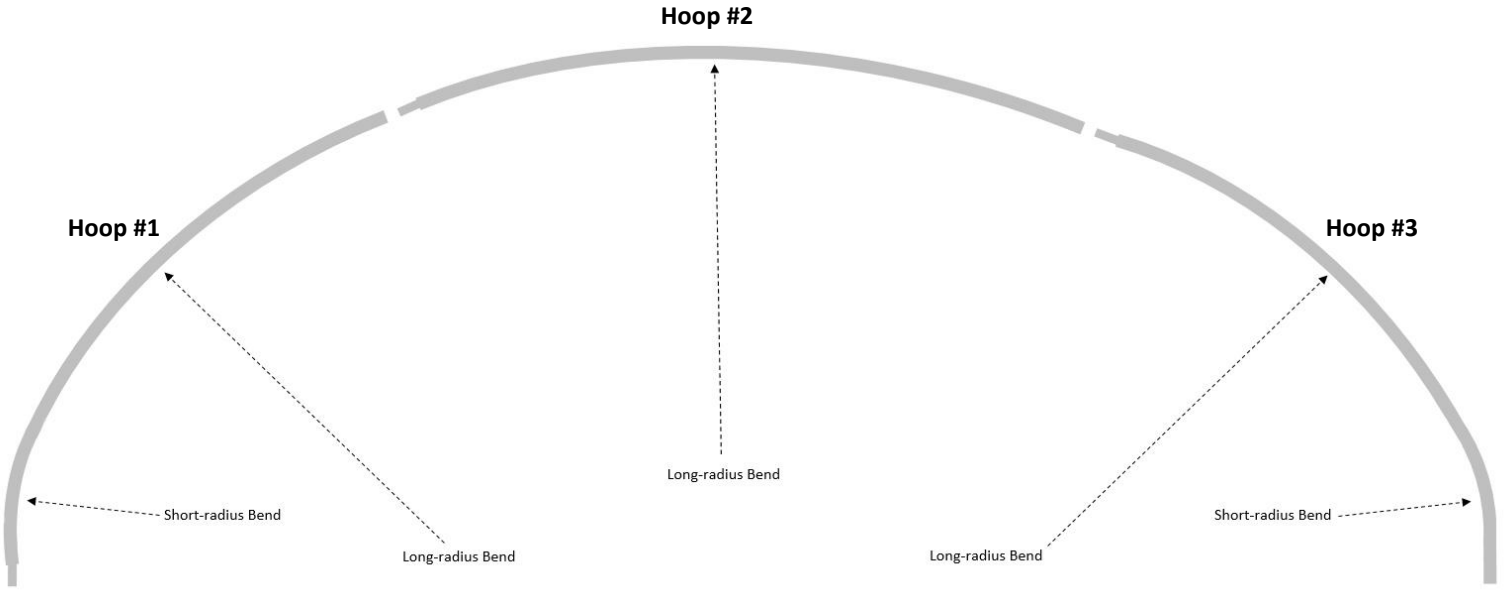


Both jigs may be mounted to any solid surface, such as a workbench, a picnic table, hay wagon, etc. They may be lag-screwed or thru-bolted into place. 5/16” mounting holes are pre-drilled in them and the screws, bolts, etc. to mount them are also included. By securing the jigs in fixed positions, and pulling the tubing around them, the operator can maintain precise control of the tubing being bent.

The long-radius bender jig, wherever mounted, must have enough room to accommodate the infeed and outfeed of pipe, as well as some type of support at the outfeed end about ¾” above the mounting surface. This will prevent "corkscrewing" and ensure that the hoops and ultimately the bows are created are in a single plane and not warped looking. This can best be accomplished with 3/4” plywood (shown here) secured with screws or nails to the surface of the table.

The short-radius jig does not require outfeed support, but must be mounted such that there is sufficient room for infeed.

Bow Assembly Diagram (3 **Hoops** are bent and connected to form each **Bow**):

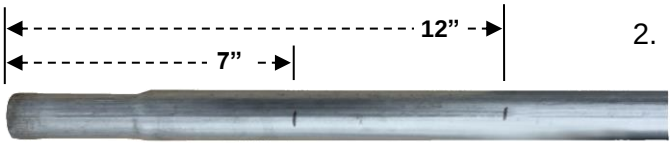


Bending the Hoops:

Hoop #1

1. After determining how many bows your high tunnel will have, set aside three times that number of top rail pipes so they can be bent.

2. Make two marks, **one at 7” and one at 12”**, from the **swaged (male) end** of the first pipe to be bent.



2.

Swaged end

3. Insert the swaged end of a pipe into the holding strap at the end of the **long radius bender**. Insert so that the **12” mark** is just to the **left** of the holding strap.


3.

4. With a smooth motion, pull back as if on a long oar (do not push), and bend the pipe all the way around the bender until the pipe just touches the bender at the end closest to you. Stop. Do not bend past the end, or the arc you create will not be smooth.

5. Release tension until the pipe is loose in the holding strap and move it through the holding strap about half the length of the bender itself. Twist the pipe with your hands so that the portion protruding past the holding strap is flat to the plywood before bending further. This will prevent corkscrewing of the pipe. It is best (but not necessary) if another person stands on that portion of pipe intermittently while bending.


4. - 6.

6. Repeat steps 4 and 5 until about 3’ of unbent pipe remains beyond the closest end of the bender, or if bending becomes difficult.

7. Insert the smaller (male) end of the lever bar into the female end of the pipe. This effectively makes the pipe longer and will instantly give you more leverage for bending the rest of the pipe.

7.

8. Continue, repeating steps 4 through 7 until the rest of the pipe is bent. Remove the lever bar from the pipe and the pipe from the bender.

9. Drive a wood screw or nail **6” away from the center bolt** of the short radius bender. This measurement is an approximation and may have to be altered after the first hoop has been completed.


9.

10. Insert the swaged end of the partially bent pipe into the holding strap at the end of the **short radius bender**. Insert so that the **7” mark** is just to the **left** of the holding strap.

11. Pull back and bend around the short radius bender until the pipe just touches the wood screw or nail from step 9. See photos bottom right.

12. Remove the pipe from the bender. This is Hoop #1.

Hoop #2

13. Insert the swaged end of the pipe into the holding strap at the end of the **long radius bender**. This pipe does not need to be marked. Insert **just past the swage** to prevent canting or kinking that portion of the pipe.

14. Perform steps 4 through 8 for the entire length of the pipe.

15. This is Hoop #2.

Hoop #3

16. Make two marks, **one at 7” and one at 12”**, from the **non-swaged (female) end** of the next pipe.

17. Insert the non-swaged end of the pipe into the holding strap at the end of the **long radius bender**. Insert so that the **12” mark** is just to the **left** of the holding strap.

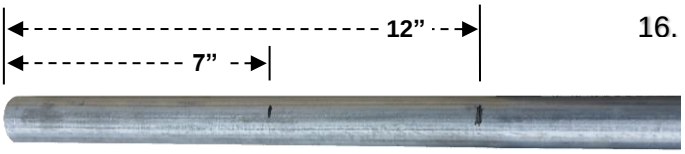
18. Perform steps 4 through 8 for the remaining length of the pipe.

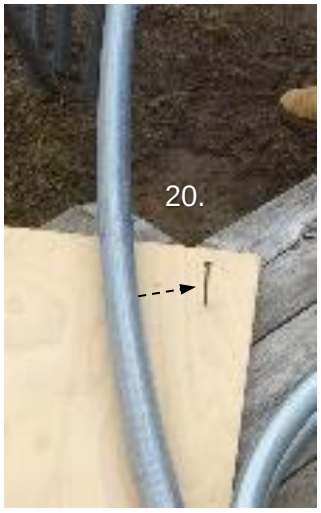
19. Insert the **non-swaged end** of the partially bent pipe into the holding strap at the end of the **short radius bender**. Insert so that the **7” mark** is just to the **left** of the holding strap.

20. Pull back and bend around the short radius bender until the pipe just touches the wood screw or nail from step 9.

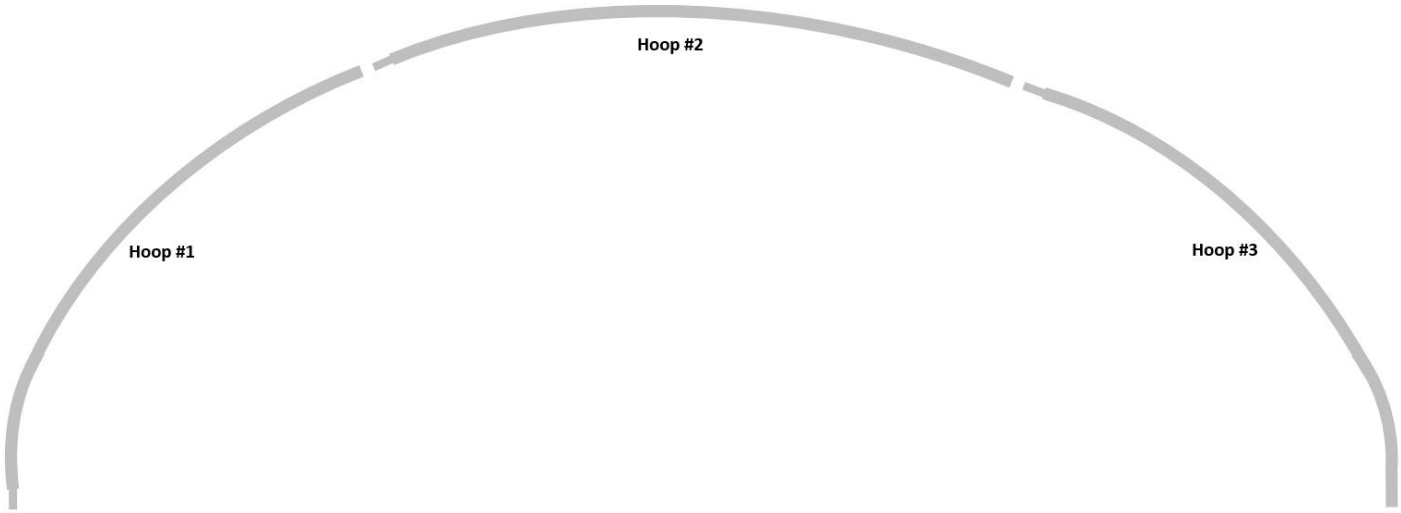
21. Remove the pipe from the bender.

22. This is Hoop #3.



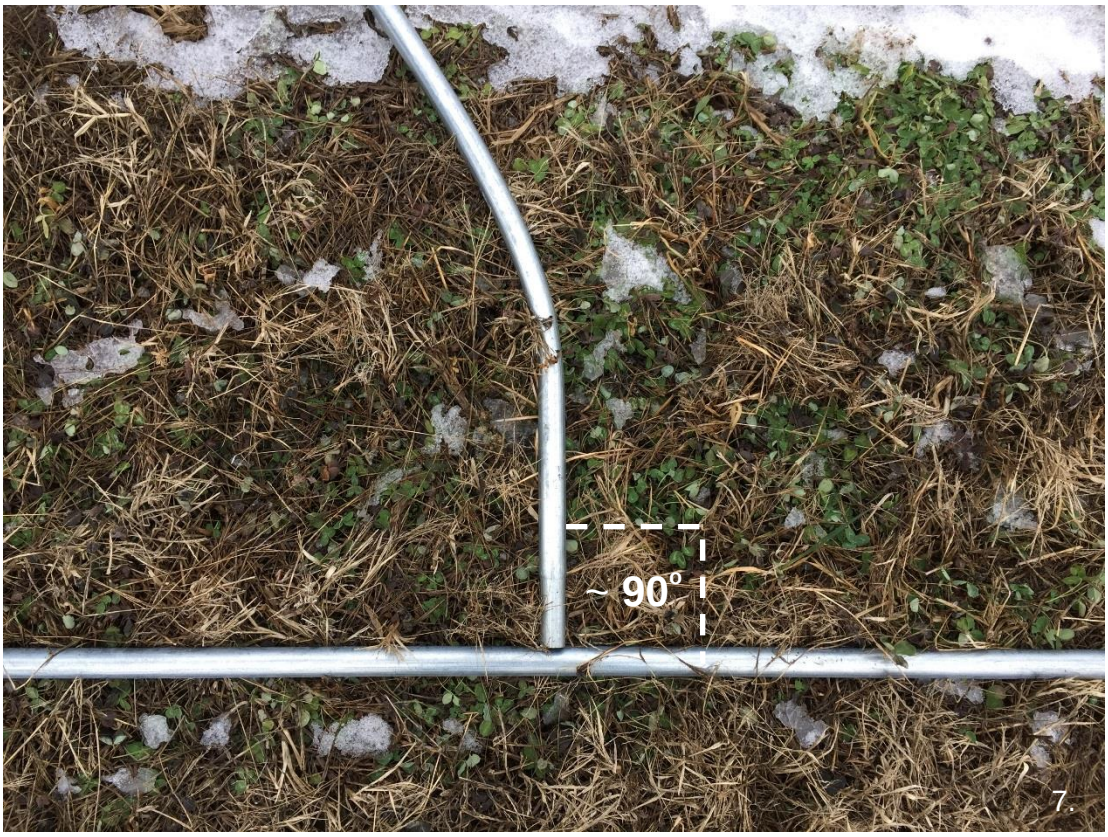


Assembling the Bows:



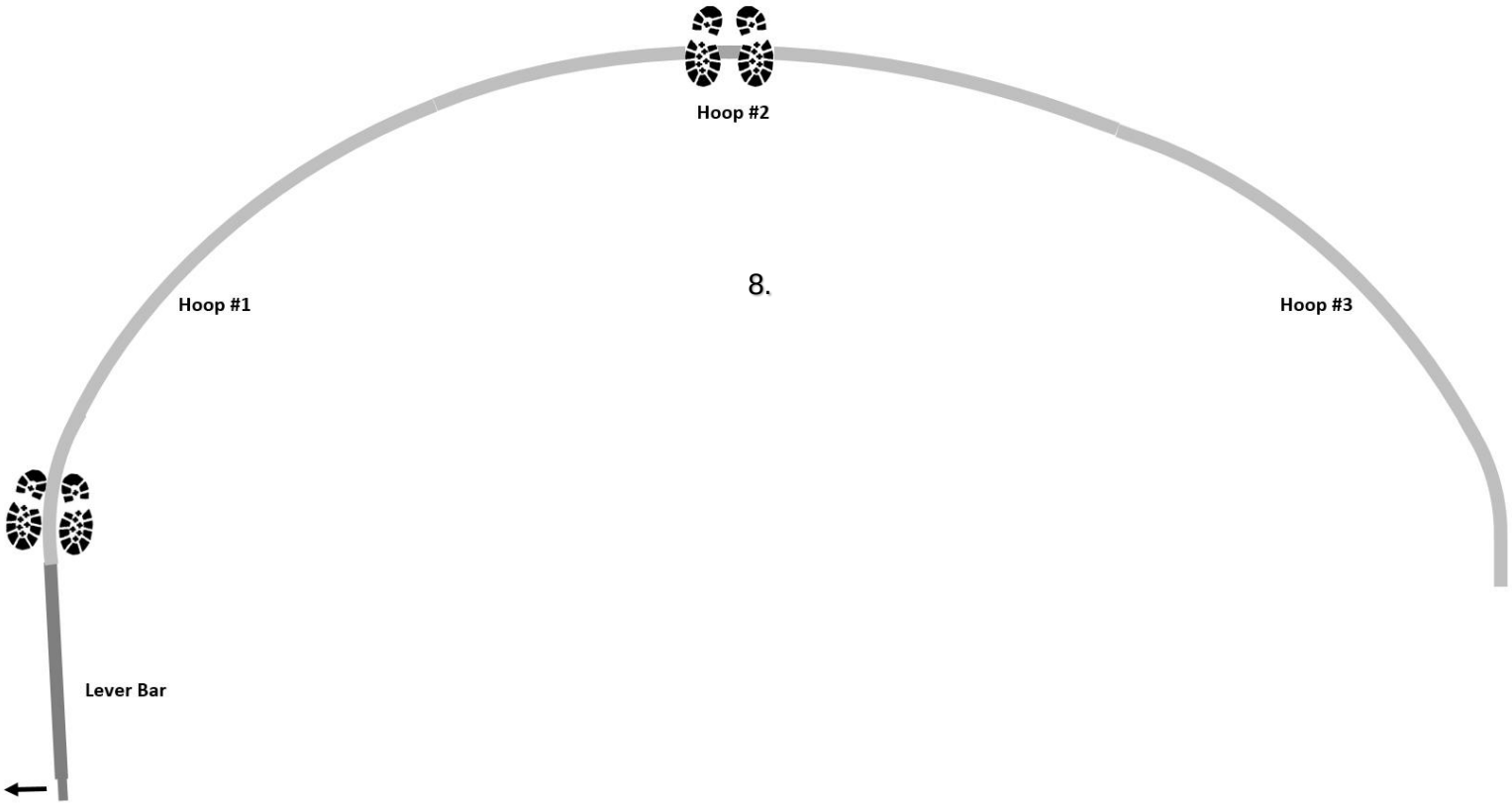
1. In a flat area, lay out Hoop #1, #2, and #3 as shown in the diagram above.
2. Insert the swaged end of Hoop #2 into the non-swaged end of Hoop #1.
3. Insert the swaged end of Hoop #3 into the non-swaged end of Hoop #2.
4. Drive a self-drilling tek screw through both of the connections created in steps 1 through 3.
5. Flip the hoop over and repeat for the opposite side.
6. Lay out three pieces of pipe at the base of the now connected hoops and connect them similarly. This will serve as a straight edge.

7. Variances in wall thickness between different lots of top rail can cause the bend radius to vary. The bottom portions of the bow (shorter sections of Hoop #1 and Hoop #3) should be at a right angle to the straight pipes. If they are, repeat steps 1 through 22 of Bending the Hoops and steps 1 through 5 above for the remainder of the hoops. If not, proceed as follows:



7.

8. With one person standing on the peak of the assembled bow and one standing with one foot firmly on each side of one of the short radius bends, use the lever bar to bend the bottom of the bow until it is at a right angle to the straight edge pipes. Generally, both sides will be either ‘toed in’ or ‘toed out’. Repeat for the opposite side as necessary.



8.

9. If the bow ends were ‘toed in’, remove the wood screw or nail from step 9 of Bending the Hoops and set it at 7” away from the center bolt of the short radius bender.

10. If ‘toed out’, remove the wood screw or nail from step 9 of Bending the Hoops and set it at 5” away from the center bolt of the short radius bender.

11. Repeat steps 2 through 12 of Bending the Hoops and 1 though 5 of Assembling the Bows for the next bow.

12. Lay this bow over the first bow and determine if moving the screw or nail has corrected the problem.

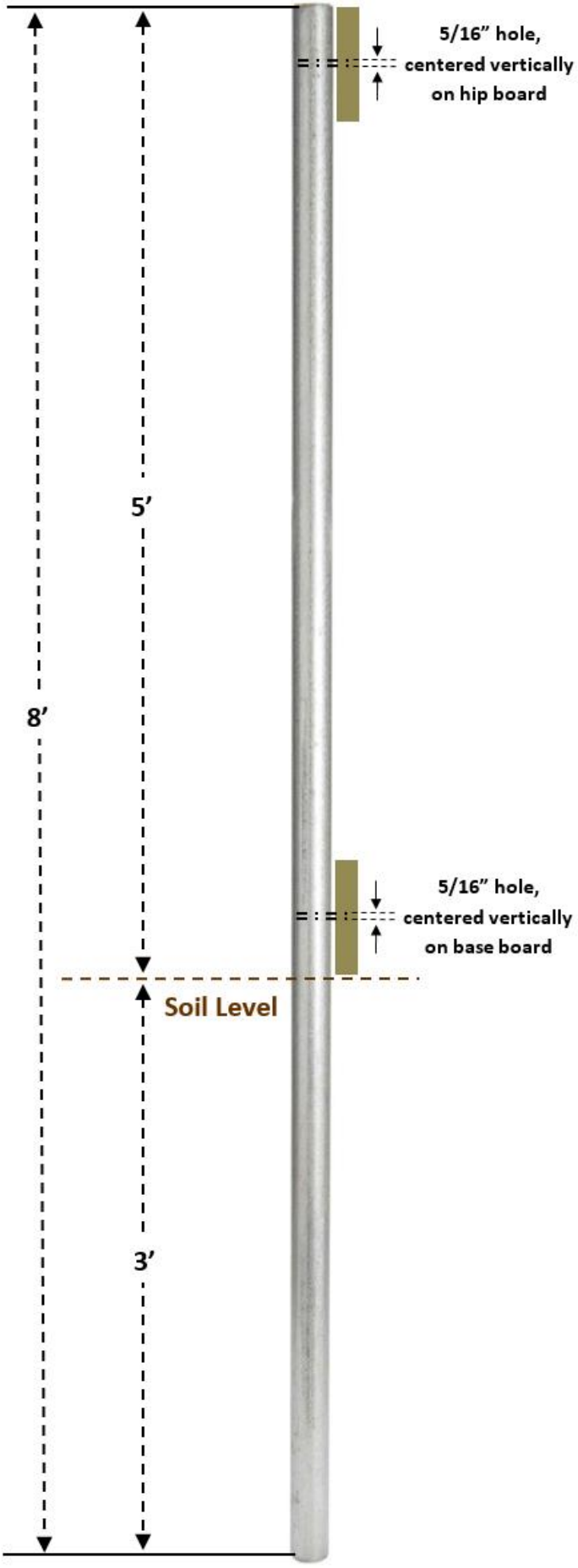
13. Adjust the screw or nail and repeat steps 11 and 12 as necessary.

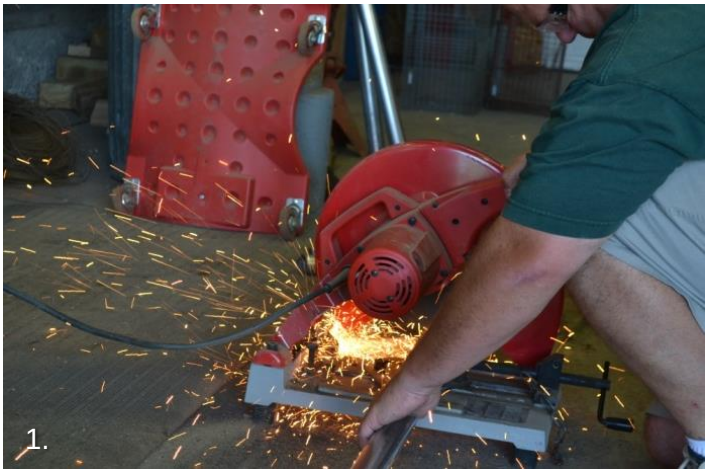
14. Once corrected, repeat steps 1 through 22 of Bending the Hoops and steps 1 through 5 above to create the rest of the bows.

Creating ground posts from chain link fence posts

Ground posts are made from 1-5/8” chain link fence "line post" material, which is commonly available in 8 ft. lengths. 3 ft. of the post will be driven in the ground, leaving 5 ft. exposed, for nice, high sidewalls (see diagram to right).

No prefabrication is necessary for these, unless desired. We simply drilled through the pipes and then the boards during frame assembly.

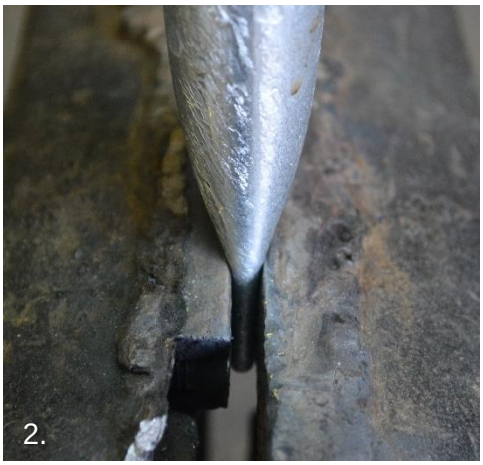


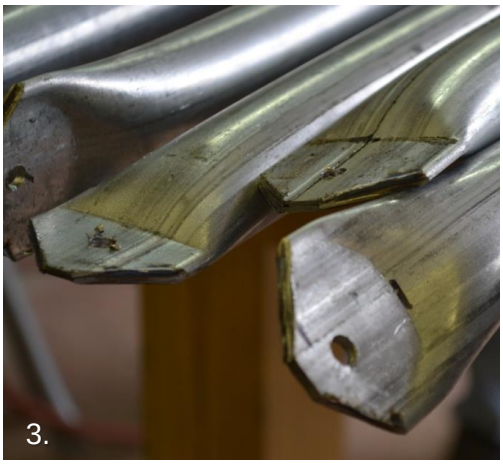


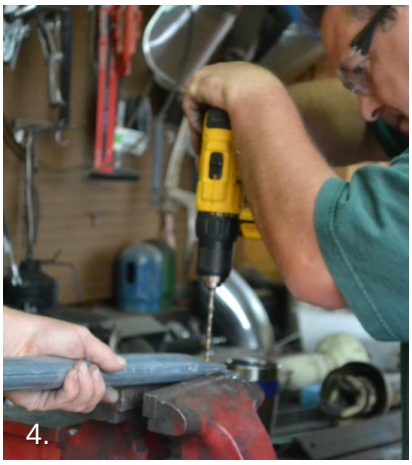
Creating Angle Braces:

1. Eight angle braces (four for each end of the tunnel) must be made from four pieces of 1-3/8" top rail. These pieces should be about 5 ft. long (exact length is not critical). Do this by cutting the swaged end off the top rail and then cutting it in half.

2. Flatten the ends with a large bench vise or hammer; ensure that the ‘flats’ face the same direction.







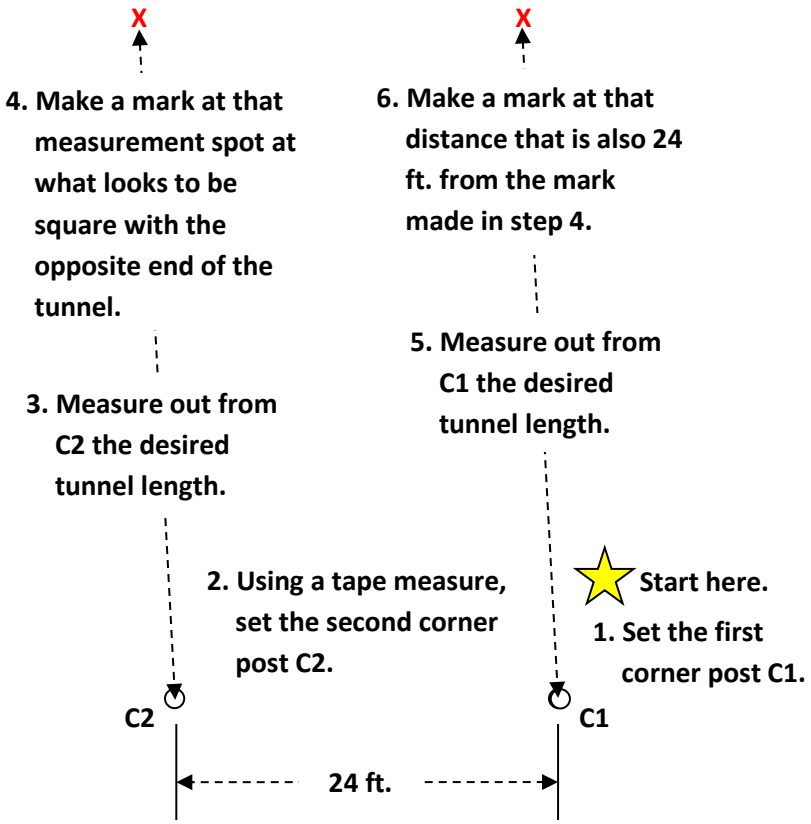
3. 'Dog ear' cut both corners off each end.

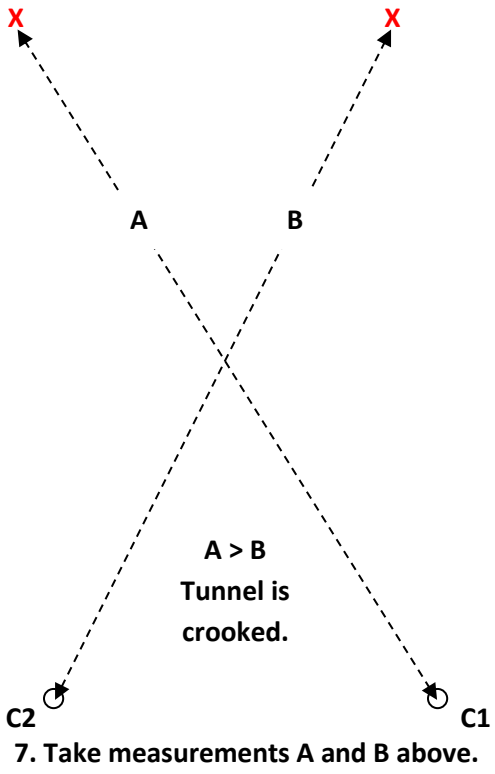
4. Pre-drill each end with a 5/16" drill bit.

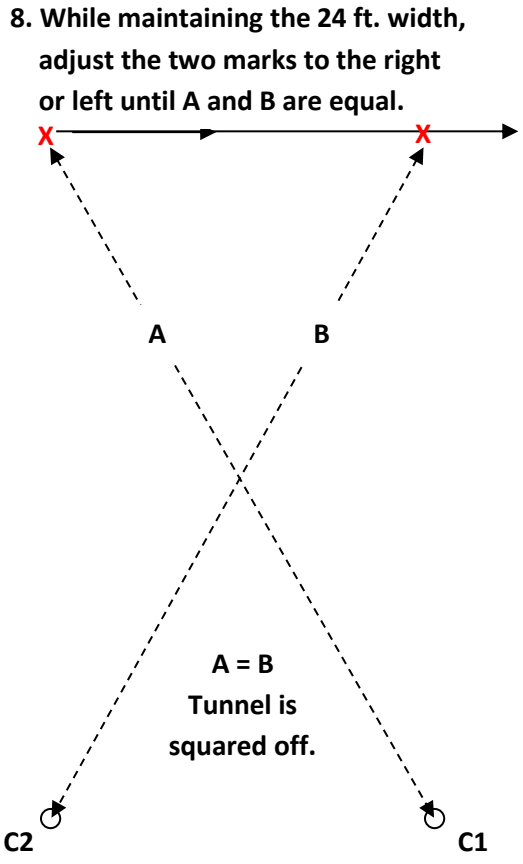
5. De-burr any cut ends of the pipe and pre-drilled holes using a hand file, die grinder, or bench grinder. It may be necessary to ream out the holes after deburring by re-drilling.

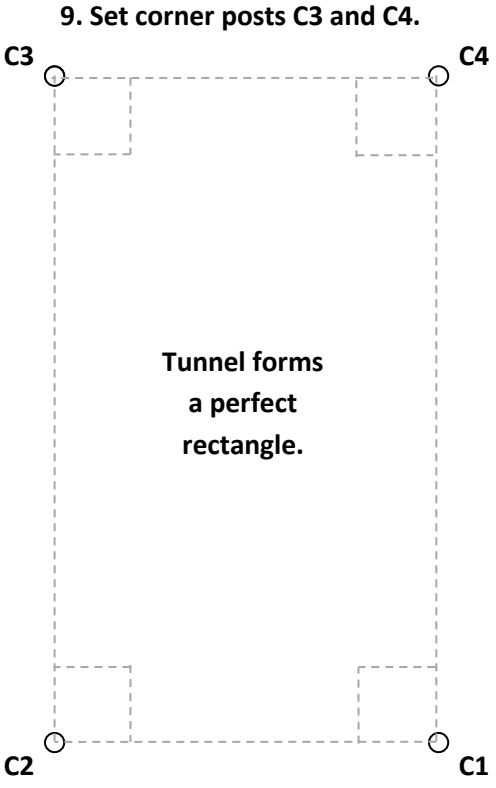
Hints on setting the corner ground posts:

Use the following diagrams to help you set the corner posts in a perfect rectangle.









Site preparation and setting the ground posts:

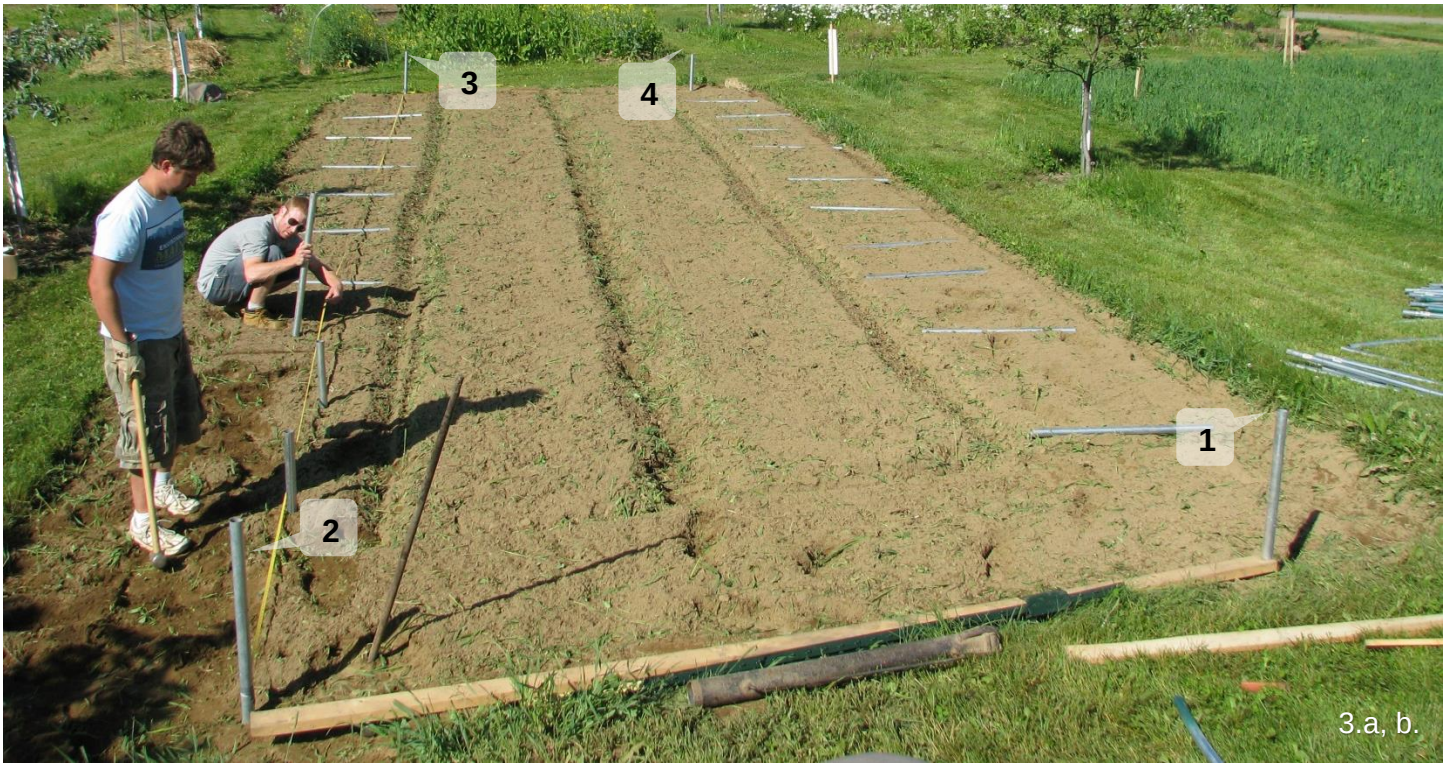
Note: *Some of the following photos (like the one at the bottom of this page) will not be of this exact tunnel, but they will illustrate the subject matter at hand.*

1. Prepare the footprint of the tunnel as you would with open soil in a field.

2. **Weed Barrier** - An option to consider at this point is weed barrier along the edges of the tunnel. This is traditionally an area where weed control is difficult and some fabric that suppresses weeds can be very effective here. If you choose this option, proceed to step 4.

3. **If you choose to forgo weed barrier, proceed as follows:**

   a. Using a ground post driver and sledge hammer, set the four corner ground posts first per the diagram below. It is best to do this from a stable ladder and start the posts with someone else holding them vertical.



b. Run a long tape measure from corner post 2 to corner post 3. Secure one end to post 2. Pull it tight and secure the other end to post 3. Secure with duct tape, clamps, or something similar. This will serve as a gauge as well as a straight line for setting the other posts.

c. Using the long tape measure as a guide, set the rest of the posts for this side of the tunnel at your desired spacing (most often 4' apart).

d. Repeat steps b and c for the other side of the tunnel.

4. **If you <u>do</u> choose to use weed barrier, proceed as follows:**

a. Perform step 3.a. on the previous page to set and square the four corner posts.

b. If you have a pair of D-handle garden forks or spades, you can quickly set up your weed barrier on a makeshift spool such as this. This makes handling and cutting to length very easy. A piece of top-rail is used as the spindle. Position at one end of the tunnel location and offset, so that it faces down the side of what will eventually be the tunnel. Pull a few inches of the weed barrier off the roll, and with a utility knife, cut it down the center so that you have started two 2' wide strips.

c. Have one person hold the utility knife near the roll with the blade through the fabric, while one or two others pull the fabric off the roll and walk with it down the side of the plot until you reach the opposite end.

d. Cut it to length, leaving about 1' of overlap on each end. A yellow centerline mark should be conveniently placed at or near the center of each of the two 2' wide strips. Position each 24' apart on center and parallel.


4.g.


4. k.

e. Make a 2" long cut centered between the sides of the fabric (probably on the yellow line) that is about 1’ in from one end. Make just a single cut in line with the length of the fabric. Slip the corner post near this end of the fabric through the slit you just made. With only a single slit, the fabric will be somewhat snug against the post, which helps prevent weeds from growing up through the hole.

   <u>A tip about woven landscape fabric</u> - Keep the top of the weed barrier fabric free of soil as best you can. If soil is allowed to collect on it, weeds will likely germinate in that soil and root through the weed barrier, which will make them difficult to kill and remove by physical means.


4.i., j.

f. Go to the opposite end of the fabric, pull it straight and somewhat taught, and make a similar cut that is even with the corner ground post at that end. Slip it over the ground post and smooth out the weed barrier along the length of the tunnel.

g. Secure the edges of the weed barrier to the ground with fabric staples along its edges. A hammer is sometimes helpful in difficult soils.

h. Repeat steps 4.b through g. for the opposite side of the tunnel.

i. Run a long tape measure down the center of one of the pieces of weed barrier fabric and secure to the corner posts with clamps, etc.

j. Make 2" slits with a razor knife for the rest of the ground posts on that side of the tunnel. For example, make a cut every 4’ if your tunnel will have 4’ bow spacing.

k. Drive ground posts in each of the slits.

l. Repeat 4.i. - k. for the opposite side of the tunnel until all the ground posts are set.

JSS #9723
Fabric Staples, box of 500

Framing the Tunnel:

1. **Bows:** Transport the first “end wall” bow to the furthest corner ground posts and insert until the bow ‘seats’ firmly against the top of the ground posts. Repeat for all other bows.

2. **Ridge Pole:**

   a. Raise a piece of top-rail up pipe **over the top of the tunnel** near one of the end walls, center laterally, and secure the non-swaged (female) end of the pipe to the endwall bow with a cross-connector. Cross-connector bolts should be positioned on the inside of the tunnel and the end of the pipe should be flush with the outside of the endwall bow. Cover the end of the pipe with duct tape.

   Note: *If this end of the tunnel will have scissor doors, leave about 6” of pipe protruding past the end wall to attach the scissor doors to later on.*

   See page 31 for description and illustration of Scissor Doors.

b. Attach the end of a long tape measure to the end of the ridge pole with a clamp, etc. and run the tape measure reel to the opposite end of the tunnel. Center it laterally and leave it hanging off the opposite end wall bow so that its own weight is keeping the tape taught.

c. Adjust the position of the peak of the next bow so that it is 4’ from the previous bow and secure the ridge pole to that bow with a cross-connector.

d. Slide the non-swaged end of a piece of top-rail over the swaged end of the ridge pole. Secure together **from beneath** with a #10 x 3/4" hex-head self-drilling tek screw.

e. Using the tape measure as a guide, continue adding top-rail and securing with cross-connectors as above for the remaining length of the tunnel. When you reach the opposite endwall, the top-rail will likely be protruding past it. If this end will have scissor doors, leave 6” protruding and cut off the rest. Otherwise cut the pipe flush to the outside of the end wall and duct tape over the end.

f. Further secure all cross-connectors installed above from inside the tunnel with #10 x 3/4" hex-head self-drilling tek screws by screwing through the side of the cross-connector and into the bow and also through the side of the cross-connector and into the ridge pole. This will prevent any slippage later on.


2.b.


2.c.


2.d.

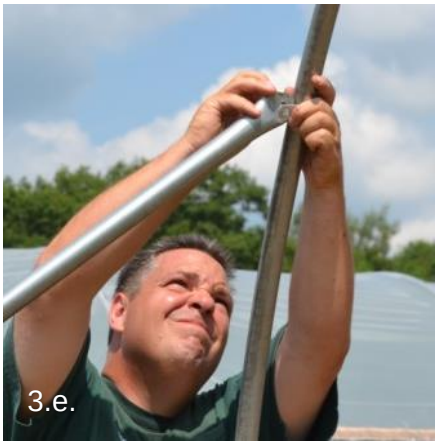

2.e.

3. **Angle Braces:** At this point, these must be installed so that all bows are vertical and plumb.


3.b.


3.c.


3.d., g.


3.e.


3.a. - g.

   a. In one corner of the tunnel, slip a 1-3/8" brace band over the end wall bow, two 1-5/8" brace bands over the second ground post, and one 1-5/8" brace band over the third ground post.

   b. Position the 1-5/8" brace band on the third hoop's ground post at ground level, with its tabs pointing toward the closest end of the tunnel, compress them with a pair of needle nose Vise Grips. Loosely secure one end of an angle tie to the brace band with a 5/16"-18 x 1.25" carriage bolt and 5/16" nut. Remove the Vise Grips.

   c. Raise the opposite end of the angle tie up and rest it against the next bow. Slide both 1-5/8" brace bands up the second ground post until the lower brace band is aligned to receive the end of the angle tie. Clamp in place with the Vise Grips. Loosely secure with a 5/16"-18 x 1.25" carriage bolt and 5/16" nut. Remove the Vise Grips.

   d. Position the second brace band on the second bow so that it is resting on the previously attached brace band and pointing toward the closest end of the tunnel. Clamp with the Vise Grips and loosely secure with a 5/16"-18 x 1.25" carriage bolt and 5/16" nut. Remove the Vise Grips.

   e. Raise the opposite end of the angle tie up and rest it against the end wall bow. Slide the 1-3/8" brace band up the end wall bow until the brace band is aligned to receive the end of the angle tie. Clamp in place with the Vise Grips. Loosely secure with a 5/16"-18 x 1.25" carriage bolt and 5/16" nut. Remove the Vise Grips.

   f. Using a plumb bob or long level, adjust the end wall bow so that it is plumb (vertically level). All bows should move together. While holding the end wall in that position, quickly tighten all the nuts on the angle ties' brace bands.

   g. Secure all brace bands installed above from inside the tunnel with #10 x 3/4" hex-head self-drilling tek screws by screwing through the side of the brace band and into the bow or ground post. This will prevent any slippage later on.

   h. Repeat steps 3.a. through 3.g. for all four corners of the tunnel.

4. **Purlins (optional):** These are horizontal pipes of top-rail, similar to the ridge pole, that are added for strength. They are **attached to the bows from beneath** to prevent collection of water and/or snow in the plastic pockets that would be created if they were attached to the top. You can install two, four, or none at all, depending on the desired strength. **We do not recommend trellising to them.** Install them the same way as the ridge pole, except cut them flush to the endwall of the tunnel. Do not forget to duct tape the ends and tech screw the cross-connectors and purlin joints.

   ***Note**: If this end of the tunnel will have scissor doors, leave about 6" of pipe protruding past the end wall on two of the purlins to attach the scissor doors to later on.*

5. **Hipboards:** We are using 5/4" x 6" x 16' decking for our hipboards and baseboards. You can choose to use any material you like. First, determine what height you would like your hipboards to be. Ours were about shoulder height, right at the top of the ground posts and offered very good ventilation.

   a. Measure and cut a 10' length of board to be used as the first section of hipboard (this measurement is based on 4' bow spacing to center board seams between bows. If you have different spacing, adjust as necessary). Clamp it to the top of the groundposts at the end of one side of the tunnel.

   b. With a 5/16" bit, drill through the groundpost and bow first, then through the hipboard. Fasten the end of the hipboard to the end wall bow with a 5/16"-18 x 3" carriage bolt inserted from the outside and secured with a flat washer and 5/16" hex nut. Repeat for the next bow.

   c. Clamp the next board in place at the top of the groundposts, abbutting the first.

d. Pre-cut and place a 2’ piece of patch board inside the seam created by the two hipboards. Center and clamp in place.

e. With a 5/16" bit, pre-drill four holes as shown through the patch board and the two hipboards. Fasten with four 5/16"-18 x 3" carriage bolts inserted from the outside and secured with flat washers and 5/16" hex nuts.

f. Repeat step 5.b. for each of the remaining bows the boards are attached to.


5.d., e.

g. Continue on down the tunnel, repeating steps 5.c. through 5.f. until the last hipboard is in place and a section of hipboard is protruding outward past the opposite end wall.

h. Cut the hipboard off flush with the outside of the end of the opposite end wall bow.

i. Repeat steps 4.a. through 4.h. for the opposite side of the tunnel.

6. **Baseboards:** These are installed the same way as the hipboards except for the fasteners used to secure them and the need to align them, since they lay flat against the ground.

   a. Measure and cut a 10’ length of board to be used as the first section of baseboard. Clamp it to the ground posts on one side of the tunnel. Similar to the first hipboard, this 10’ length will allow the baseboards to be joined in between the bows, where there is room to do so.

   b. With a 5/16" drill bit, drill through the ground post first, then through the baseboard. Fasten the end of the baseboard to the end wall ground post with a 5/16"-18 x 7" J- bolt inserted from the outside and secured with a flat washer and two 5/16" hex nuts.

   c. Clamp the next section of baseboard to the tunnel ground posts so that it butts up to previous one.


6.a.

6.b.

d. Pre-cut and place a 2’ piece of patch board inside the seam created by the two baseboards. Center and clamp in place.

e. With a 5/16" bit, pre-drill four holes as shown through the patch board and the two baseboards. Fasten with two 5/16"-18 x 3" carriage bolts inserted from the outside and secured with flat washers and 5/16" hex nuts.

f. Repeat step 5.b. for each of the remaining ground posts the baseboards are attached to.

g. Continue down the tunnel, repeating steps 5.c. through 5.f. until the last baseboard is in place and a section of baseboard is protruding outward past the opposite end wall. Before attaching, cut the last baseboard to length so that it is flush with the outside of the end of the last ground post.

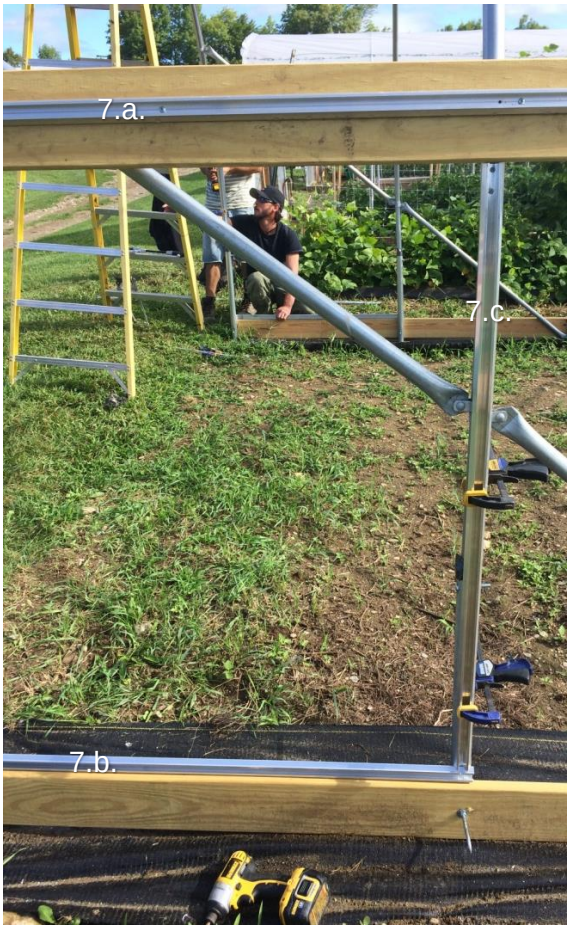
h. Repeat steps 5.a. through 5.g. for the opposite side of the tunnel.

7. **Poly Latch Channel on the Hipboards and Baseboards:** Poly Latch Wire and Poly Latch Channel are used to hold the main covering in place and secure it along the length and above the roll up sides. Hereafter we will simply refer to them as “wire” and “wire channel”.

   a. Using #10 x 3/4" phillips self-drilling tek screws about every 12", secure lengths of channel end for end down the middle or lower side of the outside of the hipboard for the full length of the tunnel. Cut off any excess on the opposite end so it is flush to the end of the hipboard.

   b. Prepare a section of wire channel to hold an overlap panel of plastic that will prevent drafts and heat loss at the ends of the roll-up sides (shown on page 27) as follows: Cut to length and secure a 4′ 2″ section of wire channel. Secure it to the end wall bow and the next bow in with #10 x 3/4" phillips self-drilling tek screws. You may allternatey secure it to the top of the outside face of the baseboard if desired.

   c. Using clamps, hold cut-to-length pieces of wire channel in between the hipboard and baseboard on the outside edge of the first and second groundposts. Secure with #10 x 3/4" phillips self-drilling tek screws about every 12”.



Traditional End Walls:

Note: *If you would like to build lower cost "Scissor Doors" instead, please skip to page 30.*


1.a.

There are a great many ways to go about this, few of which could be considered wrong. We are illustrating how we decided to craft a traditional end wall for our 14' x 200' trial tunnel. There are no rules. Build your end wall however you like. We do hope you are able to get some ideas and inspiration from ours. This is how we did it...

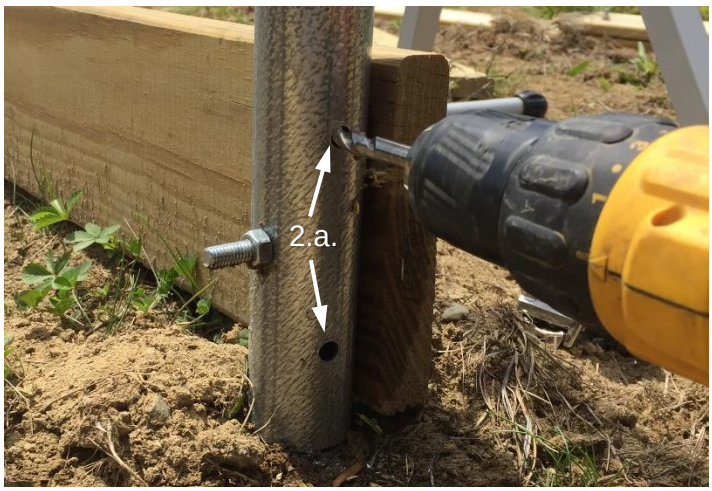
Note: *Some of the photos shown here are of our Quick Hoops Gothic Tunnel.They are only used to illustrate the methods, which are the same.*

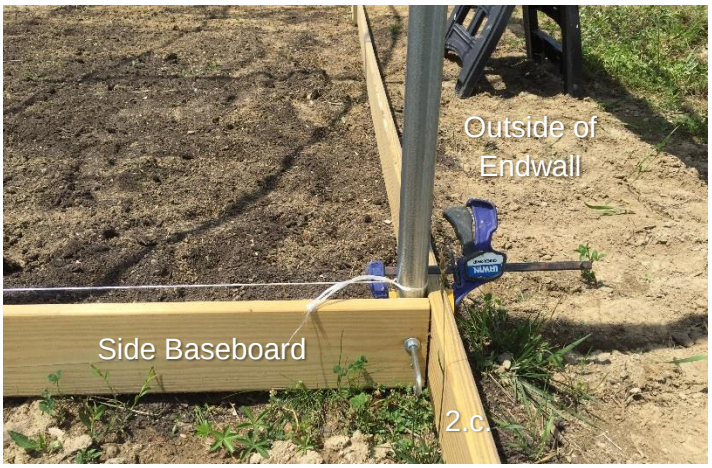
1. **Poly Latch wire channel:** this is used to hold the end wall plastic on as well as secure the main covering later on.
   a. Start by attaching wire channel to the outside and top of the end wall bow by using clamps and forming it around the bow. Start at the hipboard and work all the way over the ridge pole.
   b. Secure with #10 x 3/4" phillips self-drilling tek screws about every 12". Adding an extra one at each end of the channel is a good idea to prevent failure, since the channel has preloaded stress and will want to spring back quite a bit if allowed.


1.a. - c.

   c. Continue all the way over and cut to length just shy of the top of the opposite hipboard.

2. **Endwall Baseboard:**
   a. With a 5/16" bit, pre-drill two holes as shown through both sides of the endwall ground posts on both sides of the tunnel as shown to the right.
   b. Precut a 5/4" x 6" x 16' decking board to 12' long. Place it across the bottom of the end wall with one end flush to the outside of the baseboard. Using the pre-drilled holes made in step 2.a. above, drill through the board and fasten to the ground post with 5/16"-18 x 3.5" carriage bolts inserted from the outside and secure with a 5/16" hex nut.





c. Butt another piece of 5/4" x 6" x 16' decking board up to the end of the one installed in 2.b. above and clamp to the groundpost on the opposite side of the tunnel. Using the end of the baseboard as a guide, make a mark on the backside of the decking board and cut along that line. Attach the same way as step 2.b..

d. Pre-cut and place a 2’ piece of patch board inside the seam created by the two baseboards. Center and clamp in place. With a 5/16" bit, pre-drill four holes as shown through the patch board and the two baseboards. Fasten with two 5/16"-18 x 3" carriage bolts inserted from the outside and secured with flat washers and 5/16" hex nuts.

e. Cut a 6' x 1-5/8" line post in half and drive each half in the ground just inside the baseboard on either side of the 2’ board until the top of the posts are more or less flush with the top of the baseboard. Drill a single 5/16" hole through each of the posts and baseboard and secure with 5/16"-18 x 3" carriage bolts, 5/16" washers and nuts. These posts will add stability to the endwall baseboard and door frame.

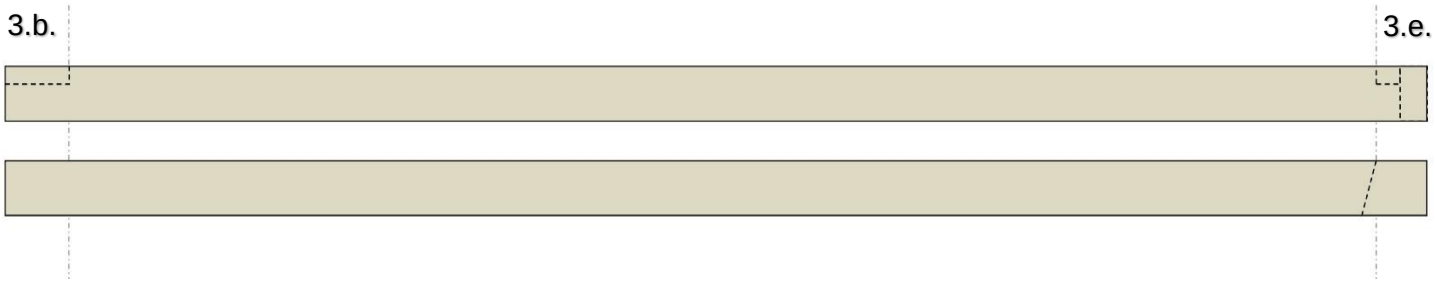
3. **Door Frame and End Wall Framing:**

a. Make a mark on the baseboard 32" to the right and 32" to the left of where the baseboards abbut in the center. These marks will be the door frame's bottom inside boundaries (see diagram on next page).

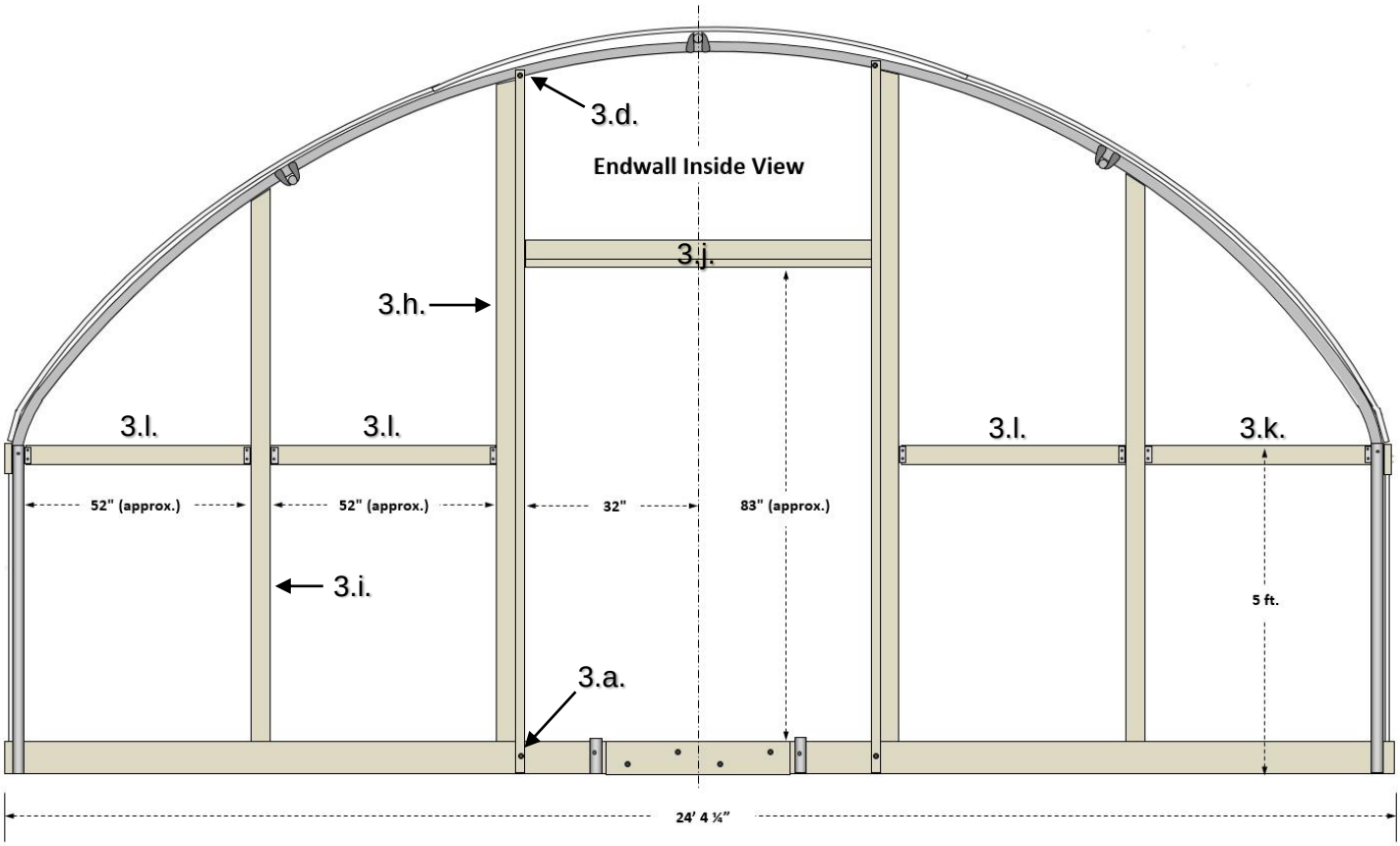
b. Cut a 1” x 5.5” notch in one end of a 2" x 4" x 12' board. Position it vertically with the notch resting on the inside of the baseboard aligned with the first mark made in 3.a. above (see diagram below).

c. Clamp in place or have a helper hold the board.

d. Position the top of the board 32” from the center of the ridgepole and clamp to the bow. Using the bow as a guide, make marks below the bow and above the wire channel attached to the top of the bow. Also make a mark on the bow, just inside the board for alignment later (see diagram on next page).



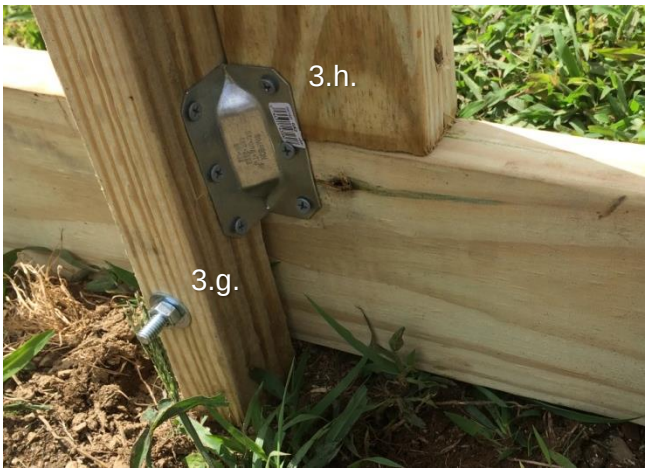
e. Finish making marks using a hand square per the top board in the diagram above. Note that the measurements in the diagram are approximate as your marks may vary somewhat from them. Notch these out 1.5" deep and cut to length so the boards will be flush with the bow.



f. Repeat steps 3.a. through 3.e. for the opposite side of the door frame.

g. Clamp one inside door frame board constructed in steps 3.a. through 3.f. in place so that its inside edge is aligned with the outer marks on the bow and baseboard. Using a large framing square, check to ensure they are at right angles to the baseboard. Adjust as necessary. At the top of the board, pre-drill and secure the board to the bow using a 5/16"-18 x 4" lag bolt and to the baseboard with a 5/16"-18 x 6" carriage bolt, 5/16" washer, and 5/16" nut. Repeat for the opposite side.

h. Rest a 2" x 4" x 12' board vertically on top of the baseboard, outside one of the door frame boards installed above with the wide edge facing outward from the end of the tunnel. Make a mark just below the bow and cut to length (see diagram on previous page). Clamp this new outside door frame board to the inside door frame board and secure with several 3" bugle head wood screws. "Toe-nail" one of the screws at a 45 degree angle at the bottom from the outside into the top of the baseboard. You can also add a metal gusset corner brace as we did (shown above right) using 1.25" drywall screws. Pre-drill from the top and secure to the bow using a 5/16"-18 x 4" lag bolt. Repeat for the opposite side.

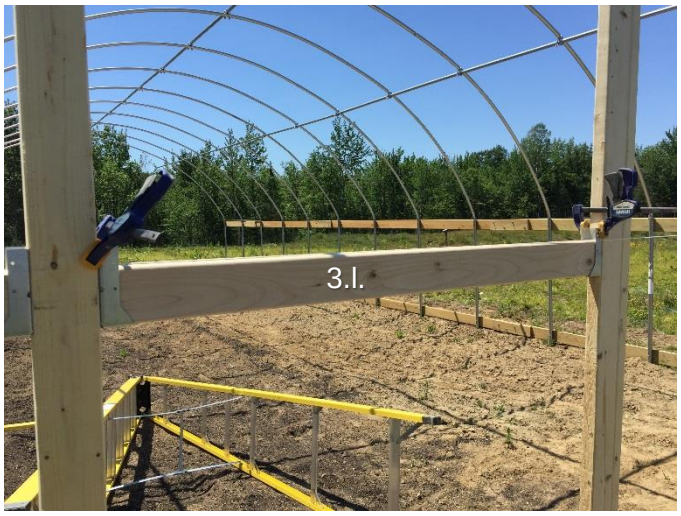


i. Rest a 2" x 4" x 10' board vertically on top of the baseboard, centered between the door frame and the endwall ground post with the wide edge facing outward from the end of the tunnel. Make a mark just below the bow and cut to length. Clamp this precut board back in its centered position on top of the baseboard and just below the endwall bow. Toe-nail with two 3" bugle head wood screws. Check for square and adjust the top clamp as necessary. Pre-drill from the top and secure to the bow using a 5/16"-18 x 4" lag bolt. Repeat for the opposite side.

j. Cut two more pieces of 2" x 4" to a length of 64". Place one at the top of the door opening so that the wide edge is facing the end of the tunnel. Secure at each end with a couple 3" bugle head wood screws. Place the second one under the first with its narrow edge facing out and flush with the outside edges of the door frame. Secure at each end with a couple 3" bugle head wood screws, then secure the second board to the first with four more 3" bugle head wood screws.

k. Run a piece of string tightly from the top of the end of one hipboard to the other. Pre-drill a 5/16" hole in the center of a 2” x 4” deck framing bracket and secure inside the groundpost, aligned so that the top of the 2” x 4” it will support will be aligned with the top of the hipboard and string. Secure to the groundpost and hipboard, with self-drilling screws and the existing carriage bolt. At an even height from the baseboard, attach another bracket to the outside edge of the middle vertical support board, using 1.25" drywall screws. Cut a 2" x 4" board to fit, notching one end for the carriage bolt. Install and secure with 1.25" drywall screws. Repeat for the opposite side.

l. Using the string as a guide, finish attaching brackets, precut boards, and install between the vertical support boards and the outside door frame boards as shown in the endwall diagram on the previous page.



m. The endwall frame is complete.

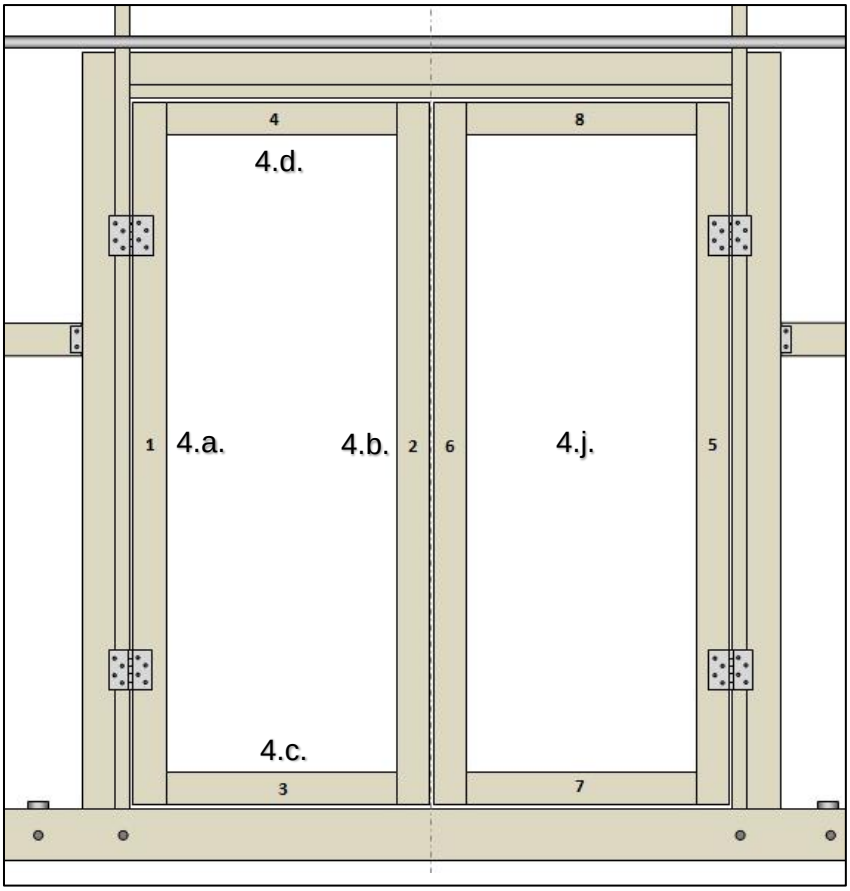
4. **Doors:** these will be built in-place for best fit. The measurements below are approximate, since the boards will be cut to fit. See diagram to the right for the sequence used for assembly.

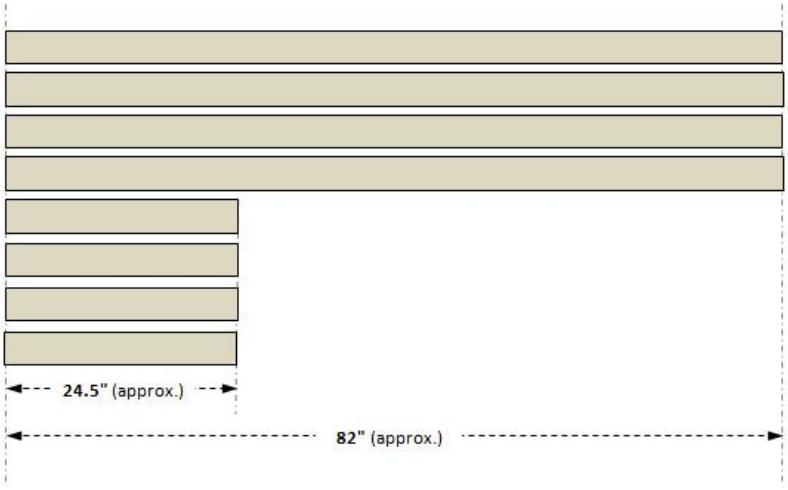
   a. Lay some type of spacer that is about a 1/4" thick on top of the baseboard inside the door frame (we used a piece of angle iron). Hold a 2" x 4" board vertically in the door opening and mark on the board about a 1/4" below the lower edge of the top of the door frame. Cut to length. Return the board to the same spot on top of the spacer and check for fit. There should be about a 1/4" space above the door. If the fit is tight, trim as necessary, then cut three more the same length. These should be about 82" long, but may be slightly different for your tunnel. Place board #1 snug to the left side of the door frame and clamp in place.

   b. Place board #2 about 1/8" to the left of the center of the door frame on top of the spacer. Check for square with respect to the baseboard using a large framing square and clamp in place.

   c. Hold a 2" x 4" board horizontally so it butts up to the first board and passes by the front face of the second. This will be board #3. From inside the door, use board #2 as a straight-edge to mark the board. Cut the board off along that mark and check for fit. Trim as necessary and clamp board #3 in place at the bottom of the doorway between boards #1 and #2. This board should be about 24.5" long, but may be slightly different for your tunnel.

   d. Repeat step 4.c. for board #4 at the top of the door.





e. Using 1.25" drywall screws, install flat metal L-straps at all four corners on the inside face of the door (see photo previous page).

f. Using the wood screws supplied with them, install hinges about 1' from the top and bottom of the left side of the door as shown in the diagram. Do not pre-drill.

g. In the middle opening of the door, pre-drill and install screw-eyes near the top of board #1 and the bottom of board #2. A large 12-point socket in a ratchet driver works very well for this job.

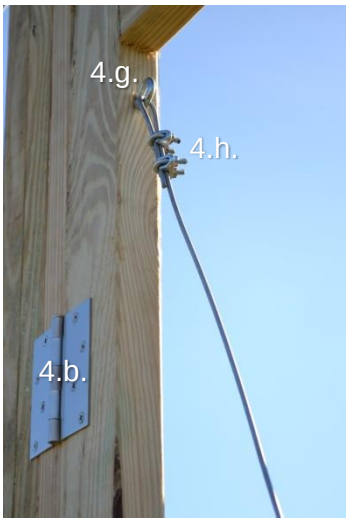
h. Using #9 wire, aircraft cable, or something similar, install a cable support assembly as shown with a small turnbuckle and cable clamps. Once installed, remove all clamps and adjust the turnbuckle until the right side of the door is centered vertically in the opening. There should be a 1/8" -1/4" gap above and below the door.

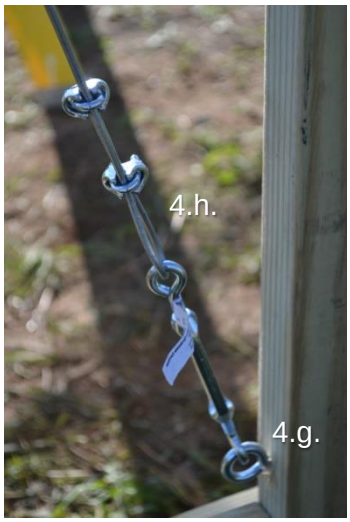
i. Swing the door open. Further secure the corners of the door with two 5/16” x 6” heavy duty wood screws at each corner. Pre-drill before driving the screws. Swing the door shut. re-adjust the turnbuckle if necessary. See diagram lower right.

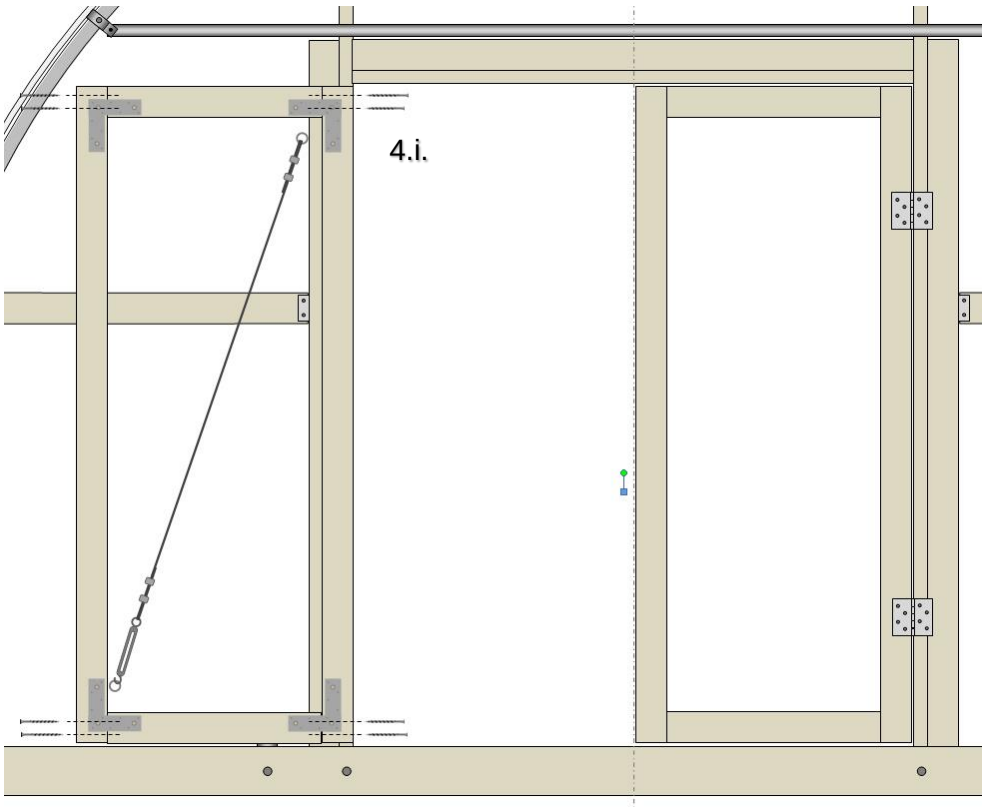
j. Repeat steps 4.a. through 4.i. for the right door. Refer to board sequence numbers 5 through 8 in the diagram on previous page. Ensure there is about a 1/4" space between boards #2 and #6. This will allow the doors to open easily.

k. If desired, install trim boards around the inside edges of the doors to keep them draft free.

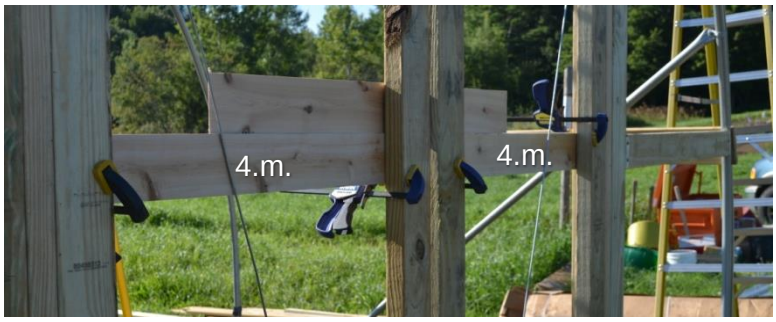
l. Using 3" bugle head wood screws at the top and bottom of the doors, temporarily screw them shut.







m. Cut two 1" x 4" boards to span the insides of each of the doors as a bit of extra bracing. Level these with another piece of board as shown to the right.



n. Cut to length as needed and install wire channel around the open holes in the doors, around the door frame, and along both sides of the endwall baseboard.

5. **Skinning the Endwall**:

a. The plastic used to cover this tunnel should be a 6 mil greenhouse film that is 32' wide. Start by cutting a piece off the roll that is 12.5' long.

b. Lay the cut panel of plastic over the endwall so that one of the long edges (preferably a factory cut end) is along the ground and all edges of the endwall are overlapped with extra plastic. There may be manufacturer's writing on the plastic. You can use that as an aid to level the plastic across the endwall.

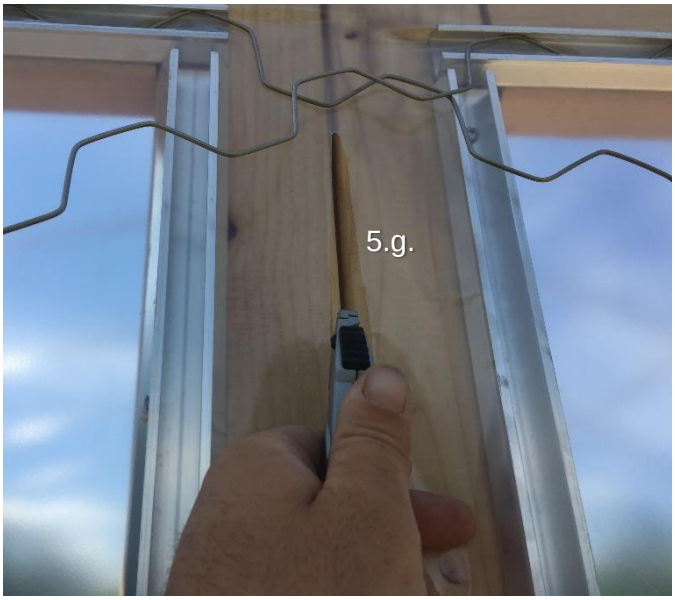
c. Starting at the top and working concurrently down both sides of the endwall bow, wire the plastic into the channel, keeping the plastic taut across the face of the endwall as you go. Continue all the way down to the baseboards (see photo previous page).

d. Fold the plastic around the endwall bow and over the area between first and second bows, below the hipboard. Wire the plastic tightly into this area and trim off any excess. This will serve as an overlap panel to prevent drafts caused by the roll-up sides. Repeat this step for the opposite side of the endwall.

e. Wire the plastic into the channel on the endwall baseboard.

f. Wire the plastic into the channel around the top and sides of the door frame.

g. Wire the plastic into the channel around each of the doors. At this point, much of the slack plastic has been taken up by the channel and may be very taught. You may need to cut the plastic between the channel on the doors and the channel on the frame to relieve the tension enough to install the wire. Be sure to pull it tight when installing the wire. When wiring, cut the wires off when you reach the end of each channel.

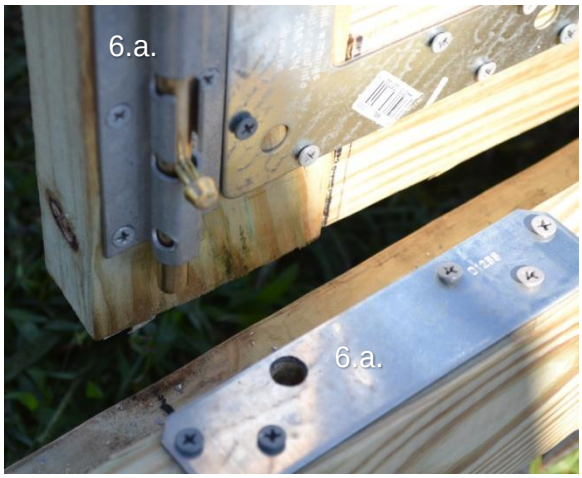


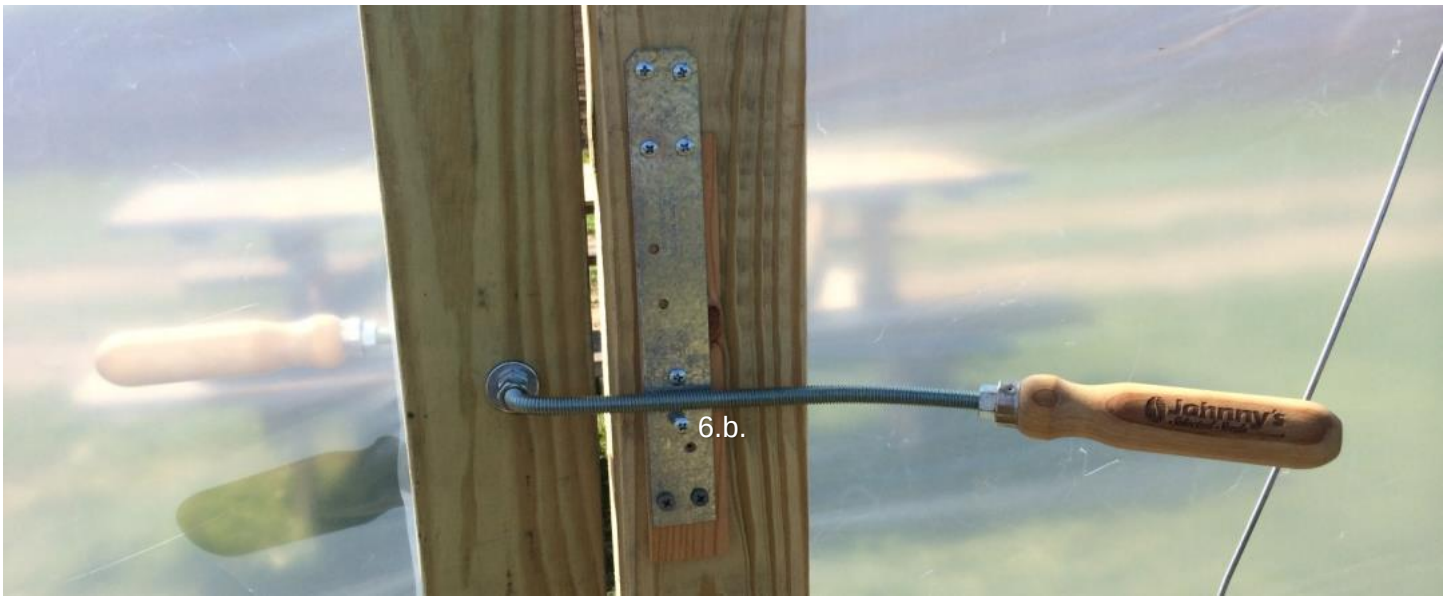
h. Trim off excess plastic along the outside edges of all the channel, leaving about an inch or so extra.

i. When you are done, the endwall should look like this:

6. **Door hardware** can be anything you dream up.

   a. First, we installed a sliding bolt lock at the top and bottom of the left hand door, which will be closed most of the time, but can be opened when needed to allow access for walking tractors, wheelbarrows, and other small equipment.





   b. Then, we created a “jackpot” lever latch that can be operated both from the inside and the outside of the tunnel. The latch was designed with a bent 3/8" threaded rods, two small tool handles, locknuts, washers, a wooden shim, and flat bracket over the shim to prevent wear and serve as a latch plate. The shimmed latch plate serves to keep the door tightly shut. We added a couple self-drilling screws to serve as speed bumps to help keep the latch in place. If you would like to create a similar latch, the part number for the replacement tool handles is **9673.500**.

Scissor Doors for an End Wall:

This is another way to do an end wall that has been developed by Eliot Coleman and is in use extensively at his Four Season Farm. It is a very low cost method, but the beauty of it, especially for a tunnel this size or larger, is that it instantly allows small tractor access, which can be a huge labor saver. We installed scissor doors on just one end of our trial tunnel. This is how we did it...

1. **Endwall Baseboard:** This design has a baseboard the same size as the traditional endwall, but it is detachable. Repeat steps 2.a. through e. from the “Traditional End Walls” section on page 20, except use 5/16” wing nuts to hold the baseboard onto the groundposts.

2. **Scissor Rails**:

   a. Place a piece of scrap 1-3/8" top rail at a right angle over the non-swaged end of a full length piece of top rail.

   b. Position a rail end T-clamp over the intersection of these two pipes. The scrap is used simply for positioning the T-clamp. Secure the T-clamp to the full length pipe with a #10 x 3/4" phillips self-drilling tek screw.

   c. Rotate the full length pipe 180 degrees, place the scrap in the cradle of the T-clamp, and secure another T-clamp on the opposite side of the pipe as in step 2.b. above.

   d. Repeat 2.a through c. for the another full length piece of top rail pipe.

   e. You may also thru-bolt with 2” hex bolts and nuts if you desire a stronger connection since the two T-clamps will serve as a hinge for each scissor rail.

f. In the Framing the Tunnel procedure (page 14), you should have opted to leave at least six extra inches of ridge pole and purlins protruding out from the endwall. If you did not, follow this procedure:

   i. Cut the swaged end of a scrap piece of top-rail, so that the non-swaged portion is 6" long.

   ii. Insert the swaged end of the scrap piece into the end of the ridge pole.

   iii. Using tek screws, secure to the ridge pole from the sides.

g. Slide the T-clamps on the end of one of the rails over the protruding ridge pole outside the end-wall of the tunnel. Add the second rail in the same way. Drill a tek screw into the side of the ridge pole just outside the second T-clamp to prevent it from sliding off. Cut the ridge pole to length just outside the tek screw.

h. On each scissor rail, measure from the top of the swage (as it is hanging) to an inch off the ground. Cut two extra pieces of top rail to this length and add onto the bottom of each rail. Secure from both sides with #10 x 3/4" phillips self-drilling tek screws. The scissor rails should hang freely and be able to rotate out to the sides of the tunnel easily. They should also should not touch the ground but come close to it. If they are too long and hit the ground, shorten as necessary.

i. Holding the rails together, align them with the center of the baseboard and clamp them securely in place.

j. With a 1/4" bit, make a pilot hole through the outside rail first, then through the inside rail. Re-drill and ream the 1/4" holes out with a 3/8" bit and continue all the way through the baseboard. Then, ream the holes in the scissor rails out with a ½" bit.

k. Insert a 3/8" x 6" fully threaded carriage bolt through the hole in the baseboard with the threads facing outward. Secure to the baseboard with a 3/8" wingnut and flat washer.

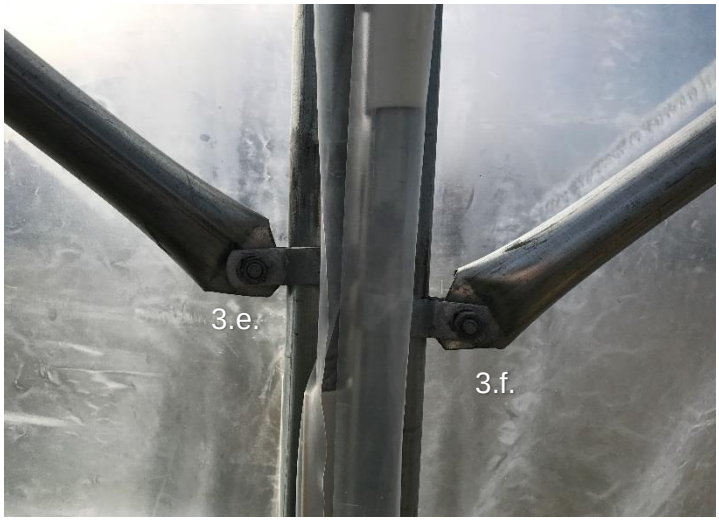
l. Slide the rails onto baseboard bolt to make sure they fit correctly, and secure finger tight with a 3/8" wingnut.

m. **Optional:** Add a section of wire channel along the top edge of each side of the baseboard. This may be used in winter to seal up the end of the tunnel (see first picture on previous page).


2.h.


2.i., j.

3. **Side Support Arms (optional):** We thought that this was a large enough opening that some extra support for the plastic might be good to help with wind. These are made the same way as angle braces on page 9, except they are longer.
   a. Cut the swaged end off two full length pieces of top rail.
   b. Press one end of each flat in a vise or with a large hammer.
   c. Dog-ear the corners off the flat sections and drill through the center of the flat sections with a 5/16” bit.
   d. Attach two rail end T-clamps to the unflattened end of each support arm the same way as the scissor rails, except install on the inside end of each of the purlins before adding the second T-clamp. Install them so that the flat section is parallel with the plane of the endwall. At this point, the support arms should be hanging straight down from the purlins.
   e. Swing a support arm over to one of the scissor rails and attach it at the point where they meet using a brace band, 5/16” x 1 ¼” carriage bolt, and 5/16” wingnut. Using two #10 x 3/4" phillips self-drilling tek screws, permanently attach the brace band to the scissor rail.
   f. Repeat 3.e. for the opposite side.

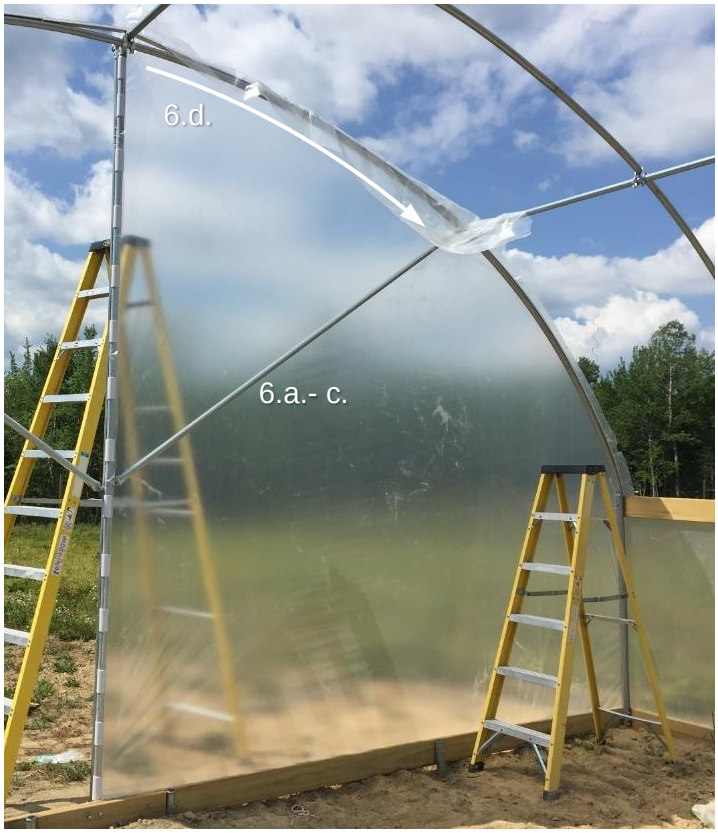


4. **Quick Release Door Latch:** This is what will be used most to secure the scissor doors and open them for venting.

   a. At about chest height, attach one half of a 1 3/8" x 1 3/8" kennel clamp to only one of the scissor rails with a #10 x 3/4" phillips self-drilling tek screw.
   b. Repeat for the opposite side, screwing only into the opposite scissor rail.
   c. Attach a fully threaded 4” x 5/16” carriage bolt to one half of the kennel clamp with a 5/16” hex nut to hold the bolt in place.
   d. Complete the latch by inserting the bolt into the opposite kennel clamp and securing with a 5/16” wingnut.

5. **Poly Latch wire channel:** This is used to hold the end wall plastic on as well as secure the main covering later on.
   a. Start by attaching wire channel to the outside of the end wall bow by using clamps and forming it around the bow. Start at the hipboard and work all the way over the ridge pole.
   b. Secure with #10 x 3/4" phillips self-drilling tek screws about every 12". Adding an extra one at each end of the channel is a good idea to prevent failure, since the channel has preloaded stress and will want to spring back quite a bit if allowed.
   c. Cut to length just shy of the top of the opposite hipboard and finish off.
   d. Cut to length and install a section below the hipboard on that side that finishes just above the footboard. Repeat for the opposite side of the bow.

6. **Skinning the Endwall:**
   a. Pull out 12.5' of 40' wide greenhouse plastic, cut it off, and cut it down the middle. That should give you two 12.5' x 20' panels. Clamp one scissor door rail to one side of the bow so that it is up and out of the way. Allow the support arm on that side to hang freely straight down. Leave the other rail and arm connected and secured in place.
   b. Lay one of the plastic panels over the end wall opening opposite of the clamped scissor door rail. One of the wider 20' edges should lay along the ground.
   c. Wrap the panel around the bolted vertical scissor door rail evenly and secure to the rail with JSS part# 7035 Snap Clamps every foot or so.
   d. Starting at the top and working down, wire the other side of the plastic panel into the channel on that side of the end bow. As you do this, keep the plastic pulled fairly taut with one hand so that the plastic is installed evenly and tightly.

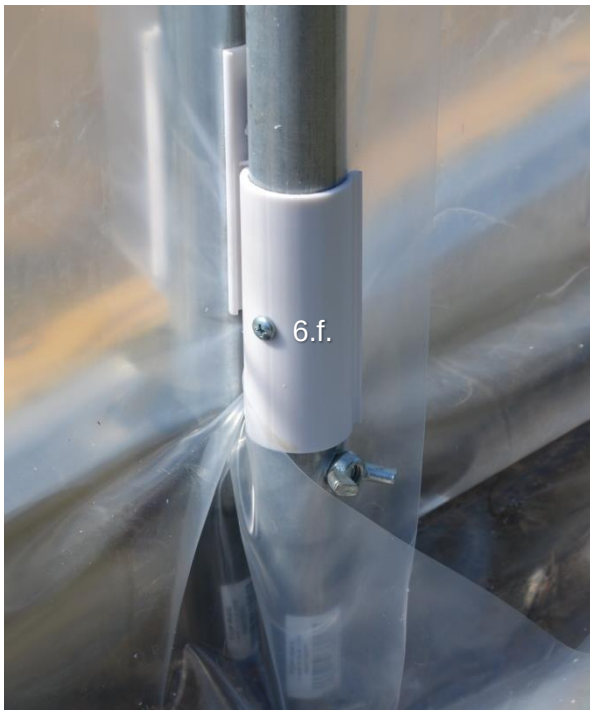


e. Adjust the Snap Clamps as necessary to remove any wrinkles in the scissor door plastic.

f. Install self-drilling screws (phillips or hex head - your choice) through the Snap Clamps. Ensure that the clamp does not loosen or release while doing so.

g. Release the clamp keeping the other scissor door rail out of the way and let it hang vertically near the other bolted one.

h. Lay a piece of cut plastic over the opposite side now and wrap it around the vertical scissor door pipe evenly. Secure in place with Snap Clamps every foot or so, but align them so that they are in between the Snap Clamps on the other pipe.


6.f.

i. Remove the wingnut holding the first scissor door rail and slide both rails onto the bolt and secure together with the wingnut. Wire the other side of the plastic sheet into the channel on that side of the end bow.

j. Adjust Snap Clamps as necessary to remove any wrinkles in the door plastic.

k. Install self-drilling screws through the Snap Clamps.

l. Fold the excess side plastic around the endwall bow and over the area between first and second bows, below the hipboard. Wire the plastic tightly into the channel pre-installed around this area. This will serve as an overlap panel to prevent drafts caused by the roll-up sides. Repeat for the opposite side of the tunnel.

m. Trim off excess plastic along the outside edges of all the wire channel, leaving about an inch or so excess.


6.l.

n. When you are done, the endwalls should look like this:

Skinning the Tunnel:

This is an "all-hands-on-deck" evolution that is best done with little or no wind. If possible, postpone this portion of the procedure if the weather is not cooperative or if you feel you do not have enough people to control the plastic. The greenhouse plastic required to cover this tunnel is 40' wide.

1. **Roll-up sides (part 1):** This design uses several pieces of ¾" EMT conduit, JSS part #9750 Snap Clamps, #10 x 3/4" phillips self-drilling tek screws, and JSS part #7033 Sidewall Hand Crank.
   a. Lay out 10 ft. sections of top rail along the side of the tunnel.
   b. Fit each of the swaged ends into the female end of each successive piece and secure them together with one phillips self-drilling tek screw in each side of the connections to prevent slipping. The completed pipe should be about a foot longer than the tunnel on each end.
   c. Repeat steps 1.a. and b. for the opposite side of the tunnel.

2. **Plastic preparation:**
   a. Position the plastic at one end of the tunnel so that it is offset, and faces down the side of the tunnel.
   b. Use a pair of D-handle garden forks or spades (or four if you have a very large roll of plastic like we did) and a piece of top rail for chain link fence as the spindle to support the roll.


2.b.


2.c.

   c. Pull the plastic off the roll and walk with it down the side of the tunnel until you reach the opposite end.
   d. Throw several ropes from the opposite side over the tunnel and loop each of them around tennis balls, smooth rocks, etc. embedded in the plastic. You can use just about anything that is handy and won't cut the plastic, even water bottles. These will serve as pull points.
   e. If possible, position a person at every rope and another on the opposite side of the tunnel from each of them.
   f. Position a ladder at each end with a person atop each of them.


2.d.


2.d.

3. **Pulling the plastic:**

   a. When everyone is ready, give the word, and raise the plastic up and over the tunnel, centering it evenly on all sides.

   b. Wire a small section of plastic (maybe 2 ft.) in the wire channel at the peak of one end of the tunnel to hold the plastic centered and in place on that end.

   c. At the opposite end, pull the plastic taut lengthwise down the top of the tunnel and install a small section of wire at the peak on that end.

   d. Continue to wire the plastic into the channel on both endwall hoops by working together at opposite ends of the tunnel, wiring downward from the peak to the hipboard on one side of the tunnel, pulling the plastic taught lengthwise and evenly as you go. Then, repeat for the opposite half of the tunnel.

4. **Roll-up sides (part 2):**

   a. Position the top rail assembly so it rests on top of the plastic and the J-bolts, up against the baseboards of the tunnel. Wrap the plastic around the top rail evenly and secure in place with Snap Clamps every two feet or so such that the top rail is suspended an inch or so above the J-bolts evenly along the length of the tunnel. Adjust the Snap Clamps as necessary, removing any wrinkles in the plastic and ensuring that the top rail is parallel to the baseboards and hanging straight. This is critical for even ventilation when rolling the sides up. Repeat for the opposite side of the tunnel.

   b. When you are satisfied with the adjustment of the Snap Clamps, install #10 x ¾" phillips self-drilling tek screws through all the Snap Clamps, and into the top rail. Phillips heads are used to prevent damage to the plastic when rolling up the sides.

   c. Trim the plastic as necessary. Trim it carefully at the ends because it can cause bunching, uneven rolling, and uneven venting. **Note:** When finished, it should still go past the endwall hoop for best seal.

   d. **Hand Cranks:** The #7033 Sidewall Hand Crank no longer comes with an adaptor to accommodate the top rail. Attach to the Sidewall Hand Crank's drive shaft using pre-drilled holes and provided hex bolt and locknut. Slide the installed adapter onto one end of one of the EMT assemblies and make a mark where you will need to drill the holes for securing with the bolt. With a 1/4" bit, drill through both walls of the EMT at those marks. Secure with a ¼"-20 x 2 ½" hex bolt and ¼" nylock nut. Attach the handle to the spindle on the end of the hand crank with smaller hex bolt and locknut supplied with the kit.

e. **Guide Rail:** Hold a 10’ piece of 3/4" EMT up to the corner of the tunnel where one of the hand cranks will be located. Make a mark 2' above the top of the hipboard. Cut it to length. Position the top rail assembly so it rests on top of the plastic and the J-bolts, up against the baseboards of the tunnel. Insert the cut piece of ¾" EMT vertically through the roller guides in the hand crank and drive it into the ground at least a foot. When finished, it should be at least 6" taller than the top of the hipboard.

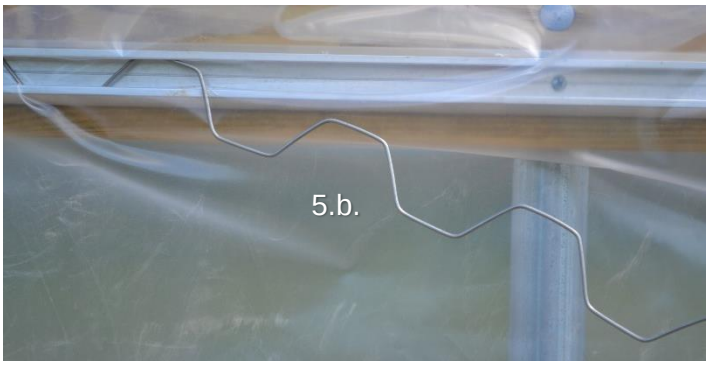
f. Turn the handle of the hand crank and take up some of the plastic until the roll is 12" off the ground. The mechanism will automatically hold the plastic at any height where you release it. Check for evenness along the length of the tunnel. Roll back down and adjust snap clamps as necessary. Repeat. When satisfied, roll all the way up. These take some adjusting, but once set up correctly, they work very well.

g. Repeat steps 4.b. through 4.f. for the opposite side of the tunnel.

5. **Poly Latch wire channel:**

a. Roll the sides up so they are each about 12" off the ground and putting tension on the main sheet of plastic.

b. Starting at one end, have two workers concurrently wire the plastic into the channel on the hipboards on both sides of the tunnel, working opposite of each other as they make their way down the tunnel. This will serve to tighten the plastic evenly and help prevent wrinkling. The plastic should tighten up nicely.



6. **Lacing:**

   a. Pre-drill 1/4" holes through the wire channel on the hipboards that centered between each of the bows, plus one extra hole at each end even with the endwall bows. Do not drill into the hipboard itself.

   b. Using a large 12-point socket and a ratchet driver, install screw eyes into each of the holes.

   c. At the end of the hipboard, assemble a spool of parachute cord between two garden forks with a piece of 1/2" EMT as the spindle.

   d. Thread the parachute cord through all of the screw eyes. When you reach the end, pull the cord down and tie off on the J-bolt at the bottom of the endwall bow.

   e. Working back towards the spool, pull the parachute cord down and over the J-bolt at each bow.

   f. Leaving some excess, cut the cord, and tie off temporarily to the J-bolt near the spool.

   g. From the opposite end, start taking up the slack and tensioning the lacing. When you reach the end of the tunnel near the spool, tie off using a trucker's hitch to further tension the lacing (see diagram below).

   h. Repeat steps 6.a. through 6.g. for the opposite side of the tunnel.

A Trucker's Hitch is used to tension lacing on the roll-up sides.

Your 24' Elliptical High Tunnel is now complete!