Treenails

Model Shipwrights of Niagara

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TREENAILS, TRENAILS, TRENELS or TRUNNELS; the what and how of them

There were a number of different types of fasteners employed in ship building over the years, including, bolts, spikes and treenails. Treenails eliminated "nail sickness" which is a wood rot that formed around an iron fastener.

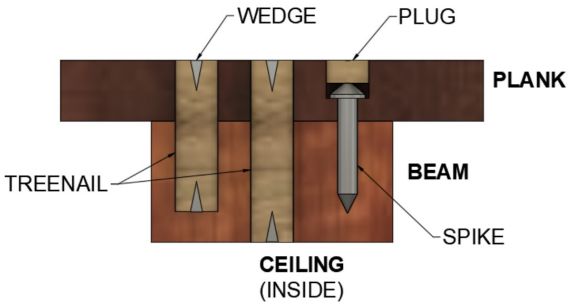
WHAT ARE TREENAILS?
It is a wooden dowel like peg fastening device used to hold a plank to a timber or beam. They have an oak treenail wedge driven in both ends.

The treenail wedge acts like those wedges you find in the wooden handles of present day shop tools to grip the head of the tool to the wooden handle by expanding the wood.

Treenails

Treenails were made of hardwood by the yard boys. English oak was used in Europe and black locust in North America. They started with dry square staves having a moisture content of about 5%, paring off the corners to create an octagon shape, then made it round by using a special rotating plane type cutter called a moot (seen in the image above). It is somewhat similar to a pencil sharpener. The process was called MOOTING.

All holes are bored, and treenails driven, from the outside of the ship inwards.



Treenails are cut flush after having an oak treenail wedge driven into their ends. They are oriented to lay cross grain to the plank being fastened as can be seen in the top left. The wedges force the peg to widen at the ends locking the peg in place. Treenails driven into a blind hole as seen above in the centre left had the wedge partially inserted into a cut in the treenail lead end so that as it bottomed out in the hole, it would set itself when driven home by hammering. As they were made and installed quite dry, once wetted they would swell to hold even tighter.

At one time very large treenails had three wedges forming a triangle and were caulked with cotton. At the same time smaller treenails had two wedges forming a cross. Later this was reduced to a single wedge.

There were three types of treenails in use:

The first was the **straight treenail** (below left). It was one size diameter along its whole length and was driven into a hole about 1/16" smaller in diameter. If the treenail was more than 24" long the second type was used.

Treenails

The **two-drift treenail** (above right) where approximately half the length of the treenail was sized about 1/8" smaller than the other half. The hole was bored half way 1/16" smaller than the large end of the treenail and then 1/16" smaller than the smaller end of the treenail for the remainder.

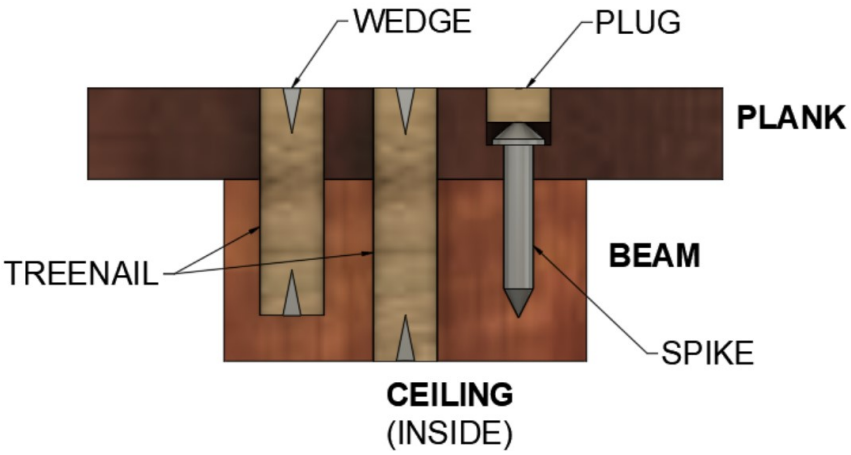
The third type was the **tapered treenail** (left) where the hole was stepped in size as described for the two-drift treenail. The large end of the treenail was 1/8" larger than the larger hole, whereas the smaller end was the same size as the smaller hole. It has been said this type has the greatest holding power as they cannot be backed out.

The 19th century saw both treenails and bolts used on hull planks below the waterline, with two bolts and one treenail at butt joints.

At the turn of the 20th century when power augers were being used, the holes were drilled one size smaller to correct for holes being oblong due to the machine operated auger being difficult to control.

When modelling, the simple straight type treenail is used with no wedges because at reduced scale they cannot be seen.

Treenails



It is written that prior to 1850 deck planks were secured to beams with treenails. After 1850 they were secured with metal spikes as seen on the right side of the image above, driven into counterbored holes, sealed with white lead, and covered with a white pine plug coated with thick shellac. These plugs were barely discernible from the colour of the deck plank, with their grain running in the same direction as the deck plank's grain.

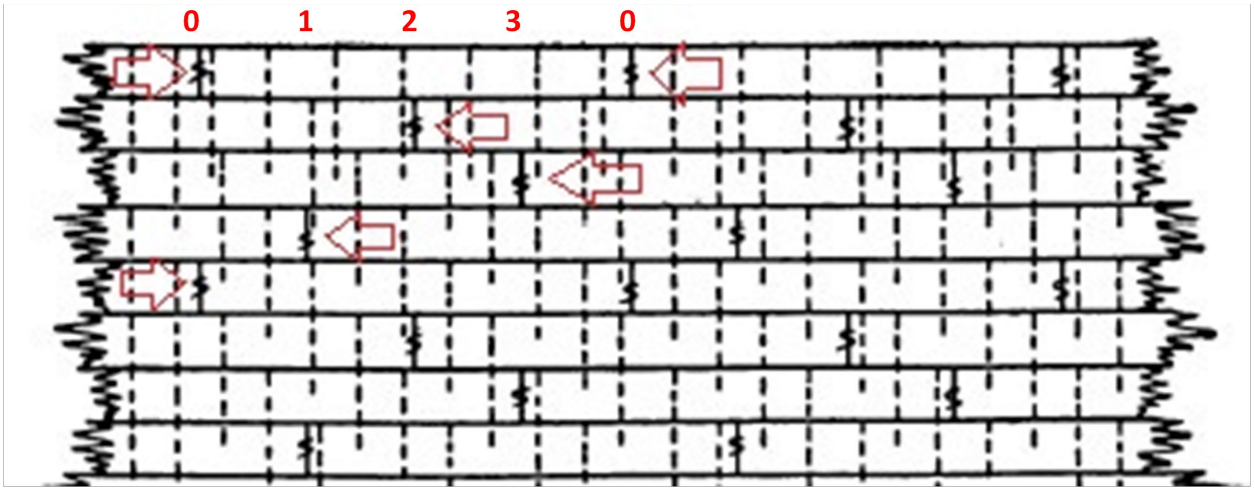
Contrary to the statement above, the deck planks of the 70 gun 3rd rate Yarmouth of 1710, a century earlier, were fastened to every beam they crossed with two spikes, and every ledge with two treenails. It is also written that in 1822 the British were using light bolts and treenails for fastening deck planks.

Due to reduced model scales treenails and plugs all look the same, so it is not a concern.

The above photo, taken on the deck on the Brig Niagara, a replica, shows deck plugs.

Treenails

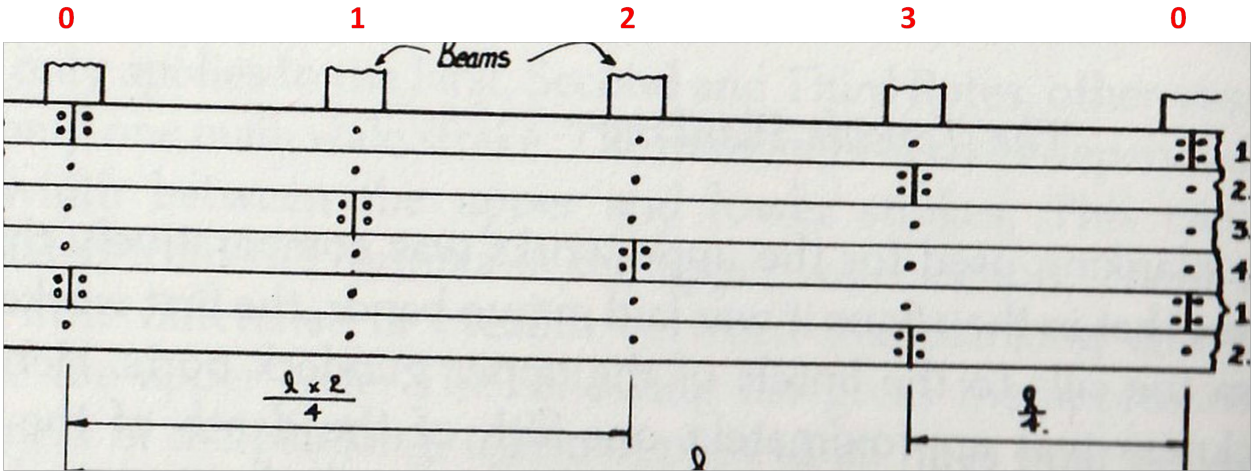
It is difficult to discuss treenails without speaking about planking.



The Three Butt Shift (2 - 3 - 1)

Source: The Elements of Wooden Ship Construction - Pg. 186

Planks were said to be 20 to 24 feet long in one source and up to 36 feet long in another source, with ends butted together over a frame. The butt joint location would be staggered or shifted and the pattern did not repeat until possibly the fifth plank as seen above. The length of the plank is divide into 4 equal sections. Both ends would be location "0", the mid-span "2", and the quarter spans "1" and "3". Note the source and date: USA, 1918. Also note that the butt joints are not always one beam or one strake away from each other, which has been suggested to be the rule.



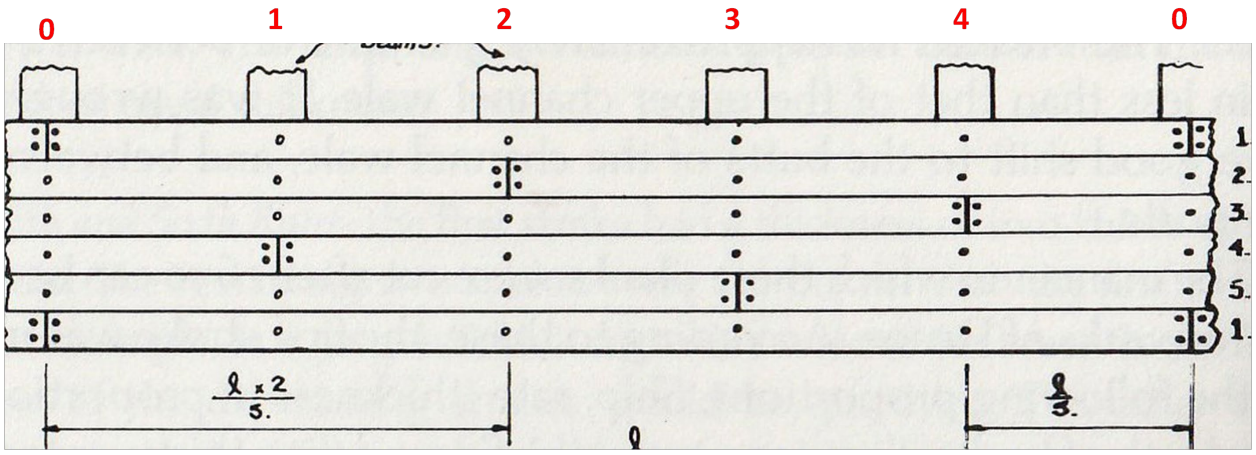
The Three Butt Shift (3 - 1 - 2)

Source: The Construction and Fitting of the English Man of War 1650-1850 (Pg 58)

Here is another version of a Three Butt Shift at locations 3 - 1 - 2, where as the earlier version was 2 - 3 - 1.

Treenails

This is for English warships, 1650 - 1850. Note once again that the butt joints are not always one beam or one strake away from each other.

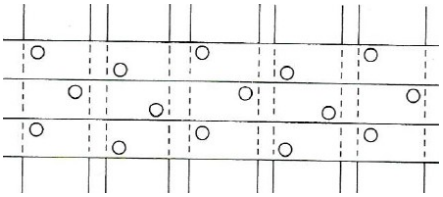


The Four Butt Shift (2 - 4 - 1 - 3)

Source: The Construction and Fitting of the English Man of War 1650-1850 (Pg 58)

This is a Four Butt Shift at locations 2 - 4 - 1 - 3, where the span is divided into five equal parts. Once again for English Men of War, 1650 - 1850. This seems the only pattern that keeps all butt joints either one beam or one strake apart.

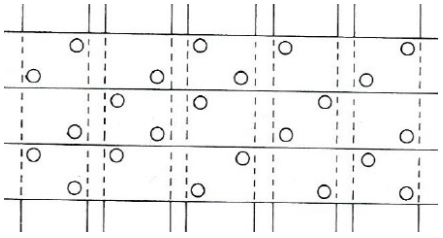
Like plank butt joints, treenails follow a specific pattern dependant on the hull plank width. Until the end of the 1600's the width of the planks were 13" to 18", the older the wider. In the 1700's they were 11" to 14". In the 1800's they were averaging 12" wide. Keeping this in mind we have the following rules...



Hull planks less than 8” wide

Source: Historic Ship Models Wolfram zu Modfeld - Pg 94

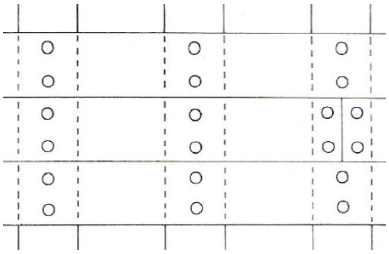
Hull planking less than 8" wide had one fastener per plank in an alternating corner pattern.



Treenails

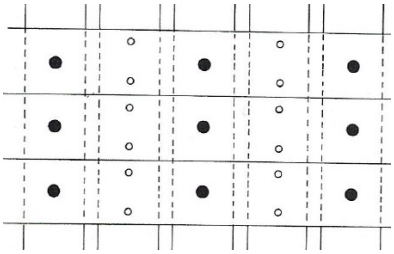
Hull planks 8” to 11" wide
Source: Historic Ship Models Wolfram zu Modfeld - Pg 94

Hull planking 8" to 11" had an alternating diagonal pattern of one and two fasteners per plank.



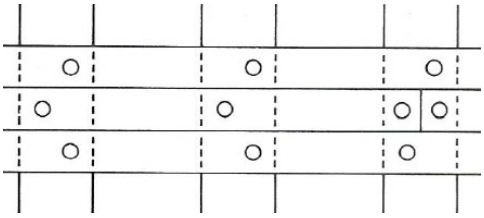
Hull planks wider than 11"
Source: Historic Ship Models Wolfram zu Modfeld - Pg 94

Planks wider than 11" had two fasteners installed parallel.



Hull planks up to the year 1700 - iron bolts treenails
Source: Historic Ship Models Wolfram zu Modfeld - Pg 94

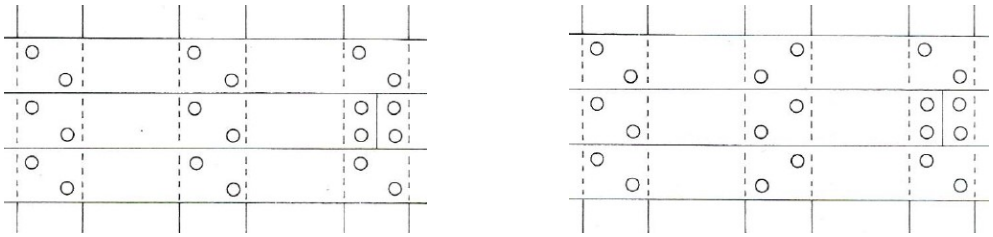
Up to the year 1700 hull planks often alternated between iron bolts, indicated above with a black dot, and treenails or iron bolts of a different size.



Deck planks less than 6" wide
Source: Historic Ship Models Wolfram zu Modfeld - Pgs 98 & 99

Similarly, deck planking less than 6" wide had one fastener per plank creating a diagonal pattern.

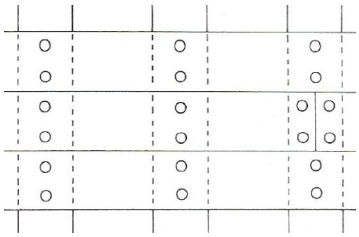
Treenails



Deck planks - two options - 6" to 11" wide

Source: Historic Ship Models Wolfram zu Modfeld - Pgs 98 & 99

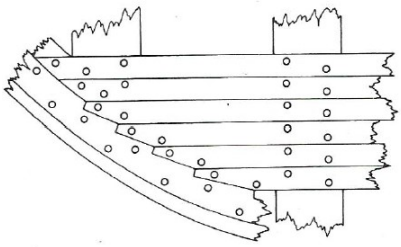
6" to 11" had two fasteners per plank installed diagonally. Either they could all be a repetitive pattern as shown above left, or an alternating pattern as shown above right.



Deck planks wider than 11"

Source: Historic Ship Models Wolfram zu Modfeld - Pgs 98 & 99

Planks wider than 11" had two fasteners installed parallel.



Deck Pattern at joggling

Source: Historic Ship Models Wolfram zu Modfeld - Pgs 98 & 99

The pattern at deck joggling was as depicted above, alternating inboard and outboard.

Treenails are sized by the thickness of the plank being secured as can be seen in this chart.

Plank Thickness		Treenail Diameter		Treenail Diameter and Number Drill Size at Model Scale							
Inches	mm	Inches	mm	1:48 (1/4" = 12")		1:64 (3/16"= 12")		1:72 (0.167" = 12")		1:96 (1/8" = 12")	
1	25	7/8	22	0.02" [0.5mm]	#76	0.016" [0.4mm]	#78	0.015" [0.38mm]	1/64" [0.38mm]	0.01" [0.25mm]	#80
2-1/2	63	1	25								
3 to 3-1/2	76 to 89	1-1/8	29								
4 to 4-1/2	102 to 114	1-1/4	32	0.03" [0.8mm]	#68	0.023" [0.58mm]	#73	0.02" [0.5mm]	#76	0.016" [0.41mm]	#78
5 to 5-1/2	127 to 140	1-3/8	35								
6 and greater	152 and greater	1-1/2	38								

Treenails

In the table above plank thicknesses are listed on the left, and to the right are corresponding treenail diameters at full scale, and then at reduced model building scales.

Many modellers default to a 1 inch diameter treenail as you cannot easily see the difference between a 7/8" and a 1-1/2" treenail at a reduced build scale.

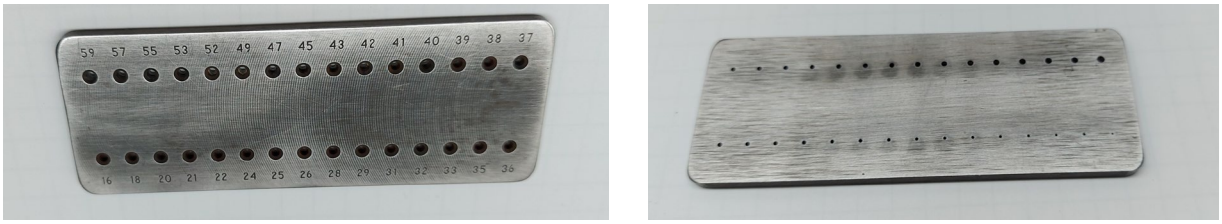
Typical Hole Sizes found in a Commercial Drawplate (inches):

0.059, 0.057, 0.055, 0.053, 0.052, 0.049, 0.047, 0.045, 0.043, 0.042, 0.041, 0.040, 0.039, 0.038, 0.037, 0.036, 0.035, 0.033, 0.032, 0.031, 0.029, 0.028, 0.026, 0.025, 0.024, 0.022, 0.021, 0.**020**, 0.018, 0.**016**

Above are the typical hole sizes in commercially supplied drawplates. 20 and 16 thousands of an inch (in RED) are the only two that can be found on the treenail sizing table above, but 15 is close enough to 16, 23 is close enough to 22 and 24, and 30 is close enough to 29 and 31. As for 10 thousands... that is extremely tiny so 16 is close enough. Remember, no one is going to take a vernier to your build.

Some modellers do not bother to use treenails, especially the plugs in deck planking, because they are supposed to be practically invisible in decking.

You might think that deck plank plug sizes would be different than treenails as the plug fits in a counterbored hole to suit the spike head. The rule for spike sizes is 1/8" square body and 2" of length for each inch of plank thickness. If the planks are multiple layers it is the total thickness of all layers. So a 3" total plank thickness would use a 3/8" square spike 6" long. The head would be larger than the body, possibly double the size, or 3/4", which is less than a treenail for the same size plank, so the above chart still applies to modellers for plugs.



Commercial Draw Plate (flat face shown on the right is the front face)

To make treenails you will need a draw plate which can be purchased or homemade. A proper draw plate has various size holes drilled through allowing stock to be reduced to a specific treenail diameter, and a larger relief bevel or dimple on the reverse side. The commercially supplied plates, such as the Byrnes Model Machine Drawplate priced at $25 US, are felt to be well worth their cost by many modellers due to the high quality and long wear life of the hardened steel material used. It might be less expensive than purchasing a flat steel bar and all the drill bits in multiple quantities required to make your own.

Treenails

A drawplate can be made from tin sheet, but it will be flimsy and difficult to work with. To make your own sturdy drawplate you need a 1/8" thick steel plate at about 1" wide and possibly 6" long. You also need a drill press, vise, and an ample supply of the requisite drill bits. First determine the number and sizes of holes you require. Scribe a centreline on the face of the plate and the equally spaced hole locations to accommodate your number of holes. Choke up on the drill bit in the drill press chuck so only 1/4" protrudes from the chuck, then using light pressure so not to break the bit, and adding a drop of lubricating oil, drill a hole through the plate. Then change the bit out to the next smaller size bit and drill a hole through the next location, then repeat through each other location with successively smaller drill bits. When done, using a 1/16" drill bit, drill half way through the plate at each hole to create a chamfered relief or "dimple". This dimpled side is the front face of your drawplate. Remove any surface burrs with a small flat file or sand paper. Do not insert a file or reamer into the hole as this will enlarge it, rendering it oversized, likely oblong, and definitely useless.

Commercial drawplates will have the hole size marked on the plate as such 59 = 0.059"
Stamp, etch, or engrave your hole sizes to help identify them.

Now that you have your drawplate you will need a supply of wood. Round toothpicks can be used, particularly if they are made of bamboo. Bamboo skewers are ideal as they have a nice straight grain, are easily sourced, affordable, and can be easily drawn down to size. You will also require a good knife and pliers. Parallel, flat nosed, smooth jaw pliers are best because when they close on the wood their grip is along the full length of the jaw, whereas regular pliers pivot and will pinch and crush where they first make contact. Alternatively, it has been suggested that gripping the wood with sand paper will help your grip, but this never worked well for me. My 5" MAK stainless steel Parallel Pliers with brass jaw inserts were purchased from Amazon at about $24 CAD.

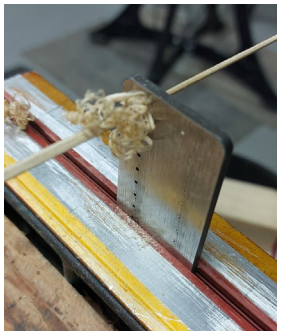
MAKING TREENAILS

Before I continue I must confess that I had no idea how easy this was to do until David Antscherl showed me. So I suspect there are others as clueless as I was.

Treenails

First your stock of wood might need to be split to a size that can be pulled through the drawplate. Usually splitting bamboo skewers into quarters is adequate. To do this safely and easily hold the skewer, square end up, pointy end down, against the edge of your shop work bench, NOT the dining room table, with about 1" protruding above the bench. Clamp the skewer against the side of the bench with your thumb. Place your thumb well below the top of the bench so you don't cut yourself. Place the sharp edge of your knife blade against the top of the skewer, centered, apply ample pressure and cut downwards. The blade will stop at the bench top before it reaches your thumb.

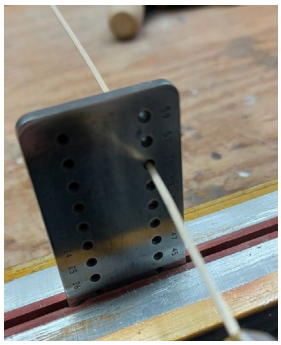
With the knife still in the skewer grab the skewer at the split end behind the knife and draw the knife through the length of the skewer. Now that you have the skewer split in half, take one half and hold it likewise with the flat freshly cut side against the work bench and split it again. Then repeat this with the other half and you will have four quarters.



Treenails

Clamp your drawplate in a secured vise with the dimpled front side facing you. Use soft jaws in your vise to protect the front and rear faces of your plate. Insert the skewer pointed end into the largest hole of the drawplate rear face (not the dimpled side). If one end of the quartered skewer isn't pointed, use your knife to sharpen the end so it can be fed into the drawplate. Grip the pointy end protruding from the drawplate front face, the dimpled side facing you, with your parallel pliers, and with a steady motion pull the skewer through the plate. Now put it back in the same hole and do it again.

You can see the peel of wood coiling up on the back side of the drawplate as the skewer is cut down to size in the image above to the left.

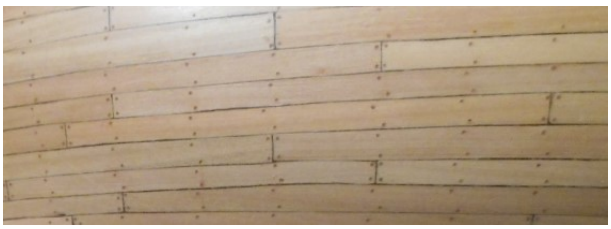


Skipping a hole size go down to the second smaller hole and repeat the process, twice as above. Continue to do this, second next smaller hole, twice, until you reach the desired size.

You will find the point on the skewer will eventually be crushed. Simply cut it off and re-sharpen the point with your knife. If your point is just slightly too large to fit the hole you can whittle it down a bit, or try stuffing it into the front facing dimpled side of the plate part way to crush it down, effectively re-sizing it, then pull it out and re-insert it into the proper, rear side of the drawplate.

INSTALLING TREENAILS

It is strongly suggested to test fit your treenail to a hole drilled in a piece of scrap before proceeding to drill holes in your model.



You will need to determine and carefully layout the pattern and number of fasteners based on the width of the plank and the location of the fastener on the length, versus end, of the plank. Drill a hole through the plank and into the beam or timber sized for the treenail, and then manually clean up the hole with the same size drill bit in a hand held pin vise.

Treenails

They cost about $15 CAD on Amazon. Do not use a random nail or compass point as they are a different size! Use a vacuum, preferably fitted with a small diameter flexible hose or tube, to suck debris from the holes.

The tube adapter kit above costs about $30 CAD from Lee Valley Tools. The treenail might be chamfered or tapered slightly on the lead end feeding into the hole, or if you prefer pointed, to assist with insertion into the plank hole. This can be done by pinching the end of the treenail between your finger with sand paper and rotating the paper lightly a few times. Machinist's refer to this as a lead on the end of a shaft creating some clearance to help fit the shaft into a tight fitting hole. The length of the treenail should be enough that a small portion, enough to grip, protrudes above the plank after insertion. Some modellers use an uncut length and snip it off with nail clippers or small wire cutters just above the deck after insertion. The tip of the point or very end of the treenail should be dipped into your glue so upon insertion it adheres to the base of the hole. You want to reduce or eliminate glue oozing out onto your plank! After dried and cured, the stumps can be trimmed down and made flush with a sharp chisel followed by light sanding or scraping.

ALTERNATIVELY

Another option is to forego the making of treenails all together and simply fill the drilled holes with wood filler using dental tools. Once dried it can be sanded flush. Test on some scrap first

to fine tune your method and visualize the final result before attempting it on your model. You can make your own wood filler with wood glue and fine saw dust, also known as wood flour, mixing small quantities until it is a putty. Do not make a large quantity as you will have a short working time before it starts to set. If you intend to apply oil or stain afterwards be aware that the glue in the wood filler might not accept the oil or stain so test your mix on a piece of scrap first.

My presentation was prepared with the help of the sources listed below:

References:

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