Contents

Introduction

The brief for this submission required me to reproduce or replicate an antique piece of furniture through traditional or modern methods. The piece I chose was the Willow Chair, designed by Charles Rennie Mackintosh, dating from 1904.

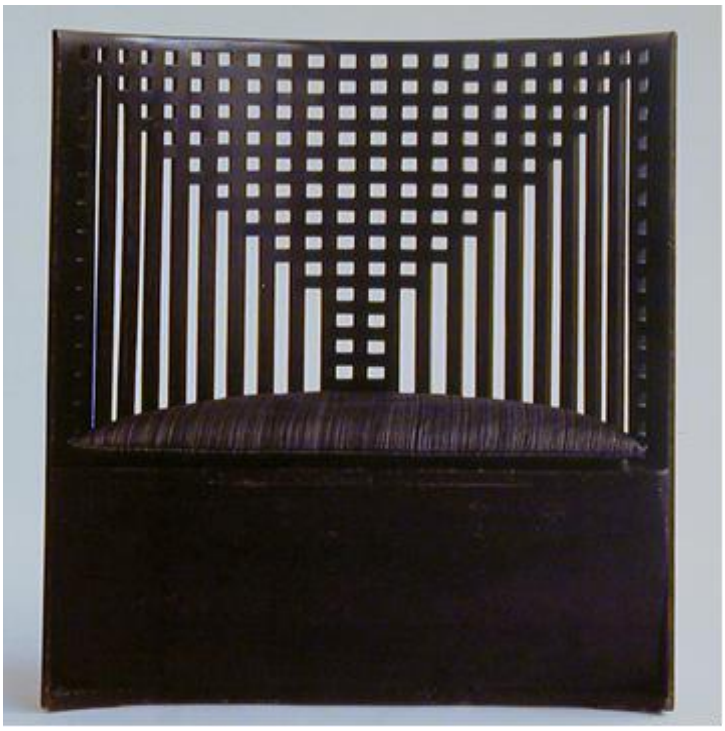


Fig. 1 the Willow Chair

Image taken from www.gsa.ac.uk/

I first became aware of this design last year while working on a research assignment based on Charles Rennie Mackintosh and some extracts from that report are included in the appendix. The chair was designed by Mackintosh to go into the Willow Tea Rooms on Sauchiehall Street in Glasgow and was positioned at the order desk. It was made from oak and consisted of a segmental base and seat with a hinged flap cut out of the seat to provide storage underneath. The back of the seat consisted of curved lattice work made up from numerous uprights separated with small inserts of timber forming the shape of a Willow tree. This was a very clever design in my opinion in that it allowed the seat to serve three

separate functions seamlessly and effortlessly. It had the storage underneath for security, takings were stored here, it also served as a beautiful room divider given its partial transparency, and also as a seat for the attendant at the order desk. This was all tied together with the subtle and tastefully formed Willow tree shape in the lattice work. I chose this design because as soon as I had seen this chair I was intrigued. I found the design very interesting and unique and thought that it was extremely eye catching. My reproduction of the chair involved the use of modern machines and jointing techniques. Some alterations were made to timber sectional sizes and overall dimensions but I feel the essence of the original design certainly remains. I anticipated this task as being a big challenge for me but also saw it as an opportunity to put into practice some of the aspects of my learning over the past two and a half years such as the use of jigs. The production of the piece went pretty much to plan but some compromises had to be made along the way and these are documented in the Methodology 2 and Conclusion sections.

Rational

My rational for choosing this piece was quite simply that I found the piece remarkably striking and thought it would be a real challenge to produce. It is a very modern looking design even by today's standards and the clean, crisp, geometrical lines of the piece are exactly to my personal taste, this can be said for a lot of Mackintoshes work. The piece incorporates both curved and straight lines in an inventive manner and the subtle forming of the Willow tree in the lattice work is both innovative and imaginative. Having researched Mackintosh last year, I found his style very engaging and did not come across a design of his that I did not appreciate. The fact that this piece is a chair was also a factor in my choice. It does not look like a particularly comfortable chair but this shortfall is more than made up for in aesthetics in my opinion and keeping the order desk attendant on their toes would also have been in Mackintoshes mind here I'm sure. While I have carried out repair work on chairs in the past, I have never produced one from start to finish, so this was also an objective I hoped to fulfil during my time at D.I.T. Furthermore, it is not a traditional or stereotypical four legged chair; it is more of a bench style with a high back that is intelligently designed to be versatile in that it served three purposes simultaneously, and this was attractive to me. I also wanted to choose something that I could feasibly produce to

a high standard given the allocated timescale for working on the piece. I saw the curved lattice work as being the greatest challenge to me along with the intricacy involved with fixing the small inserts to the piece. While these aspects pose a challenge I have no doubt that with the necessary research and calculations I will be able to overcome these obstacles. Throughout my time in college I have learned a lot, and the use of jigs in woodworking was an area that was covered at large last year. I am very comfortable making and using jigs and I consider myself very capable in this department. I foresee the use of jigs as being the basis for my creation of this piece. The chair is to be made from ash, in contrast to the original, and this is a material that I have not worked with before. The properties of ash allow it to be manipulated more easily than most other hardwoods. For this reason it is the perfect choice for this piece and I am relishing the opportunity to work with this material. I am highly positive and optimistic about the undertaking of this work and I anticipate an outstanding result. On completion of the piece I hope to have produced a piece of furniture that is both aesthetically pleasing and functional. I see the piece potentially being a centre piece for a room and a real talking point. I also hope to do Mackintoshes design justice and produce an article that even he himself would be proud of.

Charles Rennie Mackintosh

Charles Rennie Mackintosh (1868-1928) was an architect who designed schools, offices, churches, tearooms and homes. He was an interior designer and decorator, an exhibition designer, a designer of furniture, metalwork, textiles and stained glass and, in his later years, a water-colourist. He was born in Glasgow, on the 7th June 1868 and was the second son in a family of eleven children. From an early age Mackintosh expressed a desire to become an architect. In 1884 at the age of 16 he became apprenticed to the architectural firm of John Hutchison of Glasgow. In the same year he enrolled for evening classes at the Glasgow School of Art. Upon completion of his apprenticeship in 1889 Mackintosh joined the newly established and prosperous firm of John Honeyman and John Keppie to work at first, as a draughtsman. (Charles Rennie Mackintosh, Charlotte and Peter Fiell, 1997, p. 8) During his time with this firm Mackintosh undertook many important commissions that gained him a reputation as being a very original architect. His most famous architectural accomplishment was undoubtedly his design of a new building for the Glasgow School of Art

in 1896. The north end opened in 1899, but the construction of the west end did not start until 1907 and was only completed in 1909. This time lapse coincided with the most productive period of Mackintosh's career and accounted for the changes in style between the first and second phases.

Fig. 2 Glasgow School of Art.

http://www.design1900online.com/page2/page2.html

In 1902 Mackintosh received another significant commission when he was asked to design The Hill House in Helensburgh for Glasgow publisher Walter Blackie. "Built from local sandstone and rough-cast rendered, the house bears the image of Scottish baronial traditions. For the interior, Mackintosh designed fireplaces, furnishings and fittings. His attentions extended from the design of built-in wardrobes for the white bedroom to the detailing in a superb set of pewter fire tongs and poker. Walls in the house were generally white, some with delicate stencil designs in pale greens, pinks, and silver. His desire to create a total environment was in keeping with the artistic taste of the time and Mackintosh was extremely fortunate to work throughout his career with clients such as Walter Blackie, who allowed him to have complete control over a project." (Mackintosh Architecture, Academy Editions, 1980, p.40)

Fig. 3 Hill House

http://www.undiscoveredscotland.co.uk/helensburgh/hillhouse

Fig 4. Interior of bedroom · Hill House · Helensburgh, Scotland

Photo by Howard Davis. © Howard Davis

Mackintosh's most supportive client was Miss Catherine Cranston, a woman who owned a chain of Glasgow tea rooms. He was first employed by Miss Cranston in 1896 to decorate the walls of her tea rooms at Buchanan Street. His decoration depicted elongated female figures in pairs, facing each other, surrounded by roses. This successful commission led to others from Miss Cranston and in 1898 he was given sole responsibility for the Argyle Street tea rooms. It was for this project that he first designed his now infamous high back chair. In 1900 he designed the ladies luncheon room and related rooms at the Ingram Street tea rooms, and in 1903 he designed from top to bottom, the Willow Tea Rooms at Sauchiehall Street. Mackintosh along with his wife Margaret designed everything from the furniture and menus, to the waitresses' uniforms at the Willow tea rooms. It is here at the Willow Tea Rooms on Sauchiehall Street that we encounter the chair that I have chosen to reproduce, the curved lattice back Willow Chair for the order desk.

Currently on display at the Glasgow School of Art, the style of this chair is typically Mackintosh with the incorporation of squares into its design. This symmetrical and geometrical squares style was used by Mackintosh on a great deal of the chairs he designed and on other items of furniture as well. At Hill House in Helensburgh there are several examples. One such example is the chair that sits in the hallway at Hill House and another example is the high back chair from the bedroom at Hill House.

Fig. 5 Chair from the hallway at Hill House.

Fig. 6 Chair from the bedroom at Hill house.

Images taken from http://www.brucehamilton.co.uk/

Two more examples are the low back chair with chequered vertical strips, again from Hill House and the high back chair from the Room de Luxe at the Willow Tearooms;

Fig. 7 Low Back Chair from Hill House.

Fig. 8 High Back Chair from Willow Tearooms.

Images taken from www.huntsearch.gla.ac.uk and www.invaluable.com

So it is clear from these examples that this was a concept of design that Mackintosh was very fond of. One thing that these chairs have in common, aside from the incorporation of squares into their design, is that for the most part they are blocky and square looking in their overall appearance as well. This is where the Willow Chair differs from all the rest. While these chairs were extremely modern in their design for the period, the Willow chair was on another level in my opinion. The curved lattice work in the chair and the forming of the willow tree are so different from typical Edwardian chair designs that even if the chair was created today it would be considered innovative. A testament to this statement is the fact that the chair has in fact appeared in two films that I became aware of during my research, “Inception” and “Blade Runner”. Inception is a very forward thinking sci-fi type

film and Blade Runner is actually set in the year 2019 so the appearance of this chair in both of these films is no coincidence.

Fig. 9 Willow Chair in “Inception”.

Image taken from www.btlnews.com

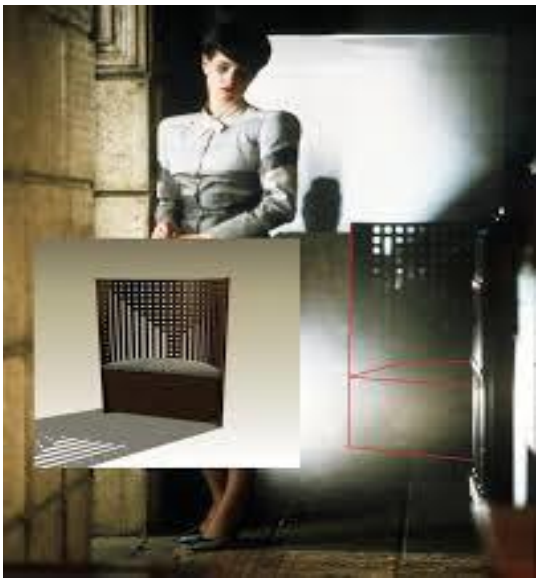


Fig. 10 Willow Chair in “Bladerunner”.

Image taken from www.propsummit.com

During my research I came across many books that gave descriptions of the chair, some brief and others more detailed but none that gave in depth information on how the chair was actually constructed. I contacted the Charles Rennie Mackintosh Society and the Glasgow School of Art regarding this issue through email and had some feedback from them, but the information I was seeking was not forthcoming. This was a bit of a setback, however based on the descriptions that I have read and some of the original drawings and pictures of the chair I believe I have an adequate amount of information to give me a decent understanding of how the chair was put together. One of the more detailed descriptions that I discovered reads "ebonised oak 118.2x94x42", "the chair is not semi-circular, but segmental" and "the lattice is made up of short horizontal insets between the continuous verticals, as opposed to the use of alternate checking of the slats as in the House' hill bedroom chair. The front of the seat, which also serves as a small locker or chest projects beyond the two sides and then slopes gently backwards towards the bottom to finish within the sides. The base runs along this panel but at either end curves out to meet the side members."(Roger Billcliffe, 2010) This is a very useful description in that it gives the material and finished used and the overall dimensions of the chair. It identifies the technique used to form the lattice work on the chair and also makes reference to the fact that the chair was used for storage. Prior to having read this description I was under the impression that the chair was actually elliptical in shape. This was therefore valuable information for when I went to design my version of the chair. So as stated in this description the lattice work is made up of continuous vertical uprights with short horizontal insets between them. Going by a plan view drawing of the chair that I discovered in the book "Charles Rennie Mackintosh as a Designer of Chairs" by Filippo Alison, 1977 (fig.11), the uprights appear to be cut square all around without any angle on them to follow the curve that they run along. This means that the small inserts would have had to have been angled on each side to ensure no gaps were present where they joined the uprights to the front and the back of the chair. This method of planing down the edges of timber to produce a curve when joined together is known as coopering and was traditionally used for producing wooden barrels. This method is also likely to have been used for producing the curved back on the base of the chair. The seat, base front and base bottom are likely to have been produced using butt joints, joining several lengths of timber together before cutting the curves onto them

possibly with an early band-saw or more likely with hand tools such as saws, spoke-shaves and hand planes.

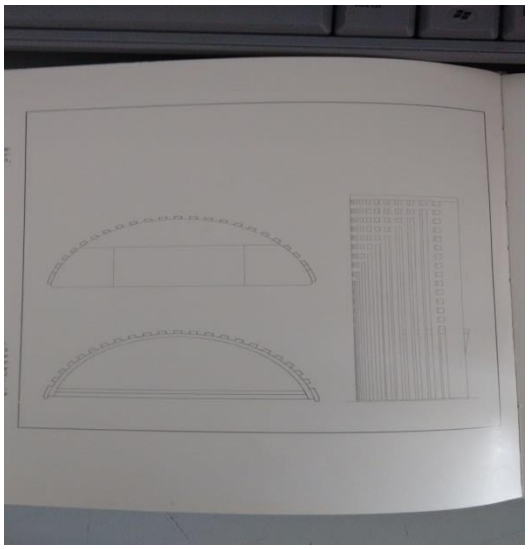


Fig. 11 Plan drawing of Willow Chair.

Image taken from “Charles Rennie Mackintosh as a Designer of Chairs” by Filippo Alison, 1977.

More information on the construction of the chair can be gained if a closer look is taken at the photo in the introduction section of this report. When zoomed into it becomes clear that the curved top rail of the chair is made up of small sections of timber spliced together, to reduce the severity of the curve required on each section I assume.

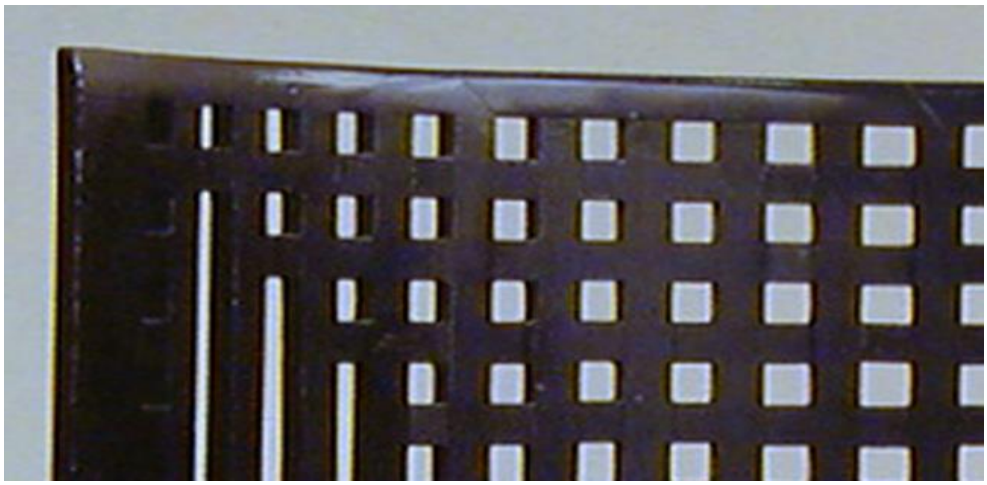


Fig. 12 Curved sections of timber spliced together.

There were several common methods for bending timber at the time when this chair was produced. Steam bending, heat bending and shaping timber using hand tools were three common methods. Judging from the picture (fig.12), the method of joining short strips of material together meant that the required curve on each length was reduced in severity dramatically so any of these methods would have been appropriate. More detailed descriptions of these methods will be explained in the methodology 1 section of this report. It is likely that mortise and tenon joints were used to join the top rail pieces to the uprights as this is a traditional and very strong joint. The glue used in the construction of the chair was most likely animal glue as this was the most commonly used glue at the time and P.V.A. glue had not been invented until 1912. The chair was finished with an ebony stain as stated in the quoted description and the method for applying this stain will also be detailed in the methodology 1 section.

Methodology 1

As stated in the introduction my reproduction of the chair will not be an exact reproduction. Changes will be made to timber sectional sizes and I will be using modern machinery, materials and jointing methods. Using modern machines will speed up the process for producing the chair. Some of my methods will be the same as the ones used in the original but on the whole my chair will be produced in a completely different way, hopefully with the same exceptional result.

Straight from breaking out the material to produce the chair, modern machinery will be used. A surfacer and thicknessing machine will be used to plane the timber down to the required sectional sizes where hand-planes would have been used in the past. Starting with the construction of the base I plan to use butt joints, dowel joints, a router, M.D.F. templates, flexi-ply and P.V.A. glue. In the research section I made reference to the fact that the traditional method for constructing the base was likely to have involved the coopering of timber. This is where a series of strips of timber are planed on each edge to a required angle and when butted together form a curve. This was the method used to produce wooden barrels and several metal rings would fit down over the timber lengths to tie the

lengths together. These barrels were used to store tobacco, flour, vegetables and liquids. (http://www.guinness-storehouse.com/en/docs/Coopering_Process.pdf)

Fig. 13 Coopered Barrel half finished.

Fig. 14 Coopered bucket.

Images taken from www.freemenofnewcastle.org and www.beaverbuckets.com

My method for producing the base will differ completely. During my studies last year I had the opportunity to produce a table made from M.D.F. and this table had to incorporate curved work. The tool used to produce the curves on this table was the router. Jigs and templates were also produced and used and it became clear to me just how useful and versatile the router was as a machine. I became familiar with the techniques used to produce jigs and templates and I was comfortable doing so. This therefore is a skill I want to put into practice again in my construction of the base. The joining of the lengths of timber that will make up the seat, base front and base bottom will be the same as the traditional method whereby the lengths are planed down, glued on the edge and butted and cramped together. I plan to make a template to run the router off to produce the curved seat and base bottom of the base unit. The router will be used again to put a rebate onto the seat and base bottom and I plan to veneer a layer of flexible plywood to sit into this rebate to produce the curved back on the base unit. I foresee this method being faster and more straightforward than the traditional method of coopering and I think it will look just as good. The base will be held together with the use of a series of internal uprights that will be broken out of pine and then doweled into place on the underside of the seat and on the top of the base bottom. A second layer of flexi-ply, this time without veneer, will then be fixed

to these internal uprights on the inside of the base to conceal these uprights and tidy up the inside of the base.

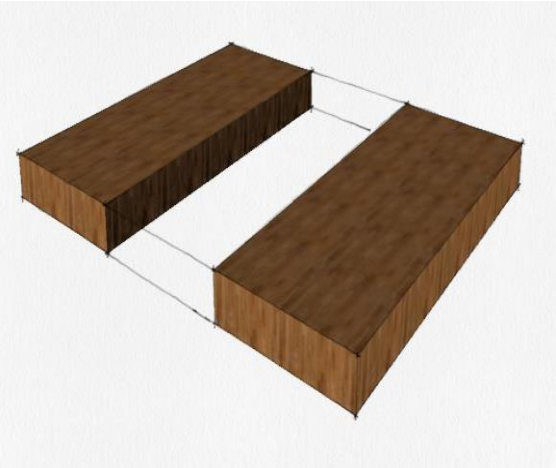


Fig. 15 Traditional Butt joint.

Fig. 16 Router.

Images taken from adhsworkshop.weebly.com and english.stackexchange.com

My method for producing the lattice work on the back of the chair will also be in stark contrast to the original method used. In the original the uprights ran continuously from top to bottom and small coopered timber inserts were fitted between them to make up the willow tree pattern. For my reproduction I plan to use timber lamination. Timber lamination is where a series of thin strips of timber are ripped on a table saw or band-saw, they are glued together layer by layer then placed into male and female formers and cramped tightly until the glue has set. It is commonly used in the production of furniture, timber joists and timber arches over doors. I plan to bend several lengths of timber using this method and these strips will sit into notches that will be taken out of the backs of the uprights. Working from the outside upright back to the middle of the chair and from the top downwards the uprights will be notched out in sequence with a 26mm notch and a 26mm gap between each notch. Each proceeding upright will receive more notches as they are worked towards the middle upright. The notches will be half the thickness of the uprights deep and the curved laminated strips of timber will sit flush with the backs of the uprights once glued and cramped in place. I have seen lamination done before but have never had the opportunity to try it myself so this was one of the reasons for choosing this method. This

could be considered experimental seeing as I have not done this before. I believe that this method of producing the willow tree effect in the lattice work will actually strengthen the overall structure of the chair and tie the whole piece together and this is another reason for my choice. The table saw will be used to cut out the notches in the uprights. I plan to use mortise and tenon joints to join the uprights to the top rail and I believe that this method would have been used on the original chair. The uprights will be fixed to the base from the inside with screws.

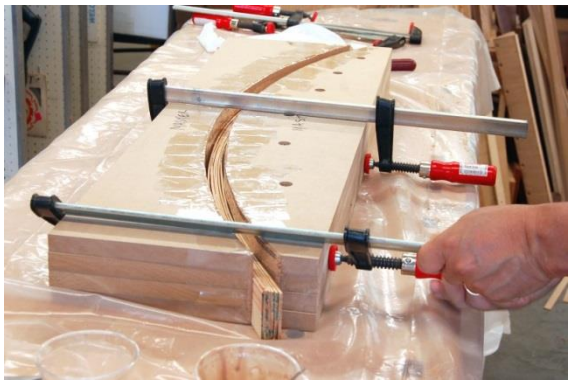


Fig. 17 Lamination Process.

Fig. 18 Laminated Beams.

Images taken from buildipedia.com and sandal-woodsblog.com

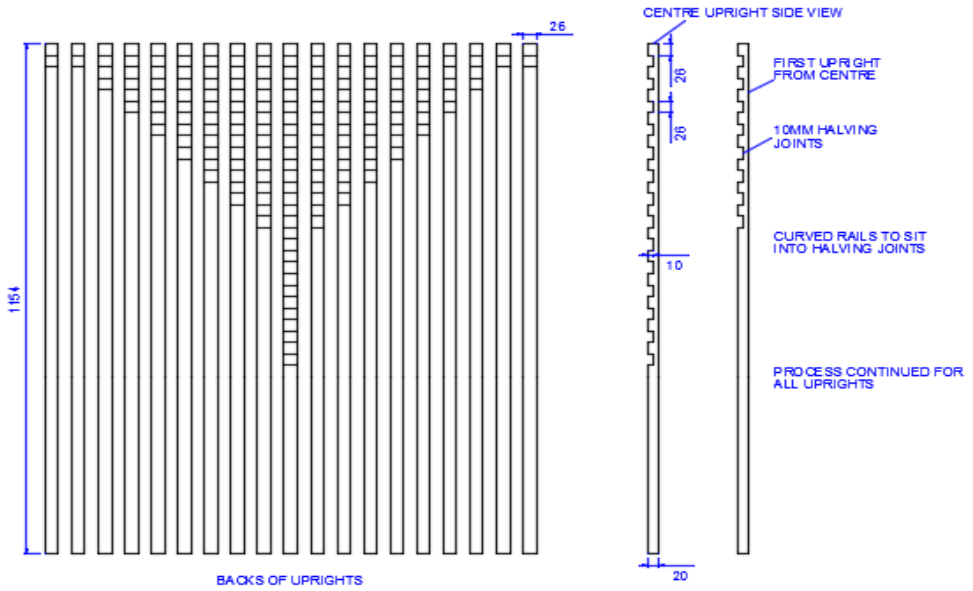


Fig. 19 Sequence for notching out the backs of the uprights.

For the top rail of the chair I plan to use timber lamination once again. The top rail will be 20mm thick whereas the other curved backing rails will only be 10mm thick. As this is the case a second set of formers will have to be produced and the router will be used to do so. As stated in the research section there were several techniques that may have been used to produce the original top rail, one of which is steam bending. “Steam bending is a woodworking technique where strips of wood are steam heated using a steam box. The applied heat and moisture makes the wood pliable enough to easily bend around a mould to create a specific shape. The moulding process is usually done by clamping the strips of wood to a positive form, with the strips of wood often reinforced on the outside with a metal band to prevent blowout.”(http://en.wikipedia.org/wiki/Steam_bending) Heat bending of timber is another method that may have been used. Heat bending is the process wherby the timber is soaked in boiling hot water until the fibres of the timber are loosened and it becomes plyable. It is then placed into formers again and let to dry out and set in shape. One more possible method that could have been used was to simply cut the timber by hand to roughly finished size and plane and sand the timber smooth with spoke-shaves and sand paper. I chose the lamination method because I feel it will be stronger than the original method of joining short pieces of timber together. Another reason for my choice is because it is a method that I will be using elsewhere during the process so I will have gained some experience by the time I go to do the top rail.

The finish that will be applied to the chair is an ebony stain. Ebony stain blackens the timber yet allows the grain of the timber to still be visible. I personally like that look on this particular chair and that is why I have chosen this finish. I am very wary of the grain still being visible as I feel this is important for the overall look of the chair. The ebonising process can take up to a week to do properly and there are a lot of steps involved. I came across a good step by step guide at http://www.wikihow.com/Ebonize-Furniture and it reads as follows.

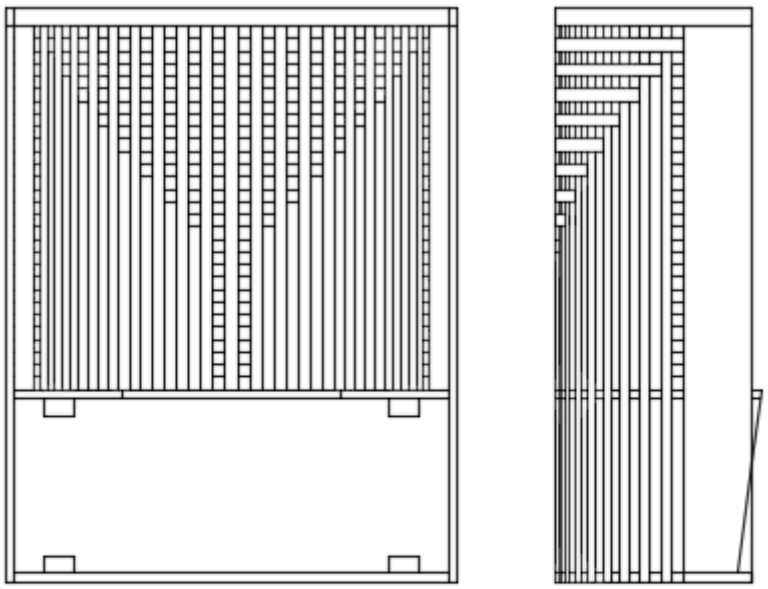
- Wash a piece of steel wool thoroughly in soap and water to remove all of the oil from the steel wool. Any remaining oil will interfere with the necessary chemical reactions, so be sure to get the steel wool very clean.
- Drop the steel wool into a plastic bottle of white vinegar and seal the cap tightly.

- Drill a small hole in the bottle cap. Gasses are released during the process of dissolving the steel wool and the bottle could burst if there is not a small hole to allow the pressure to equalize.
- Wait for the steel wool to completely dissolve. You should plan for this process to take a week, but the solution can sit for several months before you use it.
- Strain the solution through a coffee filter to remove any impurities. You can then pour it back into the jug.
- Sand the furniture. You can perform this step any time while you are waiting for the iron solution to be ready. Be thorough. If you must sand the furniture after you ebonize it, you will have to begin the ebonizing process in that area again because you will sand off the finish.
- Mix the bark tea solution. You can prepare this solution immediately before beginning the staining process. Dissolve 1 heaping tsp. of bark powder into a pint (0.473 l) of hot water and stir.
- Apply the bark tea solution. Using a small paint brush, apply the bark tea liberally to the wood. Use enough of the solution that the wood is completely soaked and the reaction takes place in the wood. Although you want the wood to be completely soaked, be sure to use a paper towel to clean up any of the solution that has pooled on top of the wood.
- Apply the iron solution. Wait for the wood to still be damp with the bark tea, but not wet. Using smooth brush strokes, apply the solution to the wood. The wood should start to blacken immediately.
- Apply a second coat of bark tea solution. Let the wood dry for a few hours so it is no longer damp to the touch. Use a clean rag to polish the surface and remove any iron deposits, and then brush on the second coat of bark tea solution as though you were painting the furniture.
- Wash the furniture. Use clean water to lightly wash the furniture. If you find imperfections, sand them down and perform the ebonizing process to that area again.

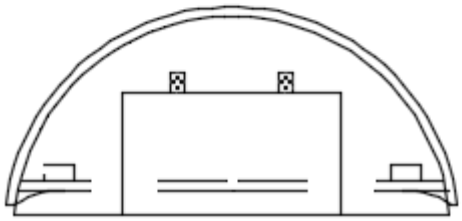
As I do not foresee myself having the time to go through this entire process I will use a ready mixed ebony stain from a bottle and apply a clear lacquer afterwards.

Cutting List

Capstone Project			Willow Chair		
No.	**Item**	**Length**	**Width**	**Thickness**	**Material**
3	Base front	900	122	18	Ash
3	Seat	900	150	20	Ash
3	Base bottom	900	150	19	Ash
31	Upright	1190	26	20	Ash
6	Cross rails	1360	26	10	Ash
2	Cross rails	1360	36	10	Ash
1	Base backing	1360	381	5	Flexi-ply
1	Inner base	1260	361	5	Flexi-ply
22	Inner upright	361	25	18	Pine
Extras: 2x50mm Butt hinges, 3.5x20mm screws, Titebond glue, P.V.A. glue					



ELEVATION END VIEW



Methodology 2

The first step in the process was to break out the material from rough. Working from the cutting list the material was first measured out and cut to length on the cross cut saw. Next the long lengths of rough material were run through the band re-saw and these lengths were then further ripped down on the table saw. The timber was left in rough sections and not finished sizes as some of it would be sitting on a shelf for a while and any twisting or bending that may have occurred in the timber during this time would be rectifiable. At this stage material for the seat, base bottom, front of base, uprights and curved back rails had been broken out and construction of the chair could now begin.

The first stage of construction was to be the construction of the base. The material for the seat, base bottom and front of the base was planed flat on one wide edge on the planing machine. The guard was set up on the machine to be as close as is practicable to the timber and the lengths were run through. These lengths were then planed flat on both narrow edges by running off the fence on the planning machine to achieve a right angle on the material. Any bows in the timber were kept down on the bed of the machine during this process. Once this was done the material was to be glued together in groups of three lengths.

Fig. 20 Rough lengths of material for the base.

Fig. 21 Material before planing.

Fig. 22 Squaring the fence on the Planer.

Fig. 23 Planing timber on the wide edge.

Fig. 24 Planing narrow edge off the fence.

Fig. 25 3 edges planed on the timber.

The next step was to glue the lengths together in groups of three to make up the required widths for the seat, base bottom and the front of the base. The nine lengths were grouped into threes. Three sash cramps were set up to cramp the two ends of the timber lengths and the middle of the joined lengths. Paper was laid down over the cramps to prevent glue getting on them. The lengths were sat up on the narrow edge and P.V.A. glue was spread over the inner narrow edges of each length. The lengths were laid down flat with the three planed wide edges sitting down on the cramps and the three rough surfaces facing up. The edges of the lengths were then rubbed together to get a better glue bond and the cramps were tightened. The lengths were set up so that the grain ran in alternate directions on each of the planks to prevent cupping of the timber once the glue had set. Two further cramps were placed over the top of the timbers to help ensure the timber stayed flat in the cramps. This process was repeated two more times and the nine lengths of timber were now three wide planks. Once the glue had set the three wide planks were taken out of the cramps and the planed sides had the excess glue cleaned off with a chisel and sandpaper. The next step was to run these planks through the thicknessing machine.

Fig. 26 3 Lengths laid out on the sash cramps.

Fig. 27Glue applied to narrow edge.

Fig. 28 Lengths cramped.

Fig. 29 2 groups of 3 lengths cramped.

The wide planks were brought to the thicknessing machine. There they were measured in thickness at their thickessed point and the machine was set up to take 2mm off. The planks were run through the machine several times with the clean side of the planks on the bed of the machine and the rough side up, taking 2mm off per run. They were run through until the required thickness was achieved. With the thicknessing complete the wide planks were ready to be shaped. (Figs. 30,31,32 follow)

3 wide planks unthicknessed.

Running through thicknesser.

Planks after thicknessing.

The next stage was to create the templates for the seat and the base bottom from M.D.F. Two pieces of 18mm M.D.F. were ripped on the wall saw. Usually thinner M.D.F. would be used for this task but these pieces were also to be used as formers for the curved back rails of the chair at a later date so 18mm was chosen. The centre point for the segmental seat and base bottom were printed out from C.A.D. at full size and laid down on the M.D.F. A router was to be used for this task. The router was fitted with a 10mm cutting bit and it had a length of threaded bar fitted to it also. A wind-on metal point was fitted to the end of the threaded bar to be held in position at the centre point of the cutting circle. The cutting radius was set and the threaded bar was tightened to the router. A vacuum was connected to the router to reduce dust and a depth of cut of 4mm was set. It was run over the M.D.F. several times, dropping the cutting depth by 4mm each time until it had been cut all of the way through. Goggles and ear protection were worn while operating this machine. This procedure was repeated once more on the second piece of M.D.F. The edges of the templates were then sanded smooth with 180 grade sandpaper.

Fig. 33M.D.F. on the wall saw.

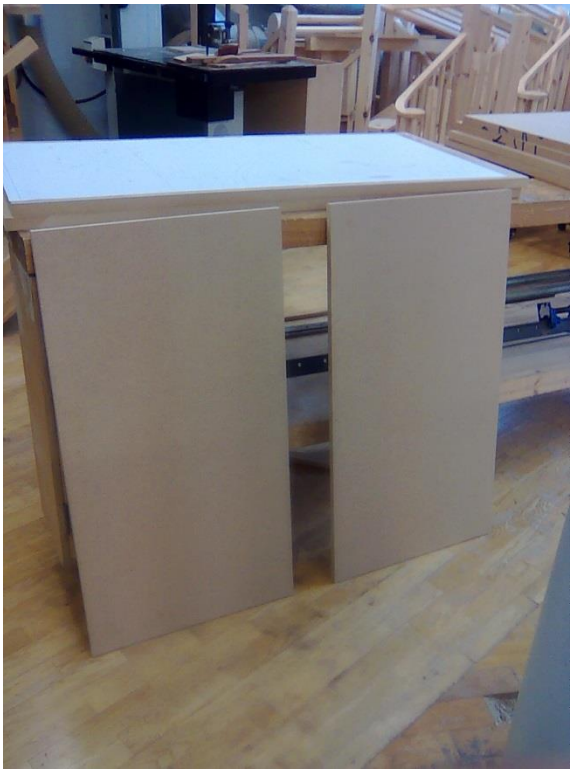


Fig. 34 Two M.D.F. pieces ready for routing.

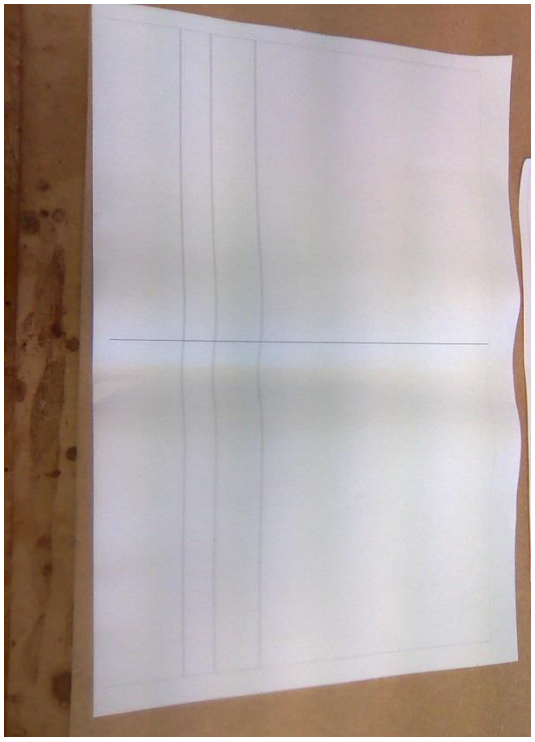


Fig. 35 C.A.D. drawing to find centre.

Fig. 36 Metal wind-on point for threaded bar.

Fig. 37 Running router over M.D.F.

Fig. 38 Sanding down the template edge.

The base bottom of the chair was to have curved details to the front of each end and was also to finish 50mm back from the front edge of the seat. Adjusting one of the templates to suit this design feature was the next job. Once again a full size C.A.D. drawing of the curves was printed out and laid down on another small piece of M.D.F. that had been obtained. This curve was marked out on the M.D.F. and cut out on the band-saw, it was then cleaned up with a spoke-shave and sanded smooth. The curve from this small template was then marked onto either end of a longer piece of M.D.F. and cut out using the same technique and a new template was created with the required curves at either end. This new template was set back 50mm from the front edge of the original one and screwed in place. The curve of the template was traced around and the new template was removed. The traced template curve was then cut out of the original template roughly on the band-saw leaving approximately one or two millimetres of waste on the M.D.F. The new template was then re-fitted to the original and a trimmer bit with a guide wheel on it was fitted to the router. The router was run off the new template and the base bottom template was complete.

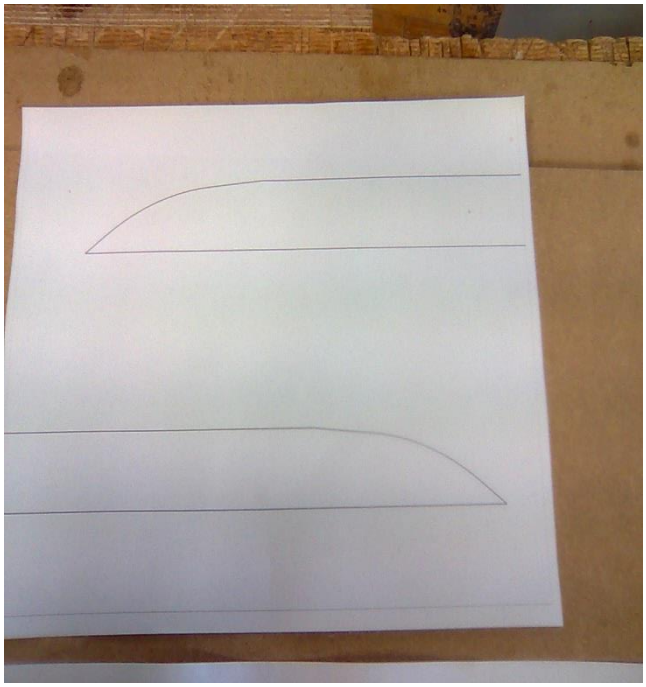


Fig. 39 C.A.D. curves printed out.

Fig.40 M.D.F. curve template.

Fig.41 Full base bottom curve template fixed in place.

Fig. 42 Router trimming bit.

With both the seat and base bottom templates complete it was time to shape the wide planks that had been prepared earlier. The seat template was placed over one of the wide planks and the base bottom template was placed over a second wide plank. The templates were traced around and the wide planks were brought over to the band-saw. Once again the shapes of each of the templates were cut out roughly on the band-saw ensuring all guards were in place and goggles were worn. A margin of approximately one or two millimetres of waste was left on each of the wide planks. Once this was done they each had their respective templates fixed to them with screws, screwing to the inside surface of each plank so the holes would not be an issue. The router was fitted with the wheeled trimmer bit and the run around each of the templates trimming off the waste on the wide planks. This operation went smoothly on the seat template but a minor issue occurred while trimming the base bottom plank. The fine point at the tip of one of the curved ends chipped off while routing and so the chipped off piece needed to be glued back in place. Luckily the chip remained in one piece and it was glued back on with P.V.A. glue and held in place with masking tape. Once the glue had set the point was as good as new. With this repair complete the next stage was to put a rebate on the bottom edge or the seat and top edge of the base bottom planks to accommodate the veneered flexi-ply that was to be fitted to them.

Fig. 43 Trimming around base bottom temp.

Fig. 44 Trimming around seat template.

Fig. 45 Chipped piece glued and taped.

Fig. 46 Chipped piece repaired.

Fig. 47 Seat plank shaped.

Fig. 48 Base bottom plank shaped.

The front of the base was to sit flush with the front edge of both the seat and the base bottom, and the base bottom front edge was to be set back 50mm from the front edge of the seat. To accommodate for this, the base bottom was placed on top of the seat and the 50mm line was brought down from the base bottom onto the seat. This line was to give the guide for where the rebate was to finish on the underside of the seat, taking into account the thickness of the base front which was 18mm. The stop points were marked on each of the planks approximately 18mm back from each of their respective front edges. The veneered flexi-ply was to be 6mm in thickness but in the absence of a 6mm rebate bit it was decided to use a 10mm rebate bit. The overhang would then be chamfered to create a feature. This seemed appropriate at the time but proved to be an oversight that will be explained further into the work log. The router was fitted with the 10mm wheeled rebate bit and the rebates were run at a depth of 10mm onto each of the planks finishing at the marked stop points.

Fig. 49 Marking the 50mm line.

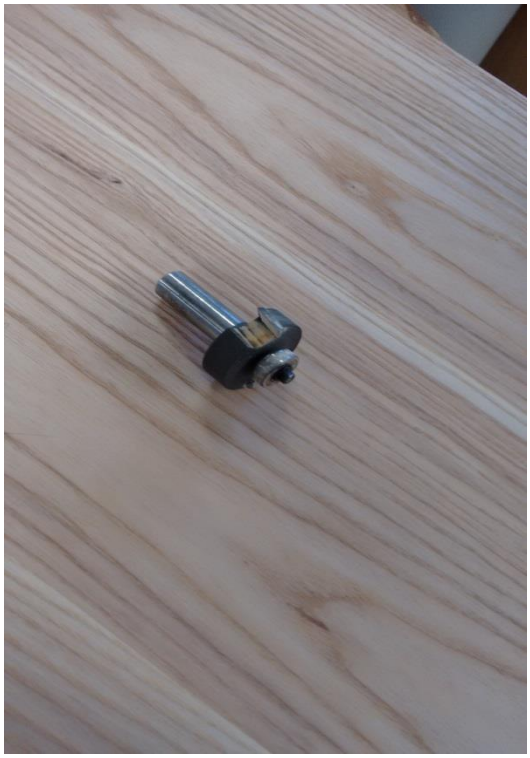


Fig. 50 10mm wheeled rebate bit.

Running the rebate.

Base bottom rebated.

Seat rebated.

Figs. 51,52,53

Having run the rebates the aforementioned oversight became obvious. The uprights were to be fixed through the flexi-ply with screws from the inside of the base. The flexi-ply not finishing flush with the outer edge of the rebate now became an issue as this would mean that any fixings would be visible. This was not a major problem to resolve and it was decided that the rebate would be packed out with two strips of 2mm material on each rebate to make up the deficit.

The next step was to begin work on the curved back rails of the chair. The use of the 18mm templates made earlier was decided against as the rails were to be 26mm in width and so more support would be needed from any formers to obtain a better bond when bending the timber. Two sets of formers were to be produced, one for the inner 10mm curve and one for the outer 10mm curve. A new 25mm thick M.D.F. template was routed out using the same technique as before with the previous templates. The same centre point was used and the same metal wind on point was fitted to the threaded bar. A 10mm bit was used for this operation and proper guarding, safety goggles and a vacuum were also used. With this one cut both the male and female formers were produced for the purpose of bending the timber for the back rails on the inner 10mm curve. Next the ash that had been broken out for the back rails was to be surfaced, thicknessed and ripped down to 5mm strips for bending. The material was surfaced on the planing machine and then thicknessed down to 26mm on the thicknesser using the same technique as before with the wide planks. Once this had been done the material was brought over to the band-saw and the fence was set up at 5mm away from the blade. The band-saw was chosen for ripping the timber in preference to the table saw as there would be less material lost during the process due to the thinner blade. Lines were drawn across the lengths of timber so that the lengths could be matched up after ripping and any waves that may occur during the process could be matched up also to ensure a better bond when gluing. With several lengths ripped it was time to place a pair into the male and female formers. TiteBond glue was applied to one of the edges of one of the strips and both strips were stuck together and forced into the formers. A length of pine was fitted to the straight edge of the male former with 150mm overhang on either end to keep it square to the female former. The formers were then cramped together with five sash cramps to ensure no gaps occurred between the timber and the former or between the timbers themselves. Small pieces of timber were fixed to

each of the formers and over the top of the curved ash to keep it flat to the bed of the table. This was left to sit overnight. Once the glue had set the ash was removed from the former and the result was ok but not fully satisfactory. The timber had curved well but on removal from the formers it had sprung outwards approximately 50mm at either end. As this was the inner 10mm curve and was to be cut into segments to be used as the insert pieces to go in front of the outer 10mm curve, it was still very much usable. The second set of formers were now produced using the same technique as before only this time fitting the router with a 20mm bit. When bending the timber for the outer 10mm curve, the two 5mm strips of timber were to be placed into the former along with the first 10mm curved rail that had already been produced, this was to keep the outer rails to the back of the former and make up the 20mm total thickness of the curved rails. It is important to note that only the outer pair of strips were glued together during this process, the inner curved piece simply acted as a packer. The formers were cramped up and the glue was let to set. Each of the rails were left in the formers for approximately an hour each and once removed the outward springing happened consistently. As these rails were to be glued and cramped to the uprights, and as they were considerably oversized in length, it was thought that this outward springing would be rectifiable. Braces were constructed from scrap pieces of timber to place each of the curved rails into while in storage before use. These braces measured the same width as the front of the seat and were to ensure the rails kept the curve that had been applied to them. This process was repeated until enough rails had been curved to complete the back rails of the chair. The top rail of the chair would be addressed later in the process.

Fig. 54 25mm M.D.F. for formers.

Fig.55 Thicknessing back rails.

Fig. 56 Ripping 5mm strips on the band-saw.

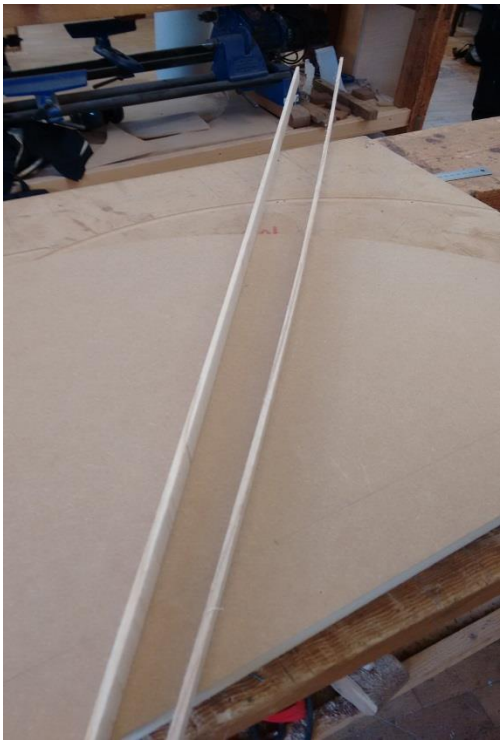


Fig. 57 Set of 5mm strips.

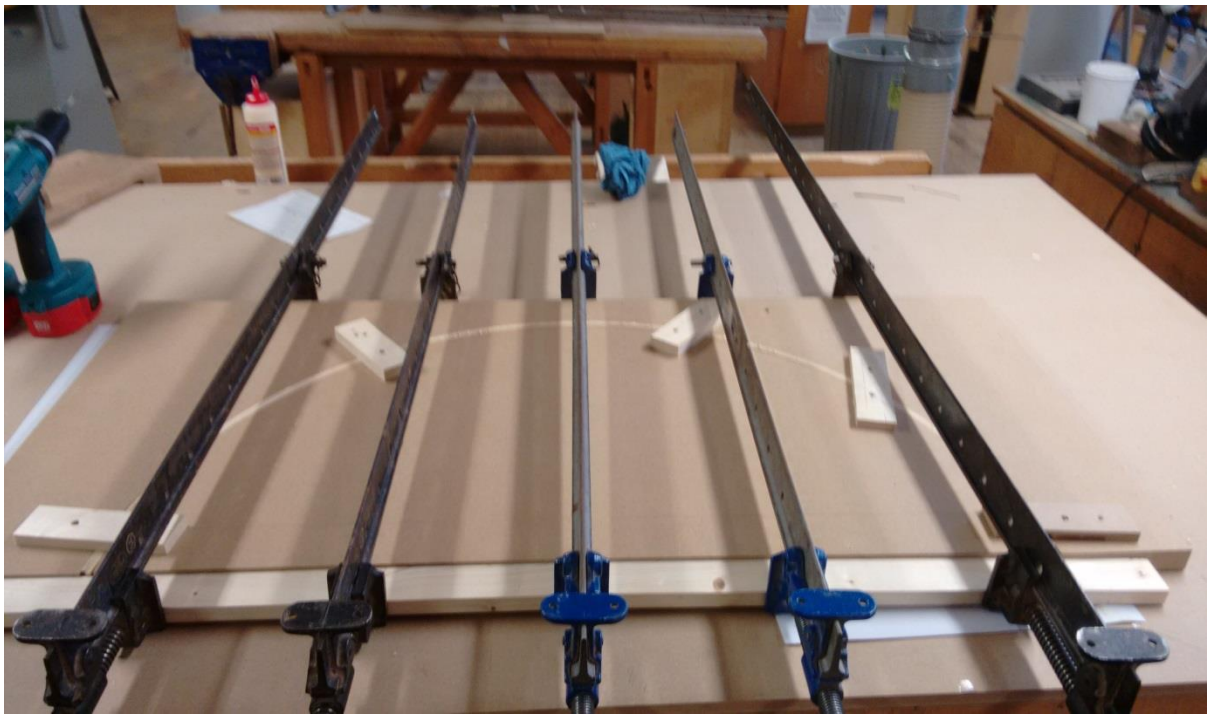


Fig. 58 Two inner 10mm curve strips in formers.

Fig. 59 Inner and outer strips cramped up.

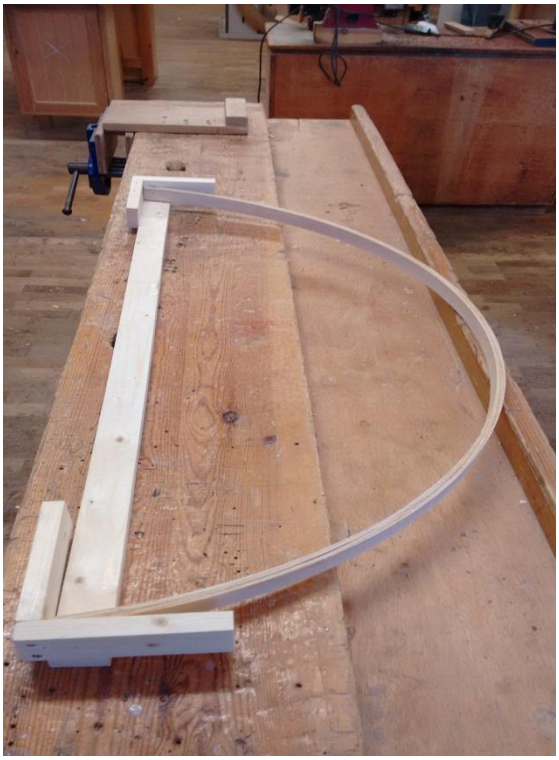


Fig. 60 Braced to maintain curve.

The next stage was to break out and veneer the flexi-ply to sit into the rebates on the seat and base bottom. The seat thickness was 19mm and the base thickness was 20mm. the rebates were 10mm deep each and the seat was to sit at a finished height of 400mm. with these measurements in mind a two pieces of flexi-ply were ripped on the wall saw, one at 381mm to sit into the rebates, and one at 361mm to sit inside the base and be fixed to the internal support uprights. Only the external flexi-ply was to be veneered. In the absence of ash veneer, oak veneer was chosen for this process. As the chair was to be finished with an ebony stain, this change would not be noticeable as the grain patterns on these types of timber are similar. Strips of oak veneer were cut approximately 10mm oversized to the width of the veneer and these strips were then taped together. P.V.A. glue was applied to the flexi-ply and the veneer was laid out on top of it. This was then placed in the mechanical press and the press was set on a cold setting. After approximately two hours the veneer was removed from the press and the veneer had stuck to it well. The excess veneer was trimmed off with a Stanley blade and the tape peeled off. The flexi ply was left in one of the braces for the back rails of the chair to help it with flexibility as it was to be stored for a day or two.

On returning to the flexi-ply it became clear that the time spent sitting up had been detrimental to its flexibility. The curve had been maintained quite well but towards the ends of the ply it had begun to curve backwards and had become far more rigid, caused by the glue setting fully. Attempts were made to bend the ply back into shape but to no avail and the flexi-ply snapped. It was decided that the process would have to be carried out again but this time it would be fixed in place in the rebates as soon as it left the press.

Fig. 61 Cutting out strips of oak veneer.

Fig. 62 Veneer strips taped together.

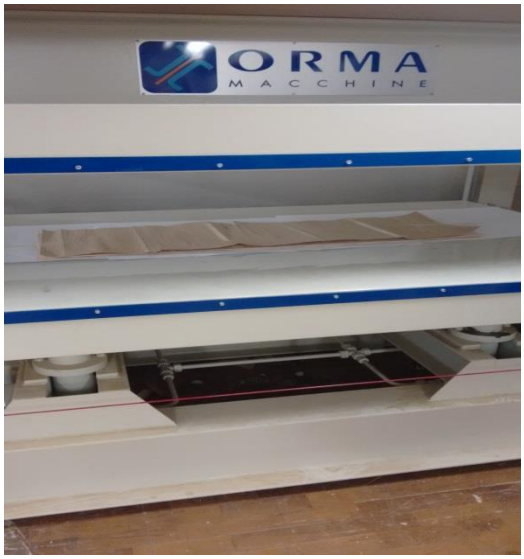


Fig. 63 Veneered flexi-ply in cold press.

Fig. 64 Veneer trimmed off flexi-ply.

Fig. 65 Flexi-ply damaged.

Fig.66 Split in veneered flexi-ply.

Preparing the internal support uprights was the next task, they were to be doweled into both the seat and base bottom. The positions of the uprights were marked using a CAD print out. They were to be positioned between the external uprights so as to leave room to fix through the flexi ply into the external uprights when I arrived at that stage. The support uprights measured 18 x 25 x 361mm and were pine. Once broken out they needed to be drilled for dowels on the top and bottom, this was to be done on the dowel machine. The machine was set up to drill in the centre of the uprights and they were drilled out on the machine two at a time. With this done I decided to resolve the issue of the rebates being too deep. This needed to be done before marking the positions of the dowel holes on the seat and base bottom as the uprights needed to sit flush with the internal edge of the rebate which was to change with the alteration I was about to make. 2mm strips of beech were ripped on the table saw at 100 in width and two layers of these were to sit into the rebate. This would mean when the veneered flexi ply was sat in place it would be flush with the edge of the seat and base bottom. The strips were glued in place with impact adhesive.

Fig. 67 Marking Upright positions.

Fig. 68 Drilling on Dowel Machine.

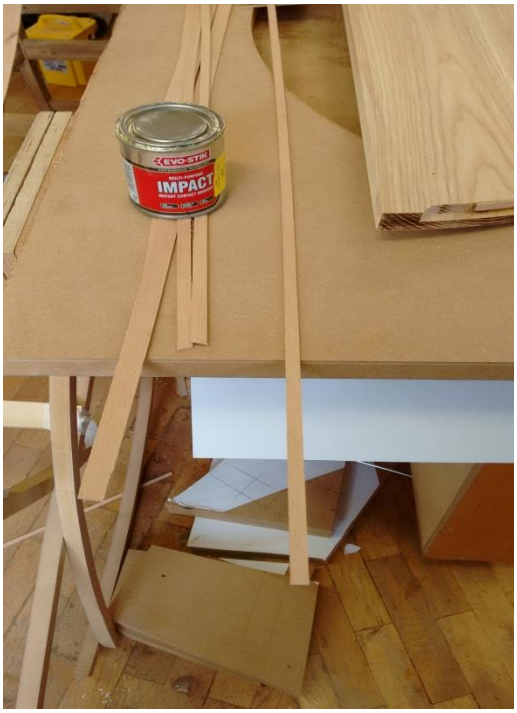


Fig. 69 2 x 10mm Beech Strips.

Fig.70 Strips glued in place.

The dowel hole positions could now be marked on the base bottom, the seat dowel holes would be marked off of these holes. A dowel marker was placed into the hole on the bottom of one of the support uprights and the upright was carefully positioned flush with the rebate edge of the base bottom. The top of the upright was tapped with a hammer and the dowel marker made a dent in the timber to indicate the position to drill on the base bottom. This operation was repeated until all of the drilling positions were marked on the base bottom. The drilling out of the base bottom for dowels was done on the drill press with an 8mm drill bit. Once all the holes had been drilled, dowel markers were placed into all of the holes and the seat was placed over the base bottom and flush all around the edge. The seat was tapped down and the positions for drilling were marked on the seat. The same process occurred on the drill press and the seat and base bottom were almost ready to be connected.

Next the angle on the front edge of the seat was to be produced. This angle was worked out by dry fitting four uprights into the seat and base bottom and sitting the seat in place over the base bottom. The angle from the edge of the seat ran back in line with the front edge of the base bottom, which was 50mm back from the seat edge. The line was marked and the angle was planed down with a hand plane.

Before connecting the seat and base bottom the storage flap needed to be cut out of the seat, this would be done with the jig-saw. The position of the flap was marked on the seat and the distance from the edge of the blade to the edge of the jig-saw base plate was measured. A piece of timber was cramped to the seat at that distance away from the cutting line and this was to act as a guide for the jig-saw. The seat flap was then cut out. The corner curves had to be free-handed as the guide could not be used for these. The base was now ready to be fitted and glued

The dowels were fitted and glued into the uprights and the seat and base bottom were fitted to the uprights. Then entire base was then cramped using a series of sash cramps. The cramps were kept off the edge of the base to allow room to fit the new veneered flexi ply that had been prepared. The flexi ply was tacked in place with panel pins and the base was left to sit overnight.

Fig. 71 Dowel Marker in Upright.

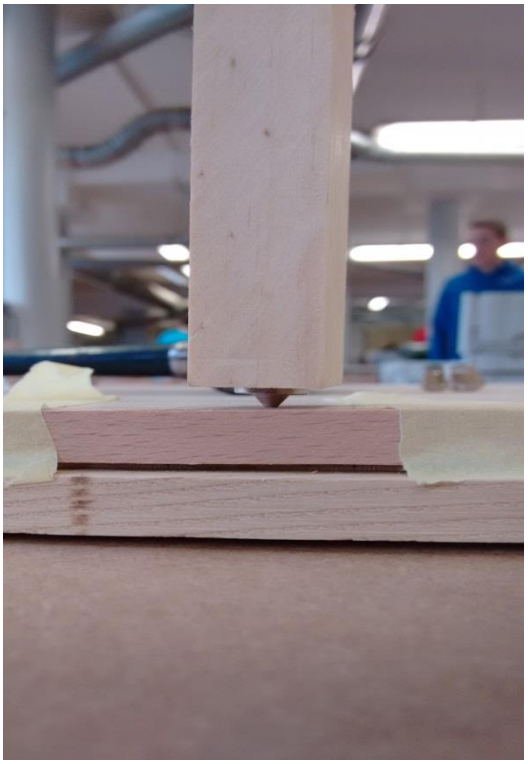


Fig. 72 Dowel Marker in Position to be Tapped.

Fig. 73 Planing Seat Edge.

Fig. 74 Cutting out the Flap with the Jig-Saw.

Fig. 75 Seat Flap Cut Out.

Fig. 76 Drilling Seat on the Drill Press.

Fig. 77 Base Bottom Ready to be Cramped.

Fig. 78 Seat Ready to be Cramped.

Fig. 79 Base After Being Cramped.

Fig.80 Pin Holes Filled.

The front of the base was the next component to be constructed. The front was to slope outwards from the bottom to the top and so therefore would not have square cuts on the edges. A scrap length of timber was placed in line with the bottom of the seat edge and lined up with the front edge of the base bottom. A pencil line was made on the scrap piece by running off the underside of the seat. This line gave me the required angle of cut for both edges of the base front. The saw blade was set to the required angle and the top and bottom cuts were made. The front was left long for the time being and would be cut to length on the width later in the process.

Work was now to start on the external uprights that would help form the back of the chair. These uprights required a series notches to be cut out of them and working from the middle three uprights outwards, one less notch would be taken out of every proceeding upright. The pictures that follow will make this description easier to understand. The uprights were 20mm in thickness and the purpose of the notches was for the curved back rails, which had been prepared at 10mm thick, to sit into. A lot of calculations were done and a CAD drawing was referred to before any upright was run through the saw. The thickness of the saw blade had to be taken into account given that the notches were to be 26mm wide and there were to be 26mm gaps between the notches. The uprights had been cut to a finished length of 1190mm at this stage, so the shoulder lines for the tenons on the tops of each upright could be cut at this stage also. The top rail was to be 36mm in width as opposed to the 26mm of the rest of the curved back rails and with this measurement in

mind and given that the saw blade was 3.5mm in thickness, the fence was set up at 32.5mm for the shoulder cuts on all of the tenons on the uprights. The blade was set at a height of 6mm for this run to allow 8mm of material remaining in the centre of the upright. Each of the uprights had the shoulder lines cut on them and each of them had the tenons cut on them also by running each of them over the saw blade repeatedly working outwards from the shoulder lines on either side. The notches were next to be cut and so the saw blade was set to a height of 10mm. Each of the uprights was numbered. The middle upright was number 1 and working outwards the uprights were numbered up to number 10 with two of each number. The cuts were also numbered seeing as there was so many of them to do. Numbering the cuts also allowed me to know which number of cut to stop on each upright as only the middle three uprights were to receive all of the cuts in the series and the other uprights were to get one less notch each as I worked out to upright number 10. The fence was set up at 62mm for the first cut on the first notch and each of the uprights were run through at this setting. The next cut had the fence set at 84.5mm which allowed for the thickness of the saw blade. The next cut was 114mm and the next after that was 136.5mm. This sequence of 22.5mm and then 29.5mm between cuts ensured that 26mm notches were cut and 26mm spacing's were between them. Once all of the cuts had been made each notch was cut out individually on the saw using the same technique as before with the tenons but this time ensuring to keep the blade within the extremities of the notches. With this job complete the uprights were almost ready to be fitted in place.

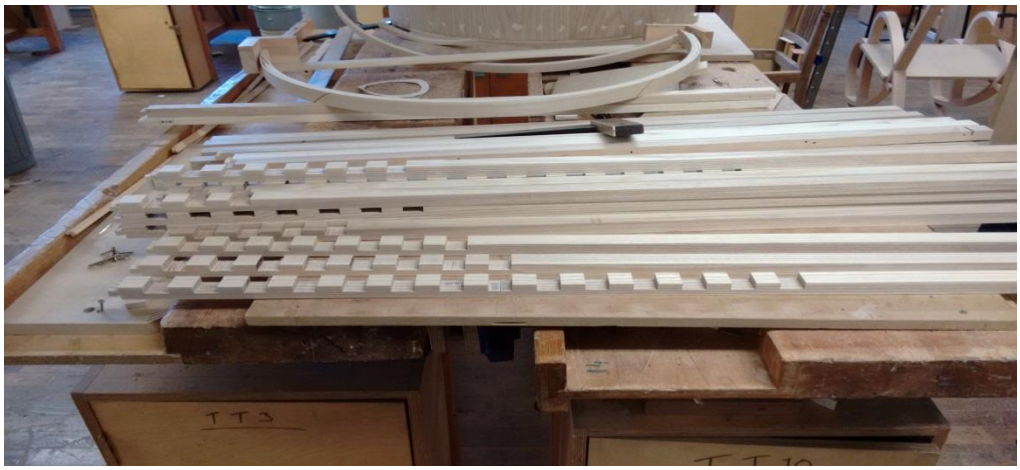


Fig. 81 Notches Cut Out of Uprights.

Fig. 82 Notches Out of Uprights.

Fig. 83 Pattern Made by Notches.

Before fitting the uprights to the base the top curved rail needed to be completed as this rail would hold everything in place and provide the framework for the rest of the curved rails to be fitted. The top rail had been curved in the same manner as the previous curved rails only this time using several strips of ash to make up a finished thickness of 20mm. Once taken out of its formers it sprung outwards like the previous curves but this time only by about 10mm in total. It was placed in a brace and was to be left in the brace until it had been glued in place. The top rail was offered up to the base and the positions of the uprights were marked on it. Having picked up the positions of the uprights the mortises could be cut into the top rail. This was done using the drill press and an 8mm drill bit. The mortises were left slightly oversized to help with the fitting of the top rail as there were twenty three tenons to be fitted simultaneously. With the top rail ready it was time to fit the uprights to the base.

The uprights were fitted starting from the middle upright and working outwards. The middle upright was positioned and fixed from the inside of the base with screws. A scrap upright was used as a spacer to position the proceeding uprights and they were fixed the same way and going by the numbering sequence. Prior to commencing this process I had

realised that I was four uprights short and there was no ash left. To overcome this issue I broke out four uprights from oak and it was decided that these uprights would butt onto the ends of the ash uprights and have no tenons on them. The top rail would be cut at the point where the oak uprights met the ash uprights. The ash uprights were all fixed and glued in place and the oak uprights were left off to be fixed after the top rail was. With this done I dry fitted the curve that was to sit second from the top and this was to be used as something to cramp to when fitting the top curve. The mortises on the top rail were filled with glue and the top rail was placed into position with the brace still attached. 26mm scrap pieces of timber were placed between the uprights to maintain equal spacing's and cramps were used to pull the top rail down tight to the uprights. With the top rail glued into place it was time to fit the remaining curves. The curved lengths of timber were sanded down and glued and cramped into place. A lot of cramps were used in this process to avoid gaps in the joints. Starting from the top and working down, one curve was done at a time. The glue used was Titebond which was set hard enough to remove the cramps after half an hour so it was taking half an hour per curve until I reached the bottom few curves when I had enough cramps to do several at once. The curves were left slightly longer than needed so once the glue had dried they were then trimmed back flush with the uprights using a Japanese saw. With this job done the chair was taking shape.

Fig. 84 Top rail before Mortises.

Fig. 85 Top rail after Mortises.

Fig. 86 Uprights fixed in place.

Fig. 87 Uprights viewed from the back.

Fig. 88 Top Rail Cramped into position with bracing still attached.

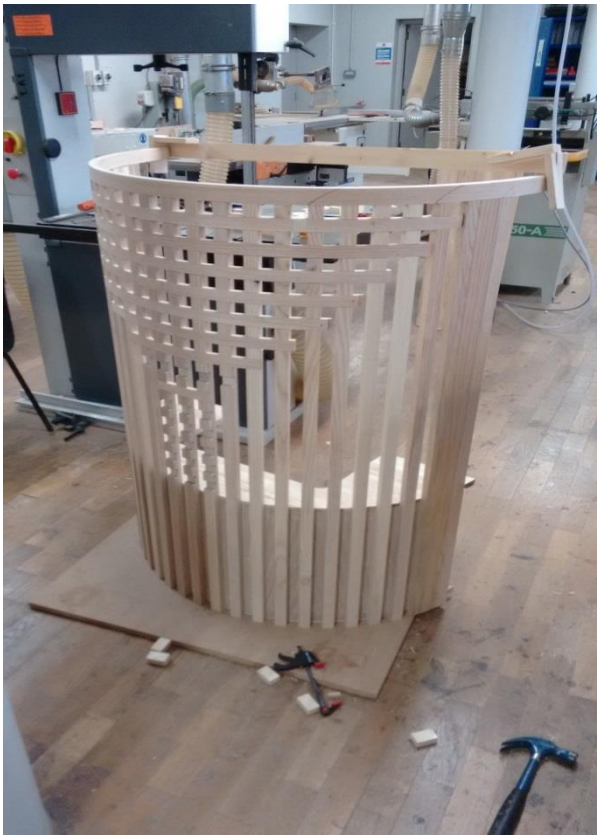


Fig. 89 The back of the chair with several curves fitted.

Fig. 90 Curves left long.

Fig. 91 Curves cut back flush.

Once the glue had set and all of the curves had been fixed in place the top rail was cut at the point where the last ash upright finished. Two oak uprights were then fitted to either side of the chair to finish off the upright fitting process.

The next job was to fit the internal flexi-ply to the base. The flexi-ply had already been cut to the correct width so it was dry fitted in order to determine the amount of waste on it lengthwise. With this done the flexi-ply was cut to length on the table saw and screwed into place fixing into the internal pine uprights.

Fitting the front of the base was my next task. The front had already been cut to width with the correct angles on each edge so it just needed to be cut to length and fixed in place. Timber brackets were constructed from 40mm x 40mm pine at 150mm in length and had the same angle that the front was to sit at cut onto one edge. Four of these brackets were made, two for the underside of the seat and two for the base bottom. They were each set 18mm back from the front edges of the seat and base bottom and were glued and screwed into place. The front was then dry fitted and the cut off points picked up and marked on either end. The front was cut to length on the table saw and fitted into place. It was glued and fixed through the timber brackets from the inside of the base. (Figs 92,93,94 below)

Oak/Ash Uprights.

Internal Flexi-ply.

Timber Brackets.

Fig. 95 Timber brackets fitted to seat.

Fig. 96 Sloped front fitted to base.

Fig. 97 View from the front with the front fitted.

The penultimate job was to fit 26mm x 26mm timber squares in front of the curved timber back pieces between each of the uprights. This was to pack out the curves so that they sat flush with the uprights to the front of the chair as well as the back. A template square was cut with a Japanese saw and every other square was cut using this template as a guide. The vast majority of the squares needed to be sanded down on the table sander so that they fitted tightly in place. Each of the squares was then glued into place with Titebond glue. Once this was done I moved onto the two rows of squares that run down each side of the chair. The same process was used as before only on this occasion the 26mm scrap timber spacers were used to keep uniform gaps between the squares. The two outside rows of squares were not sitting in front of the curves so two layers of squares were necessary on each side for the squares to finish flush with both the front and the back of the uprights. With this done the seat flap would be the final item to be fitted to the chair.

Fig. 98 Curves prior to squares being fitted.

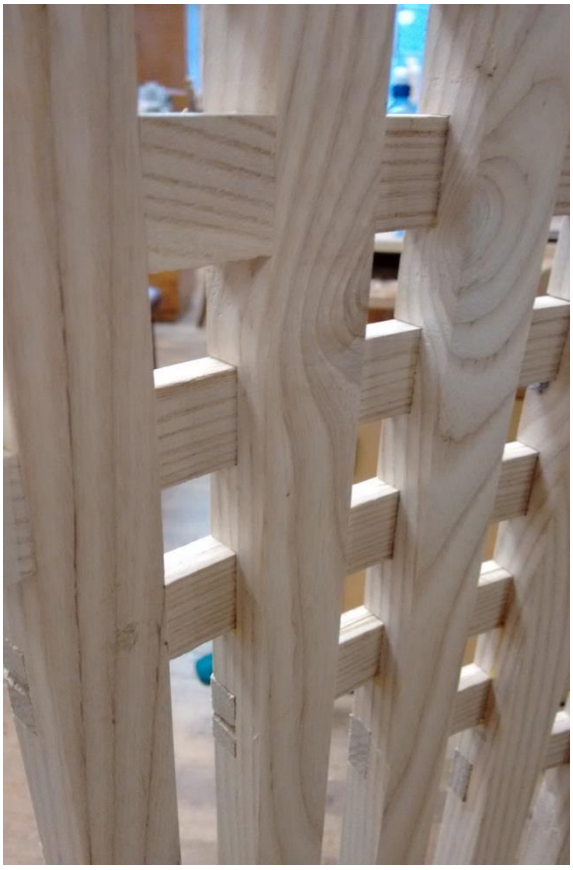


Fig. 99 Square fitted in front of curve.

Fig. 100 Cutting squares using template.

Fig. 101 Double layer row of squares.

The final item to be fitted was the seat flap which was to be hinged onto the seat using 50mm butt hinges. The hinges were positioned equidistant from the centre of the flap and marked on both the seat edge and the flap edge. The depth of the hinge was marked on both as well and a mallet and chisel were used the chop out the material. The hinges were screwed into place on the flap and the flap was screwed into place on the seat. With that the chair was ready to be sanded.

The chair was first sanded with 60 grit sandpaper in order to level off any area where two meeting timbers were not flush with each other. Once this was done 180 grit sandpaper was used and then finally 240 grit sandpaper to give the chair a nice smooth finish. Any screw holes or gaps were filled with oak wood filler and let to set. Once the filler had hardened it was sanded off again with 240 grit sandpaper and the chair was ready to receive its finish.

Fig. 102 Chair sanded and complete.

Fig. 103 Back View of the Chair.

Fig. 104 Front view of chair.

Estimated/Actual Time Chart

Estimated Time Chart	Willow Chair
Week 1	Break out material for base jig and make jig.
Week 2	Break out the rest of the material for the piece and rip uprights and cross rails to appropriate widths.
Week 3	Put cross rails in base jig and rip pieces for base, seat and front piece.
Week 4	Glue pieces together for base, seat and front and make template ellipse for base and seat.
Week 5	Remove cross rails from jig and mark out uprights on them.
Week 6	Begin work on halving joints uprights to cross rails.
Week 7	Continue work on halving joints.
Week 8	Shape base, seat and front and begin work on bottom piece (seat box)
Week 9	Finish seat box and put hinged opening on seat.
Week 10	Put moulding and top rail and begin fixing piece together.
Week 11	Finish fixing piece together and sand entire piece.
Week 12	Finishing
Week 13	Finishing.

Actual Time Chart	Willow Chair
Week 1	Broke out material.
Week 2	Glued and cramped material for seat, base front and base bottom.
Week 3	Constructed templates for seat and base bottom.
Week 4	Shaped seat and base bottom using templates.
Week 5	Constructed formers for curving back rails.
Week 6	Cut strips for back rails and placed in formers.
Week 7	Veneered flexi-ply, cut internal uprights, glued and cramped base together.
Week 8	Machined uprights.
Week 9	Prepared top rail and fitted uprights and top rail to base.
Week 10	Fitted all cross rails.
Week 11	Fitted square insert, seat front and seat flap.
Week 12	Sanding.
Week 13	Finishing.

Conclusion

In conclusion I am extremely pleased with how my chair turned out. I had admired the chair for a long time from the photos I had seen of it. With all the research I had done this year and last on Mackintosh I had been looking at the chair a lot and so it was strange in a way to see it actually gradually appearing in front of me. I was confident at the outset that I would be able to produce the chair to a high standard but I am genuinely surprised at how well it looks in real life. The chair is definitely a head-turner and I am proud to be able to say that it was me who produced it. Producing the chair was not without its difficulties and if I was to do it again I would consider making fundamental changes to the techniques I used. The construction went as planned and ran smoothly up until the point where I had completed the base, aside from the flexi-ply breaking after having been veneered. From that point onwards the task became more time consuming than I had ever imagined and this was down to my chosen technique for producing the lattice work in the chair. Machining the notches out on the uprights took over a day and I could possibly have looked into creating some sort of jig that could have cut these notches out a lot faster with a router. The square inserts was another task that was painstaking and slightly frustrating. The gaps between the uprights varied from square to square sometimes by no more than point one or two of a millimetre but this meant sanding down each square individually several times over in order to get a good snug fit. There was approximately 150 of these squares cut out, sanded down and glued in place so it really was a mammoth task that I had not anticipated being so difficult. If I was to produce the chair again I would certainly consider using the traditional method of planing down the sides of a few lengths of timber to the required angle to fit between the uprights and then cutting them to length. This method would also have meant no curved cross rails though and I am pleased with how the chair looks with the cross rails in place. The choice to use lamination to produce the top rail is something else I would reconsider. I was unable to prevent the top rail from springing outward even if it was only slightly but had I shaped solid timber instead this could have been prevented. Sanding the piece was another big job but I was fully aware that this would take time. So overall the chair has turned out better than I had anticipated and I am very happy with the result. This is a piece I will probably hold onto for many years and be proud to have associated with me.

CAD Drawings

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Appendix