Building the Aeolian Harp

36” Arwens Evenstar Harp of American Black Walnut and Yellow Poplar

Dedication

Dedicated to Lin, my wonderful wife of 28 years, for all of her patience and support all these years. In loving memory of my sister Jeannie, who helped me take my first steps down this Aeolian journey.

Published by East-Wood Products

East-Wood Products
P. O. Box 2190
Edgewood, New Mexico
87015-2190

www.harpmaker.net

Library of Congress Cataloging-in-Publication Data available upon request.

ISBN 978-1-60530-927-9

Published in the United States of America

2008

Introduction

Robert A. (Harp) Corrigan is a woodworker who has lived in the mountains east of Albuquerque, New Mexico since 1982. He heard an Aeolian harp for the first time in the early '70s on a Nitty Gritty Dirt Band album "Symphonium Dream". This was during a 3-year period when he was living on the road as a homeless person. Years later, when he had married and built a life for himself, he began his quest to start reproducing these rare and mysterious instruments. In 1992, he made his first prototype Aeolian harp and then spent another year researching and experimenting with various string materials to build these harps with modern materials. Since then he has been marketing his harps over the internet to institutions, artists and customers all over the world.

Forward

By Harp Corrigan

When I first began to learn about these harps, it seemed tragic to me that such an interesting, historic and ancient instrument was hovering on the edge of extinction. What a loss to humankind if one of our oldest musical instruments should be forgotten. It became a passion of mine to re-introduce this amazing instrument to the general public.

The purpose of this book is to share the information, tips and techniques I have developed over the years to build harps that would perform well. It is my hope that when more of my fellow woodworkers begin to build their own Aeolian Harps, knowledge of and interest in this ancient instrument will be rekindled and the harp will once again thrive in the popularity it enjoyed during the romantic era.

Much of this work is written with the assumption that you already posses some woodworking skills, and there is no need for elementary explanations of basic woodworking procedures. As always, please remember to utilize basic shop safety rules and some degree of common sense when using power tools and finishing compounds.

I would enjoy hearing about your experiences building your own harp, or any comments you may have about this work. Please feel free to e-mail me at:

harp@harpmaker.net

Or visit my web site, www.harpmaker.net
Thank you, good luck and happy harping.

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Chap. 1

A Very Brief History of the Aeolian Harp

Musicologists generally agree that the first musical instrument known to man was a harp. Some have theorized that it was probably some form of wind harp. It is known that wind harps predate any recorded history. Ancient Egyptian hieroglyphs found in the tombs of Pharos depict harpists. The native peoples of the islands of Indonesia have been flying kites with wind harps and wind flutes attached since before any recorded history. It is believed that this was a way for early people to communicate from island to island. When European explorers first ventured into remote regions of both Africa and South America, they found people who had developed their own versions, or designs of wind harps. Suffice to say that the wind harp has been around for a very, very long time.

Homer the Greek philosopher wrote one of his mythological tales that involved Hermes, the messenger god. Briefly, the tale told of how Hermes had killed a sea tortoise and had eaten it. As the carapace lay drying in the sun, the sinews drew tight across the openings in the shell. It was then that Aeolus, the god of winds, sent forth a wind to blow through the shell and set the sinews to vibrating. This created a melody which Hermes then took to the people of Greece, and this melody became the Greek National Anthem. Or so wrote Homer, circa 900 BC. This is also how the harp began to be called the Aeolian harp, for Aeolus, the Greek god of winds.

There are many examples of medieval castles that were built with tall, narrow openings high in the walls. Many of these openings were built into the castle for defense purposes, but many were also for the placement of wind harps.

Here we must make a distinction between wind harps and Aeolian harps. While all Aeolian harps are wind harps, not all wind harps are Aeolian harps. At least, not by the modern encyclopedic definition. Colliers World Encyclopedia, among others, defines an Aeolian harp as:

Any wind harp who's strings, however many there are, are:

1. All the same length. (vibrating length)
2. They are of different diameters
3. They are tuned in unison. That is to say that they are all tuned to the same note.

This third point above is the basis for the mystery of the Aeolian harp that has plagued scientists and students for hundreds of years. How does an instrument whose strings are all tuned to the same note produce all the wonderful and varied harmonies that one will hear. In the 1950's there was a group of physicists who came up with what they called the "Aeolian Theory" to

explain this mystery. However, at the time of this writing, and as far as this student of the Aeolian harp knows, this theory has never been proven under scientifically accepted controls, so it must remain just a theory.

I diverged from the timeline briefly to make the distinction between wind harps and Aeolian harps so I could introduce Athanasius Kircher (1602-1680) who is credited with the development of the modern Aeolian harp. Kircher was a 17th Century Jesuit who is credited as the DaVinci of his time. He is also called the "Last Renaissance Man." A quick look at his biography is most impressive, and he is credited with many inventions and innovative ideas. He also wrote about 40 books on everything from Egyptian hieroglyphics to geology, medicine and gravity. Another of his interests was music, specifically harmonics. He conducted many experiments in Aeolian theory. Now it just happened that another inventor, Robert Hooke (1635-1703) was responsible for the invention of the sash window. This style of window became very popular all across Europe. It was Kircher who developed a design for an Aeolian harp that would make full use of this type of window. By building a harp as a long narrow box that could sit on the sill of this window, and then closing the window down on top of the harp, one could concentrate all of the available breezes across the strings. This produced a harp that would sound more often in even the lightest breezes. Closing the window down on top of the harp in firm contact also had the added benefit of transferring some of the sound into the window frame and the adjacent wall, thereby increasing the volume of the harp. This style of harp quickly became the most popular worldwide because of its efficiency. There were many other styles of harps being built. The Swiss were fond of a cylindrical design that was hung from trees or the eaves of houses. The French were partial to elaborate, free standing harps that could easily be carried out onto their terraces, or into their gardens when they were entertaining. One popular style was a 3-sided vertical box, with strings on all three sides. The idea being that no matter which way the wind was blowing, at least one set of strings would sing. It is a little known fact that when King Louis XVI of France (1754-1793) was a little bit concerned about the unrest among the people of France, he ordered hundreds of Aeolian harps built and placed all around Paris. He was aware of and a believer in the soothing qualities of the sound of the harp. This was apparently too little, too late for Louis. He still lost his head. There is a certain magic in the sound of the harp, but miracles? Maybe not.

The Aeolian harp reached the peak of its popularity during the Romantic period, generally from 1825 to 1900. During this time, Aeolian harps could be found anywhere, and in almost every home. Many of the famous poets of the romantic era wrote about Aeolian harps. Samuel Coleridge once fell asleep to the sound of a harp and then wrote his poem titled "The Aeolian Harp". Consider for a moment that all through history, up to the turn of the 20th Century, people had no music in their homes. There were no I-pods, no CDs, no MTV. Unless a family member knew how to play an instrument, there was no music. Traveling minstrels could make out pretty well just traveling around and

entertaining their hosts for an evening in exchange for a meal and a place to sleep for the night. Of course, there were mechanical music boxes available for the well-to-do, but few could afford these luxuries at that time. However, almost anyone could afford a wind harp, and most did.

Those people in the 1800's must have really been fond of their harps too, because the only material available for strings at that time was natural "gut". Any harpist can tell you what a hassle natural gut strings are. Because it is an organic, it is constantly going out of tune with the slightest change in temperature or humidity. In addition, because it is an organic, it will not stand up long to exposure to the elements. It is the nature of the Aeolian harp that it **MUST** be exposed to the elements. One can only imagine how much time and effort it must have taken for people in the 1800's to keep their harps singing. But they cherished their harps, and kept them strung and tuned.

At the end of the 19th Century, 3 things happened in the history of man that all but nailed the coffin shut for the Aeolian harp. First, there were rumors of this new invention called radio. The technology was growing rapidly, and it was promised that soon there would be commercial broadcasts coming across the airwaves that anybody with a radio (and electricity) could tune in to. Then there was also this new invention that Mr. Edison called his "Talking Machine". For the first time in history, people could buy large black discs that magically contained the sound of popular entertainers and performers. At the beginning of the 1900's people could have music in their homes whenever they wanted. They could put their favorite 78s on the Victrola, or they could tune the radio to hear, "Live, from the Waldorf-Astoria Hotel in New York City, it's - - - -

Both of these inventions served to drive the popularity of the Aeolian harp down, but it was Robert Louis Stevenson and the London Times who finally and quite accidentally killed the Aeolian harp. In 1899, Robert Louis Stevenson wrote one of his south-sea island adventures called "The Beach at Falesa". In this story, the villain hung what Stevenson called "Tyrolean" harps in the trees at a secluded beach. The villain used these harps, and a few other tricks of 19th Century technology to dupe the island natives into believing that he could bring the wrath of the gods down on the natives if they failed to do his bidding. The hero of the story discovered this villainy, and exposed the ruse to the Chief of all the island tribes. While explaining the harps to the Chief, the hero said, "In my country, everyone knows of these things, and only a *damfool* (one word) would give 2 cents for the thing!" The London Times printed this story in 3 parts, covering late 1899 and early 1900. Now understand, in 1899 R. L. Stevenson was one of the most widely read and respected authors of his time. When people all over the world read that Robert Louis Stevenson said that "only a damfool would give 2 cents for the thing", they destroyed their harps. They threw them in the fire, threw them out with the rubbish or tossed them into the attic to collect dust and be forgotten. After all, no one wanted to be perceived as a damfool. I have no doubt that this was a purely unintentional reaction to Mr. Stevenson's

story, but the results were devastating never the less. Even historical records regarding the history of design and development of the Aeolian harp were tossed out as rubbish. This explains why the general quote regarding the demise of the Aeolian harp is that “in the early 1900’s the harp fell into disfavor”. But now people had their Victrolas, and in 1920 the first commercial radio broadcasts were being sent out over the airwaves, so who needed a wind harp anymore?

Fortunately, a few harps were kept as museum pieces, curiosities of a bygone era. It was with photos of these rare museum pieces that I was able to start re-creating this wonderful instrument. It might be fair to say that the Aeolian harp was one of the first tragic fatalities to be run over by technology.

Chapter 2
Planning Your Harp

The plans and dimensions I will present here are to produce a harp that will be approximately 5 inches from front back, 4 inches high, and 32” long. The depth and height are very closely true to Kirchers original design. The main variable here is the length. You are welcome to change the length of your harp to suit your needs. The primary consideration is the width of your window that you plan to put the harp into. Assuming of course that you have standard, sash type windows where the lower portion will slide up and down. A window that slides open horizontally will work well too, you just stand the harp up on end and slide the window closed against it. If you have casement type windows that are hinged on one side and swing open either inwards or outwards, good luck. I once engineered a way to mount one of these harps in this type of window, but the extra baffles and mounting hardware promised to be more expensive and more troublesome than building the harp. When potential customers approach me about building a harp for their casement windows, I just ask them to contact me when they move into a house with “real” windows.

The next thing to consider when deciding on the length of you harp, is that you may as well build the harp as long as your window will allow. I have been building these harps for almost 20 years, and I have built over a hundred of them. One hard fact is that the longer a harp is, the more easily it will sing in light breezes. Longer harp = longer strings, and longer strings are set to vibrating with less wind. As a matter of fact, I won’t even build one less than two feet long anymore. Once, when I first started building these harps, a person who lives here in New Mexico wanted one for her kitchen window. Unfortunately, her

window was only eighteen inches wide. She also wanted it to match her kitchen cabinetry, which was Knotty Pine. I learned 2 valuable lessons from that harp. The first one was that the poor harp was so short; it needed hurricane force gales across the strings to sound. The second lesson was that Pine is not an ideal material for one of these harps. Every wood species will lend its own voice to the sound of the harp. Moreover, Pine just doesn't have a very desirable voice. Well, not to my ears anyway. If you want to choose Pine, feel free, and I hope you have better luck than I did.

If you do have the horizontal slider type windows in your house, then you are lucky. On average, horizontal sliders are taller than the average sash window is wide, so it will allow for a longer harp.

Remember also that air is like electricity and water. When it is moving, it will follow the path of least resistance. If you were to place a three-foot harp in a window that was 4 feet wide, most of the available breezes would just blow around the end(s) of the harp, reducing its ability to sing for you. One trick that I use frequently is a clear plastic baffle. It's just a piece of clear acrylic, approximately 5 inches wide, 8 inches long, and 1/8 inch thick. The window that I test all of my harps in will accommodate a harp 41 inches long. When I need to test a harp that is shorter, I place this clear plastic baffle at one side of the window, against the outer screen, and then I trap it in place by putting the harp against it. Then, when I bring the window down on top of the harps cover piece, all of the available breezes are directed across the strings.

So please feel free to adjust any of the dimensions in this guide to suit yourself, but especially the length of the harp. Remember, longer is better!

While you are planning your harp, it is a good idea to decide what woods you will use in its construction.

First, let's discuss the end blocks. These need to be 4/4 stock, or hardwood that has been planed down to ¾ of an inch thick. I almost exclusively use Hickory, and I hand pick Hickory that has a lot of grain character for aesthetic reasons. Hard Maple would also be a good choice. Both of these wood species are very hard and stable. The end blocks are going to hold the tuning and bridge pins and they will need to be hard and dense. These woods also exhibit less expansion and contraction with changes in humidity than many other woods, and this will help to hold the tuning pins securely when they have the tension of the strings trying to unscrew them. The end blocks will also be supporting the cover piece, so hardness and durability will help there as well. If Hickory or Hard Maple are difficult to obtain in your area, choose something that is available that displays similar characteristics.

Next, consider the material you will use for the front, back and cover piece. These pieces are going to be seen the most, so you want something that

is going to look nice. Any hardwood will do, whatever your personal preferences are. I have used almost every hardwood that is available to me, and believe me, I can get almost any commercially produced hardwood. Whichever specie you choose, it will have an effect on the voice of your harp. As a general rule, the harder and denser the wood is (high specific gravity), the brighter and crisper the sound of the harp will be. Softer or lighter hardwoods (low specific gravity) will produce a mellow, deeper tone. The same rule holds true for Celtic harps. A Celtic harp made of Walnut (soft) will have a deep mellow voice, while an identical harp, made of Maple, will have a very bright, crisp voice in comparison. Harps made of Cherry seem to fall in between the two, and the specific gravity of most Cherry samples will fall between Maple and Walnut as well. My own personal favorite is American Black Walnut. I love to work with this wood. It is easy to work, smells wonderful when being worked, and finishes very nicely. Choose whatever wood tickles your fancy. Maybe you want it to match your woodwork, or your furniture, or perhaps something to contrast with its surroundings.

For the bottom of the harp, the piece that almost no one ever sees, I choose hard Maple. I choose Maple because of its stability. Having the bottom of Maple just adds a lot of strength and dimensional stability to the harp. I am sure that the Maple is also having its influence on the harps voice, but the degree of influence is not enough to offset the value of its strength.

Next comes the soundboard. For this piece, you want to select a wood that has good tonal qualities. Oddly, most of the preferred woods for soundboards are softwoods. Of course, Spruce is the top choice. Fine grained, quarter-sawn Sitka Spruce is the first choice. If you can find that, go for it. I cannot even obtain that here in New Mexico anymore, so I have had to find other woods out of necessity. I might inject here the fact that the worlds most famous luthiers, Stradivari and his student Guarneri, both used Spruce for soundboards on all of their instruments. Other woods that have worked very well for me are Linden, or Basswood. Carvers love this wood for its clarity and softness. As I have discovered, it is also a very good choice for soundboard material. This is especially true if you plan to add any decorations such as carving, chip carving, or pyrography to your soundboard. The very clear appearance of Linden, and the lack of extremes in grain texture make it a very good choice for any of these types of decoration techniques. Redwood is a good choice for soundboard material. It usually has a deep red color, so it is not ideal for pyrography, but it will work. It is just that the burning sometimes does not show up well. Yellow Poplar is also another good choice. I use Yellow Poplar frequently, because it has good tonal qualities, and I can usually find pieces with varied and interesting grain patterns. It also decorates, whether by pyrography or carving, very nicely. These are just a few examples, and from the examples, you should be able to get a fair idea of what you need for each specific component of your harp. The woods I have mentioned here may not be available in your area, but other woods with similar properties should be, so feel

free to substitute whatever you can get.

You will also need some material for your string bridges and cover locating pins. I use Maple for the bridges, and ¼" dowels of Maple for the pins. Here again, I choose Maple for its hardness and durability. While you are getting the ¼" dowels for the cover locating pins, pick up some 1/8" dowels of whatever is available. You will use four very short pieces during the assembly, and I will be discussing some handy uses for more of that 1/8" dowel when we start finishing your harp. Two 12" lengths should be enough.

Chapter 3
Materials

I have already touched briefly on the wood species you might choose for your project. In this chapter, I will go into more depth on what you need to start your shopping list.

Whenever I am building one of these harps, I always start with the end blocks, so let's start there. For these blocks, you will need a piece of Hickory or Maple (or similar material) that is just over 10" long and 3 and 1/2" inches wide. You will be cutting 2 identical pieces 5 inches long, so 10" plus your saw kerf will be the minimum. After ripping the stock to width, I run the edges over the jointer to produce smooth, square edges along the length.

Next, come the front, back, bottom and cover piece. For these pieces, as well as the soundboard, you want thin stock. Because I make so many of these harps, I buy stock in thick slabs, and then I re-saw and surface plane them down to thickness myself. Many of you may not have access to some of the machinery I have, so you might have to shop around to find stock that is thin enough to work with. Another option would be to seek out a wood milling facility in your area that could prepare the stock to the thickness you need. Stock that is 1/4" thick will do, but that is as thick as you would want to go. Thinner would be preferable. I frequently use stock that is 1/8" or less. A lot depends on what species of wood you choose to work with. Some woods are much easier to take down to very thin sections, and others are very difficult to machine down to 1/8" or less. The reason for such thin stock is resonance. Thinner stock will amplify the sound of the harp better than thick stock will. The Maple bottom piece can be a little thicker than the other components, which will just enhance the strength that the maple is adding to the soundbox structure. So you will need a piece of thin Maple, 36" long, and 5 " wide **after** you have trued up the sides, and squared

up the ends. Make sure the sides are square and parallel.

I make the front, back and cover pieces all out of the same material, just for aesthetic reasons. Therefore, for these pieces you will need to start with material that is 6 feet long and at least 6" wide. The front and back of the harp can be cut from a piece 3 feet long, and at least 5 and 3/4" wide, and then the cover piece is going to finish up at 30 and ½" long, and 5 " wide.

During assembly, you will be installing glue joint bracing pieces where the front and back glue to the bottom, and also where the font and back glue to the soundboard, so if you start with wider material, you can rip these corner braces as you take the width of the harp body pieces down to size. Otherwise, you can rip these thin pieces from other thin stock. So if you can purchase material that is wider than the 6" minimum, it will work in your favor.

The soundboard material should be at least 1/8" thick, up to ¼" thick. On harps where I am going to be doing 3-D carving, such as the Celtic knots, I will use ¼" stock. If there will just be a basic soundhole, or pyrographic designs around the soundhole, then I will use thinner stock.

For the string bridges you will need to rip a piece of Maple that is at least 9 or 10" long. This piece will be triangular in cross section, and about ½" wide at the base of the triangle. There will be more on cutting this later, but you will want to make sure you have enough Maple on hand to make these pieces.

You will need a ¼" diameter dowel of Maple. If you can locate a short piece, good, because you will actually only need a little over 4" of this for the harp.

When it comes time to apply the finishing coats, I like to use wipe-on polyurethane. The application is easy, drying time is short, it possesses UV inhibitors, it is weather and waterproof, and I really like the results. You can use whatever finish you prefer, but remember that the harp will be exposed to the elements, and will need to be protected. Stains are also optional. I rarely ever use any stains myself, but that's a personal choice.

You will need to purchase the hardware for your harp. You will need a minimum of 24 Zither Pins. These are 3/16" diameter, 1 & ¾" long. They are threaded on one end, and squared on the top end to accommodate a tuning wrench. They have a small hole drilled through to thread the harp string. You will also need a tuning key, or wrench to fit these pins. Whomever you choose to purchase your pins from should also be able to provide you with a suitable wrench. At the end of this book, I have listed some possible sources for this hardware.

You will also need to get some string material. This is monofilament

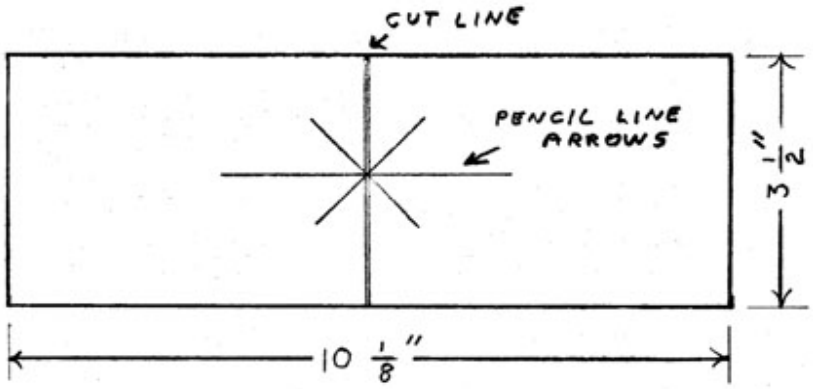
nylon, more commonly known to most of us as fishing line. For the 32” long harp discussed in this work, you would need eight pieces of fishing line with eight different diameters, each piece at least seven feet long. Later, in the stringing section, I list in more detail the diameters of string that I use. This list of diameters and the order I use them in (the string schedule) is only a guideline. The actual diameters are not that critical to the harps ability to sing, so feel free to substitute something close if you have any trouble locating specific diameters in your local area. Just be sure that what you get is round, monofilament nylon.

Chapter 4
Material Preparation

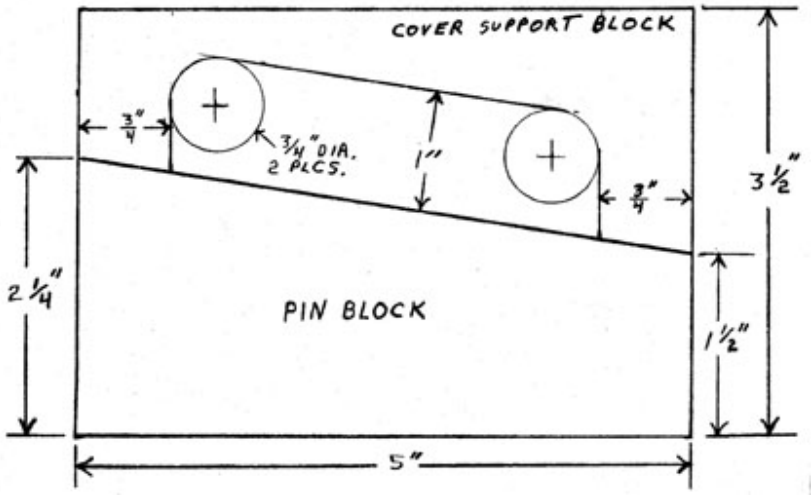
Whether I have purchased thin stock off of the shelf, or have re-sawn and thickness planed the stock myself, the first thing I do is rough sand all of the stock on both sides. This is to remove any machine marks that might be left from the machining processes. I sand the pieces with my random-orbit palm sander with 80-grit sandpaper. I sand all of these planks before cutting out any of the pieces to size. With 80-grit paper on a palm sander, it is easy to round over the edges, and thin out the corners of the rough stock. Taking care of any machine marks this way before I cut out any of the components, I do not have to worry about uneven thicknesses at the edges or ends of the pieces. I do the same with the Hickory that I will cut the end blocks from.

Chapter 5
Cutting the End Blocks

Now we can actually start cutting some pieces. The end blocks are a little involved, and require a little bit of careful layout. The drawing below shows how I first divide the 10” length in half, and book match the grain together. I do this because when you look at the front of a finished harp, the end grain of the cover support pieces is showing, and the grain pattern is a mirror image on each end of the harp. Looking at the end of the harp, the grain on the pin block also matches the grain on the corresponding cover support block.



Once you have cut these two blocks apart, fold them together so the arrows are against each other, and pointing in the same direction. The arrows are pointing to the front of the harp. Use double faced, or carpet tape to fasten these two blocks together. I use 2 pieces of 1" wide tape, one near the top, and one near the bottom. Once you cut these pieces again, making a total of 4 pieces, you will want them to remain stuck together through additional shaping operations. Also, when you clamp them together to stick the tape to both sides, be sure that the bottom and top edges are flush. A little bit of miss-match on the ends can easily be cleaned up on the disk sander. Once they are securely taped together, you can lay out the following cuts on one face of the blocks.



As you can see here, the end blocks are divided to form one pin block, and one cover support block for each end of the harp. When you have these cuts laid out, begin by drilling out the ¾" diameter holes. I like to use a ¾" Forstner bit in my drill press. Make sure the table is square, or plumb, to the

spindle, and do not break through the bottom of the hole. Stop just short of breaking through, flip the piece over, and finish the hole from the other side to avoid any tear out on the edges of the hole.

In the photo above you can see how the end grain on the front of the end blocks are book matched, and mirror each other. You can also see the arrows I have drawn on the top of the blocks to help keep them in the proper orientation to each other. The cut lines have been drawn, and the ¾" diameter holes drilled through.

Now we can start cutting out the pieces. Start by cutting the long diagonal cut. I usually do this on my band saw. Having separated these two (or 4) pieces, I take them to the disk sander and smooth out the saw blade marks. Just sand them enough to clean up the saw marks. When it is cleaned up, put two pencil mark arrows, point to point, on the top (diagonal) surfaces of the pin blocks. These are to help keep the pieces in their respective positions during assembly. When you start gluing up the soundbox, as long as the two arrows are pointing towards each other, you know you have the blocks on the correct ends of the harp. Now take the top portion, the cover support block, back to the band saw and make the cuts into the ¾" diameter holes to free the center portion. Just try to cut as close as possible to a line that is tangent to the outside of the drilled hole. Then cut along the diagonal line connecting the 2 holes. **Do not** throw this center piece away. We are going to use it later.

Here the blocks have been cut on the band saw.

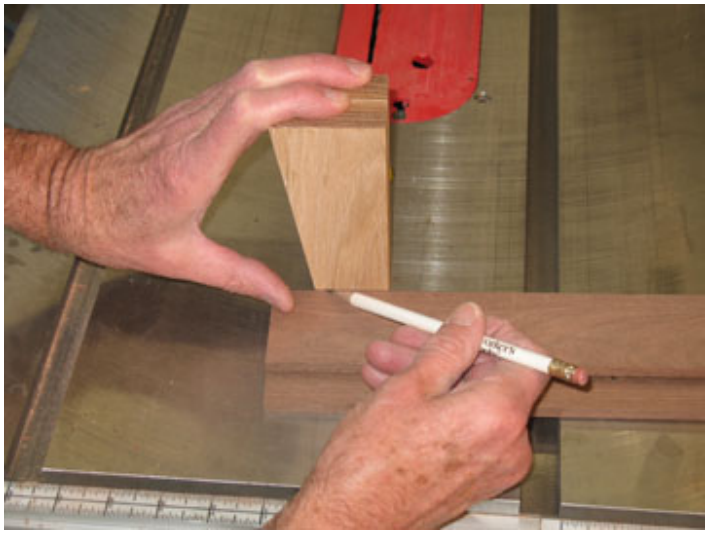
At this point, I use the combination of my 1” belt sander, and my oscillating spindle sander to clean up these cuts. Whatever machines you can use, or if you have to do this by hand, you want to sand all of these inside surfaces so that they are cleaned up, smooth, and since they are hopefully, still stuck together, identical. At this point, you should have two pin blocks, which are still stuck together, 5” long, 2 & ¼” tall at the back and 1 & ½” tall at the front. You should have two cover support blocks that are 5” long, 2” tall at the front, and 1 & ¼” tall at the back, with a center cut out that is 1” deep, 3 & ½” long and centered on the 5“ dimension, with 3/8” radius inside corners. Use your pencil and put the same kind of arrows on the top of the cover support blocks that you previously put on the pin blocks, so that you can keep them in the proper relation to each other as well. Set these aside for now, while we start cutting the other pieces of the soundbox.

Chapter 6
Cutting the Front, Back, Bottom and Soundboard

Now, take the piece of material you have chosen for the front and back of this harp, and cross cut a piece about an inch longer than your finished harp length. Rip less than a saw kerfs width from the edges of this piece so you have true, parallel edges. Look closely at the grain patterns, and decide which part of this plank will make the front of your harp. This piece is narrower than the back, but it is the part most people are going to see first. Now you want to rip the front

of the harp. However, do not cut it at the 1&½" dimension that is on the front of your pin blocks. You have to add the thickness of the bottom piece, and the thickness of the soundboard to this 1 & ½" dimension. As you can see in the sketch below, the front and the back of the harp cover the edges of the bottom and the soundboard. Assuming that you might be using ¼" stock that you were able to buy off the shelf for all of your components, then you must add ½" to the 1 & ½", giving you a total of 2" width (or height) of the front piece. But wait, we are not through yet. Later on, when you have glued the soundboard down into the soundbox, you will sand down the top edges of the front and back so that they are flush with, and on the same angle of the soundboard, so allow yourself a little bit of slack here, and given the dimensions above, cut that front piece 2 & 1/8" wide. Using the same rules that we used to cut the front, rip the back of the harp. By these examples, the back would then be 2 & 7/8" wide, or high. Hopefully, you will have enough width on the piece that you can cut a couple of narrow strips about ¼" wide, and as long as the harp will be, before finishing up at your 2 & 7/8" dimension. Now that you have the front and back cut to width, and the long edges are parallel, true up the ends nice and square to your desired length.

Now there is another cut you have to make to the pin blocks. You must shorten them up, a dimension equal to the sum of the thicknesses of the front and back. This is easily done by laying the front piece on top of the back piece on a flat surface with their edges flush. Stand the pin blocks up on the front, or narrow end, and slide them up against the front and back pieces. Scribe a line across the pin blocks along the top of the front piece. This is your cut line. You want to cut this much material off the front of the pin blocks. We do this so that when we position the cover support blocks on top of the finished harp, the width of the cover and the width of the harp will be identical. See the photo and sketch below.



After making this cut, clean up the saw cuts on the front and back of the pin blocks at the disc sander. There is nothing critical here, just clean them up enough to provide for a smooth glue joint.

Here we are ready to cut the bottom of the harp to size. You will want to treat this piece of Maple just as you did the material for the front and back. Rip just a hair off of each side until you have straight, parallel sides. Now run one side along the jointer to get a really true, straight, square and smooth edge. This edge is going to be one of your visible glue joints, so the better you can make it, the better the harp will look. I put a small "X" on this edge so I know that this edge is ready for glue. The other edge of the bottom is still saw-cut rough, and hopefully wider than the pin blocks are now. This is a good time to cut the soundboard support rails that will run along the length of the soundbox, underneath the soundboard. As you have noticed, the soundboard sits at an angle, so you will want to match this angle for the soundboard support rails. Crank your table saw blade over to 9 degrees, and rip a thin strip about 3/16" wide. Make sure you have your good edge, the edge with the "X" against the rip fence. Now, square your table saw blade again, and rip another thin strip. Now you will have 2 thin strips, each with one side that is at a 9 degree angle. Set these aside for later. Now you can finish taking the bottom piece of your harp down to the same width as the length of the pin blocks. **This is critical.** When you rip the bottom to width, leave it just a hair wide. Then, take it to the edge jointer and joint the remaining edge. Take light cuts, and sneak up on the final width. You want to finish jointing this piece so that it is exactly as wide as the pin blocks are long. While doing this, you can go ahead and separate the two pin blocks, and peel off the double-sided tape. This way, you can check the fit on each end of the bottom, to make sure that the fit on each end of the harp is as close as you can get it. These joints will be visible on the finished product, and any miss-match is going to show. The arrows that you drew on the top of the pin blocks will help keep them on the correct end of the harp, and the soundboard will glue down on top of them later, so the arrows will never be seen. When you are satisfied with the width of the bottom piece, go ahead and cut the ends of the bottom to the same length as the front and back, and square to the long edges.

At this point, you should have the 2 pin blocks, the front, back and bottom of the soundbox cut to size, and ready to glue up. Here you will also need those 2 long strips that are corner braces for the glue joints between the bottom, front and back. These are not the two we cut with the 9 degree angle, rather, these should be the square ones. You will need to cut their length so that they will fit between the pin blocks. It is not critical that they run the entire length of the glue joint, so go ahead and cut them 2 to 3 inches shorter than your finished harp length.

Chapter 7

Gluing Up the Soundbox

When I am gluing up a soundbox, I glue the front, back and bottom together with the pin blocks located at the ends all at the same time, in one operation. In order to do this easily and accurately, I built some special clamping jigs. These are just 4 long, narrow pieces of ¾" Baltic Birch ply. The ones I made are 4 feet long, and they will clamp a harp of any length up to 4 feet. The sketch below shows how I fashioned these clamping blocks.

I had some adhesive backed laminate that I applied to the top face of the cradle where the harp parts will clamp down. I used some thin rubber strips on the face of the side pressure blocks to prevent marring and to even out the clamping pressure. I lay one of these pieces along the end of my workbench, with the center of the clamp fixture against a bench dog. I then lay the other side of the fixture alongside the first one, with the center of this piece against my bench vise dog. When I have applied the glue, and am ready to start clamping everything up, the bench vise tightens up against the front and the back of the harp, with the bottom piece located between them. Before getting out the glue bottle, I have all of the pieces laid out in their respective positions. I then take a piece of waxed paper that has been cut longer than the harp by 2 or 3 inches. This has also been cut in half lengthwise. One half of this wax paper is saved for another harp assembly. Half of one sheet is enough to prevent any of these harp parts from sticking to the clamping fixture, and I do not have a lot of excess waxed paper interfering with my efforts to get everything clamped up accurately before the glue starts to set.

I use regular old yellow woodworkers glue. I have tried many of the "new and improved" glues on the market, and for my opinion, you still cannot beat regular old yellow woodworkers glue (sometimes called "Hide" glue) for this application. It is inexpensive, has a fair working time, and its waterproof when it is fully cured. Another thing I have handy is a piece of plywood, about 4 inches wide and about 6" shorter than the harp I am gluing. This is a bottom clamping block, and it holds the bottom of the harp flat and securely down in the clamping

fixture. Another thing I have handy is 6 pieces of spring steel, about 5 inches long. This spring steel is about 1/8" wide and about 1/32" thick. Both ends of each piece are sharpened to a point. A great source for this material is an old discarded windshield wiper blade refill. Many of them have thin pieces of spring steel inserted as stiffeners. Any other source of similar material will work for you. Later, when you see how I use these pieces, you will probably be able to come up with something in your shop that will serve the same function, and work just as well.

I have pencil marks on my clamping jig to indicate the center of each piece, so I can center the fixture between the bench dog and the vise dog. I will also make a small pencil mark on the inside face of the bottom of the harp, at center, so I can line it up with the center of the fixture as well. After I have put the waxed paper down into the clamping fixture, I position the bottom of the harp in the fixture, on top of the waxed paper.

In the photo above, I have dry fit the pieces together in the clamping jig. The long reach vise grip clamps are clamping down on a piece of ¾" thick material, in this case MDF, to hold the bottom piece down flat in the clamping jig.

Then, working quickly now, I apply a very small bead of glue along the bottom, inside face of the back of the harp. Slide the back of the harp down into the fixture, between the harp bottom and the clamping face of the fixture. Now apply glue in the same manner to the front of the harp, and position it in place. Now just snug up your bench vise so it is just pinching these 3 parts together. No real clamping pressure just yet, it is just holding the whole mess in place. Now I take that 4" wide piece of plywood and lay it on top of the bottom of the harp. Use a couple of long reach clamps to clamp the bottom of the harp firmly down into the fixture. Check this, front to back and end to end. Now apply glue to the pin blocks on the bottom, where it will glue down on the bottom of the harp, and about 2/3 of the way up on the front and back. I do not apply glue all the way up to the top of the pin blocks because a lot of squeeze out at the top of the pin blocks just gets in the way later. Now, spread the tops of the front and back pieces apart with one hand, while you slide the pin block down in place with your other hand. Make sure it is positioned properly, square to the end of the bottom. I will usually locate the pin block .005" to .01" inside the end of the bottom. This makes it much easier to sand everything up flush and flat later. Make sure also that the ends of the front and back are flush to the end of the bottom piece. Now repeat the process on the other end, with the other pin block. Grab a piece of scrap wood that is ¾" thick, 1" wide and about 6" long. Lay this across the harp, spanning from the top of the front piece to the top of the back piece, and about 1" inside the pin block. Use a long reach clamp to apply enough pressure down on the front and back to make sure the bottom edges of these pieces are also fully nested down into the fixture, flush with the bottom of the harp. Again, repeat on the other end. Now you can apply clamping pressure to the center of the fixture with the bench vise, and use additional clamps at the ends of the harp, both on the clamping fixture, and on the front and back of the harp, pinching the pin blocks securely.

In this photo, you can see the initial clamping once I start gluing the pieces together. First, I clamp the end block down onto the bottom of the harp. Then apply clamping pressure to the top of the harp front and back to make sure that they are seated down fully into the fixture. Next, use a clamp across the two sides of the fixture to tighten the front and back against the bottom and pin block. Then one more clamp on the upper portion of the front and back to pull them in tightly against the pin block. Repeat the process on the other end of the harp.

Once you have checked to confirm that the bottom of the harp is down flat in the fixture, and the front and back are also down all the way, and securely clamped to the pin blocks, remove that piece of ply or MDF that was holding the bottom down flat. On the inside edges where the front and back meet the bottom, you should have a little bit of glue squeeze out all along the length of the inside of the harp. I usually squeeze a little more glue down into these corners just to ensure a good glue joint. Then, take those long, narrow strips that should be about 3/16” square, and push them down into the glue joint. As I mentioned earlier, they don’t necessarily have to go from pin block to pin block, but I rarely leave more than an inch at either end that doesn’t have this glue joint doubler in place. Once I have these doublers in place along the front bottom and back

bottom glue joints, this is where those little pieces of spring steel come in handy.

I push one sharpened end into the doubler at the front, and then bend the steel over to push the other sharpened end into the doubler at the back. The spring pieces supply just enough spring pressure to hold these strips in place while the glue sets. I use 6 of them, evenly spaced along the length of the harp. When they are all in position, I go over each location again, using finger pressure just to ensure that the strip is securely pressed down into the corner, and then I can go take a break with a cold one while the glue dries.

The photo below shows my soundbox glued up. I have removed some of the clamps to allow me to install the joint doublers. Only the clamps and blocks that helped push the front and back pieces down into the fixture, and the clamps holding the bottom clamping block have been removed. You can see the little spring steel clamps that hold the joint doubler strips in place while the glue sets.

Chapter 8

Completing the Inside of the Soundbox

When the glue has had time to completely set up and dry, it is time to pull this soundbox assembly out of the clamping fixture. Remove all of the clamps, remove the little spring steel clamps from the doubler rails, and loosen the bench vise. Lift the soundbox assembly out of the clamping fixture, turn it upside down and peel off the wax paper. Examine these bottom glue joints closely to see how well you did. If everything went well, the bottom should be flat, with the bottom edges of the front and back flush to the bottom of the harp. Of course, there will be glue squeeze out all along these joints, but don't worry, that will sand or scrape off later. Now look at the glue joints around the pin blocks. The front, back and bottom should be tightly glued to the pin block with no radical gaps or voids. Of course there is glue squeeze out here too, but that is easily taken care of. This is why I locate the pin block just slightly *inside* the ends of the bottom and front/back. It will now be very easy to sand down these thin sections of end grain until they are flush with the face of the pin block. In the process, I will also remove all traces of glue squeeze out. However, we won't worry about that for now. We are going to move on to some work we have to do on the inside of the soundbox.

Remember when we first stated fashioning the pin blocks and cover support blocks? We had to drill those holes in the cover supports, and then band saw out that center portion. Ok, now what did you do with that center piece? You need it now. Found it? Good. Now we are going to make 4 small blocks that will glue into the soundbox, on the top inside face of each pin block, just below where the soundboard will glue down. These blocks will accept the cover locating pins later. You should have one side that was sanded smooth of band saw marks when we separated the pin blocks from the support blocks. The opposite side, a shorter side, will still be rough from the band saw. Take this to the disc sander, or belt sander, whatever, and smooth it down. Try to keep this surface parallel to the opposite long side, as much as you can by hand, but don't waste a lot of time and energy on it, it is not that critical. Just get it close.

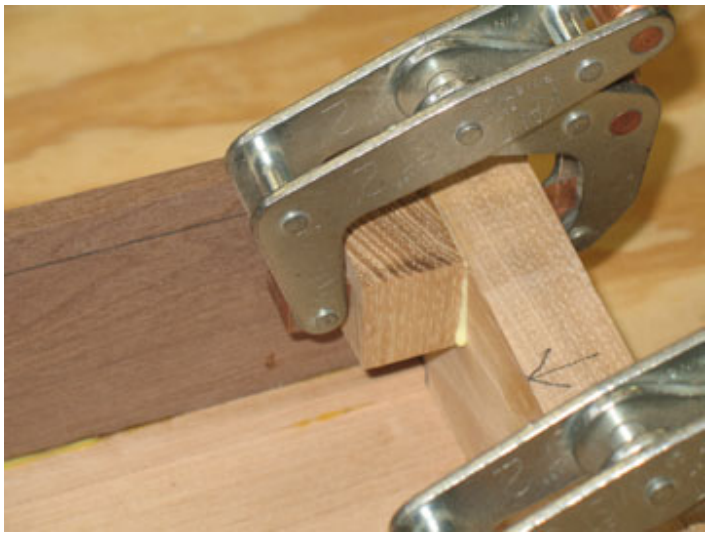
Now use your bevel gage to transfer the angle of the top of the pin block on to either end of this block as you see in the sketch below. Find the center point between these two angled lines, which should be at about 9 degrees, and draw a line square to the long side to bisect them.

The scrap piece from the cover support cutout has been laid out to become cover locating pin blocks.

Take this block to the band saw, and saw off those radius pieces close to the angled lines. Then to the disk sander to sand the cut edges right up to the layout lines. Now you can go back to the band saw to separate them by cutting right down the centerline. You should have 4 little blocks, almost cubes, except that the top of each one is angled, and that angle matches the angle on the top of the pin blocks at each end of your soundbox.

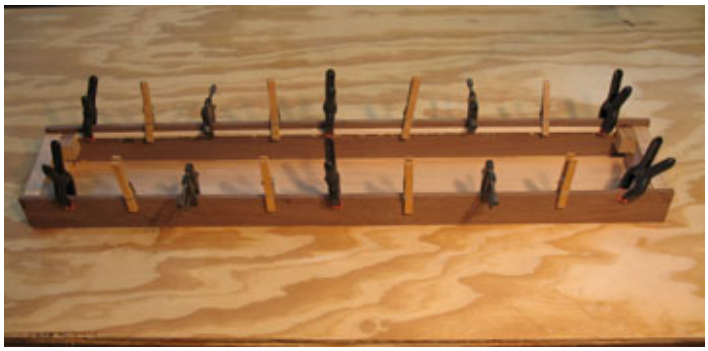
Before we glue them in place, you want to establish a straight reference line on the inside of the front and back, that will run the length of the harp from one pin block to the other. Use a metal straightedge that is longer than your harp. Do not use a wooden yardstick, they warp and bend. I keep a piece of aluminum angle in my shop. It is ½" X 3/8" X 1/8" X 48", and it has no other use but to be a reliable straightedge longer than a standard yardstick. Put the harp on a work surface, front down, and place the straightedge on top of the front, and up against each pin block. Use a pencil to draw a line on the inside face of the front, from end to end. Now turn the harp over so it is on its back, and do the same to the inside face of the back. These are guide lines that will help you when you are positioning the soundboard support rails.

Now we are ready to glue those cover pin blocks into the corners of the soundbox. They should glue tightly against the inside face of the pin blocks, and just *below* the angled top of the pin blocks. It would be all right to glue them flush with the top of the pin blocks, but do not let them be higher than the pin blocks. Flush with or below, that's the only way to go. I usually apply glue to both sides of the block, where it is touching the pin block and where it is touching the front, or back. Just a little added insurance that it is not going anywhere. Locate all four of them, glue and clamp them in place.



Ok, it is time to hunt down those two other long strips that you ripped. You remember, the ones with the 9 degree angle on one side? Yep, those. We want to glue those to the inside faces of the front and back, right along that pencil line that we drew from end to end. These pieces are going to support the soundboard on the inside, just like the other braces support the glue joint between the front/back and bottom. You will have to cut a few inches off the length, so that they will fit in between the cover locating pin blocks. Make sure when you glue them in, that the angle on the top of the strip matches and aligns with the 9 degree angle on the top of the pin blocks. As you apply clamps, and

spring type clothespins work great here, make sure that the strip follows the guide line, so you have a true, straight line from end to end.



Chapter 9
Soundboard Preparation

While the glue is setting up on the soundbox, this is a good time to start getting the soundboard ready. It has already been sanded smooth, at least 80 grit smooth, and now we are ready to start cutting it to size. First, make sure that at least one long edge is good and true. There is no need to joint this edge just yet, just rip it straight and even. Now measure across the top of the pin blocks to see how wide the soundboard will be when it is ready for installation. It should be the same as the length of the pin blocks, but it will measure just a little longer because of the angle at the top of the soundbox. Go ahead and rip the soundboard about 1/8" wider than the measurement at the top of the pin blocks. Crosscut the ends so that they are square, and the same length as the front and back pieces. At this point, you should have decided about the soundhole, or soundholes, and how you are going to decorate the soundboard of your harp. This is when you want to take care of that. If I am just putting a basic round soundhole in a harp less than 36", I lay out the center of the soundboard, and use a 2 & ¼ " hole saw to drill the soundhole. If the harp is going to be 3 feet long or more, I will put 2 soundholes, equally centered. Whatever you choose to do to make your harp unique, now is the time to do it.

You have decorated the top of your soundboard to your hearts content, the soundholes are cut and sanded smooth and you are ready to start fitting this soundboard to the soundbox. Adjust the fence of your jointer to an angle that

matches the top of your pin blocks. Again, it is going to be something close to 9 degrees. It is a simple matter to use a bevel gage and transfer the angle from the harp to the jointer fence. Look again at the sketches of the end of the harp and think about how this angle has to be cut on the front and back edges of the soundboard. Ordinarily, when jointing the edge of a board, you would try to joint with the grain to avoid any chipping out of the grain. Here you do not have that luxury. You will have to run each edge over the jointer, regardless of grain direction, producing that angle so that the soundboard will fit between the vertical front and back pieces without any gaps or chipping. So set the depth of cut to a very shallow cut, and joint each edge at the proper angle alignment. Test the fit often. By now, the glue on the rails that support the soundboard will have dried, and you will have cleaned out any glue squeeze out that might be in the corners where the soundboard has to seat. You should put the front edge of the soundboard down into its position first, and then lower the back of the soundboard down into place.

In the photo below, the soundboard width is getting close, but will not quite seat down into the pocket.

Continue jointing these edges until the back of the soundboard just snugs into place against the back of the harp, and on top of the pin blocks.

Congratulations, the soundboard is now almost ready to glue down into the soundbox. But first, we have to add a few pieces to the underside of the soundboard. Turn the soundboard face down on your work surface, and measure in 2 inches from each end. Use a square to draw a vertical line at this 2 inch dimension. On my 32 inch harp, with one soundhole, I will also locate two reference lines on either side of the soundhole as well. On these locations, we are going to glue a small stiffener to the back of the soundboard. These stiffeners will just be small scraps of hardwood, approximately ¼ inch by ¼ inch, and 3 & ½ to 4 inches long. Measure the distance between the soundboard support rails that you glued to the front and back, and cut your stiffeners slightly shorter than this. This is so that the stiffeners will not interfere with the rails, preventing the soundboard from seating down in place on the rails. If your harp is long, and has two soundholes, you might just want to use 3 stiffeners. One two inches in from each end, and then one more at the center, in between the two soundholes These stiffeners are to prevent the soundboard from bowing or cupping later on. They will help keep the soundboard nice and flat. The two stiffeners that are located 2" in from each end also do double duty by supporting the string bridges that will be located directly over them on the top of the soundboard. I put a mark on each of the lines that I have drawn on the back of the soundboard, locating the center (front to back) of the soundboard, and also a small mark on the center of each of my stiffeners. These marks just make it easy to locate the stiffeners when I have applied glue to one edge, and clamp them down in place on the bottom side of the soundboard. Let the glue on these stiffeners dry, and then you can move the soundboard and the soundbox into the finishing room.

Chapter 10
Finishing the Inside of the Soundbox

If you are planning to put any identification marks, your signature, date of manufacture or anything else like that on the inside of the harp, now is the time to take care of this. I usually use my pyrography pen to burn my initials on the inside bottom of the harp, and sometimes the month and year of manufacture. I locate this signature near the front of the harp, underneath the soundhole location.

With that taken care of, I start applying finish coats to the inside of the soundbox. Whatever finishing product you have chosen to use, apply enough coats of this product to weatherproof the inside of the box. Eventually, the harp is going to get rain blown in on it while it is sitting in your window, and some of that rain is going to get down inside the harp through the soundhole. By applying finish coats to the inside of the harp, you are just providing added protection. We are not going for a glossy or impressive finish here, just waterproof the exposed wood inside the body of the harp.

Use some caution while you are doing this. Glue will not adhere well to wood that has been coated with poly. Remember that the soundboard has to glue down on top of the end pin blocks, and to the top of the support rails, and to the front and back of the harp above these rails. Do not apply any finish to those surfaces. Coat the underside of the soundboard at the same time, but do not apply any of the finishing product on the last ¾" at each end of the soundboard, and also leave at least 1/8" along each long side dry. I usually give the inside surfaces of my harps at least 3 or 4 coats of poly. Considering drying times, this is usually a two-day process. While the harp is in the finishing room, this is a good time to start on the string bridges, and cover locating pins.

Chapter 11
Making the String Bridges

The string bridges are pieces of hardwood that hold the strings in alignment, parallel to and above the top of the soundbox. They also establish the vibrating length of the strings, and they maintain the string spacing. They are just two little triangular pieces of wood, 4" long, but they are one of the most critical parts of your harp. Making these pieces correctly is rather involved, and requires some careful layout and measuring.

Begin with a piece of ¾" Maple (or similar hardwood) that is 12"long. Make sure you have at least one good edge against the rip fence of your table saw. Raise the blade enough to cut through the stock, and then tilt the blade over 20 degrees. Rip enough stock off one edge to clean up that edge at 20 degrees. Flip the piece over, end for end, and move your fence closer to the saw blade. Move over enough that the saw blade produces a sharp corner at the 20 degree cut you just made. This should be ½", plus the width of the saw blade kerf. This will give you a triangular piece that is ¾" tall, ½" wide at the base, and 12" long. The completed bridges will only be ½" to 5/8" tall, and this height adjustment will be taken care of in the shaping that we will do shortly. After re-setting your saw blade back to 90 degrees, use your crosscut slide and clean up one end, and then cut 2 pieces of your bridge blank, each 4" long.

Take these two bridges to your stationary belt sander, and carefully holding them against the moving belt, sand the sides of the triangle smooth, and then sand another angle near the top of the triangle to reduce the height of the bridge. This also increases the acute angle at the top of the bridge, making them less fragile and easier to work with. See the sketch below of the bridge cross section.

While you are still at the belt sander, create a 1/8" radius at the top on each end of the bridge. Just a slight round over to remove the sharp corner, and it makes the bridge look cleaner. A more "finished" appearance.

At this point, I like to flat sand the sides of my bridges with progressively finer grades of sandpaper on a hard, flat surface to smooth them out. I usually work up to 150 grit before I start the next operation, and then I finish sanding up to 220 grit **after** I have cut the string grooves, and drilled the locating pin holes.

Let's drill the locating pin holes first. I use my bench vise with soft jaw covers installed, and open the vise about 3/8". Turn the bridge upside down (point down) and set it down between the jaws so that the base of the bridge is up. Carefully locate the center of the 4" dimension, and make a sharp pencil mark 1" on either side of center. At these two locations, mark the exact center

of the width of the base of the bridge. This width was ½" when we started, but depending on how much you had to sand off to clean up the sides, that dimension may be less now. You should have two hole locations, exactly 2" apart, and perfectly centered on the base of the bridge, in both directions. Use an awl to dimple these locations accurately, and then take them over to the drill press. Use a drill press vise to hold each bridge as you did when laying out these locations, and mount a 1/8" brad point drill bit in the chuck. Set your depth stop to drill these holes 1/4" to 3/8" deep. Make sure the base of the bridge is horizontal, or perpendicular to the drill bit when you drill. Later we will be installing short pieces of 1/8" dowel into these holes, and they in turn will locate into 1/8" holes we will drill in the soundboard, so accurate layout of these holes is important.

We can now start on the more difficult part of making these bridges. We have to cut notches in the top angle of each bridge for the strings. The first thing to do is hold the two bridges together, side by side, and turn them over so you are looking at the bottoms or bases again. With your pencil, draw two arrows, one on each bridge, point to point, as in the sketch below.

Here we have just established the inside and outside faces of the bridges. When we are ready for final assembly of your harp, this orientation will matter. As long as you keep the bridges aligned arrow to arrow, everything will line up well. The strings will appear perfectly parallel, even if you are off location slightly when you cut the string notches. Still holding the bridges together, side by side, turn them over and clamp them between the soft jaws in your bench vise as I have them in the sketch below.

Use a ½" wide machinists scale, either 6" or 12" with fine, crisp graduations, and lay it along the side of one of the bridges. Here you want to use the side of the scale that divides an inch into tenths or one hundredths, not the side that has fractional graduations. Slide it side to side until you have located the exact center of the bridges 4" length. With a very sharp pencil, make a mark exactly 1/10 of an inch on either side of center. Now make more marks towards each end, each mark exactly .200" inch apart, 8 marks on each side of the center of the bridge, for a total of 16. Try to be as accurate as you can here. These locations are going to locate the strings, and you will want them all to be parallel and evenly spaced. Use a paring knife first, and just push it down into the crowns (or points) of the bridges at these 16 locations to start

your notches. Then take a 6” or 8” long fine tooth, triangular file, and carefully locate the corner of the file into each of these notch locations and start filing the notches in each bridge.

The notches on the ends of the bridges will be deeper and wider than the notches in the center of the bridges. I guess this is as good as a time as any to discuss the “Aeolian Theory”, what is has to do with how these harps work, and why the string notch depth matters.

Sometime around the 1950’s, a group of physicists studying Aeolian harps came up with what they called the “Aeolian Theory” to explain how the magic works. The question that has plagued scientists, students and philosophers for centuries is, “How can an instrument whose strings are all tuned to the same note, produce all of the beautiful harmonies one hears from an Aeolian harp?”

I can remember as a child going to a stream or smoothly flowing river, and holding a stick down in the moving water. I observed a curious thing there. The interruption of this round stick in the smoothly flowing water created counter-rotating eddies in the water just downstream from the stick I was holding. See the sketch below.

The physicists studying this knew that air acted much like water when in motion. They theorized that when you had a number of cylindrical objects (such as round strings) interrupting the air flow, all on the same plane as the direction of air movement, that this effect would compound again and again as the air encountered more and more obstructions.

This sounds perfectly logical to this student of these harps, but it still does not seem to completely explain just how the different harmonies are coming into play. In addition, the sketch I have included above is just speculation as to what might be happening to these eddies in the air stream as they encounter consecutive obstructions.

In December of 2004, the Aerodynamics class at Nihon University in Tokyo, Japan, under the direction of Professor Hajime Fujita, decided to use the university’s big wind tunnel to investigate this phenomena. The university commissioned one of my harps to test in their wind tunnel. After many months of testing the harp at various wind speeds and with various tunings of the strings, their research was complete. Professor Fujita reported to me that several

papers had been written on the research, and a number of degrees had been earned because of their research. When I inquired about the results, and if any definitive explanations of the “Aeolian Effect” had been agreed upon, I could not get a concrete answer. Professor Fujita only told me that the papers had not yet been translated into English. I can only assume that the “Aeolian Theory” is still only that, just a theory.

Never the less, this is why I cut my string notches as they are in the sketch below. I put the thinnest strings at the center of the soundboard, with the thicker strings on either end. I cut my string notches accordingly, so that the centerlines of the strings are all on the same plane, or at least very closely so. One could really go overboard here, and calculating the diameter of each string, and using trigonometry to calculate the exact depth of each notch to locate that round string diameter into that triangular notch at a specific tangent point, and so on and so on, but I think that would be overkill. The method I use gets them close, and it seems to be close enough, because the harps sing very well when made this way.

As you file these notches into the bridges, you will no doubt notice something else that is happening. Because you have the two bridges clamped together, inside face to inside face, your string notches are deeper on the outside face of each bridge than they are on the inside face. As Martha would say, “This is a good thing!” When you are stringing and tuning your harp, where the string exits the notch on the inside face of the bridge, it is going straight across the harp, parallel to the soundboard. However, on the outside of the bridge, it is making a sharp angle down, towards the soundboard. The notches are deeper on this side of the bridge, providing more of a nesting spot for the string, which helps to keep the string on location.

After filing all of your notches to your satisfaction, then you can go ahead and finish sanding the sides and ends of the bridges smooth. They are ready to start being finished.

The Maple I use is normally very light in color. If I am going to be mounting them on a soundboard of wood with a dark color, I will leave them natural. Usually however, I am going to mount them on a soundboard of light colored wood. I like them to stand out in contrast. I want you to see them. Bridges that will go on a soundboard of Spruce, Linden or Poplar go through a process some woodworkers call “Ebonizing”. This is merely a process using dye to turn the wood black, so it very closely resembles Ebony. Black leather dye works great here. If you are going to dye your bridges or just clear coat

them in their natural color, take a few minutes to make this job a lot easier. Go grab that piece of 1/8" dowel you bought before. First, cut 4 short pieces of this 1/8" dowel anywhere from ½" to ¾" long. Lightly chamfer the ends to remove any burrs and set them aside where they will not get lost. With the rest of that 1/8" dowel, cut 2 pieces, each at least 2 &½" long. You can insert one end of each of these dowels into the holes we drilled into the base of one bridge, and then push the other bridge on to the dowels at the other end. Now you have a handy way to hold these 2 bridges while you apply dye and your finishing product of choice. In addition, when you have applied your finish coats, you can lay these dowels on the edge of a short piece to 2X4 to dry. I use the same basic finishing processes on the cover locating pins, which we will make next. You may as well be finishing the pins at the same time you are finishing the bridges, so lets get them done.

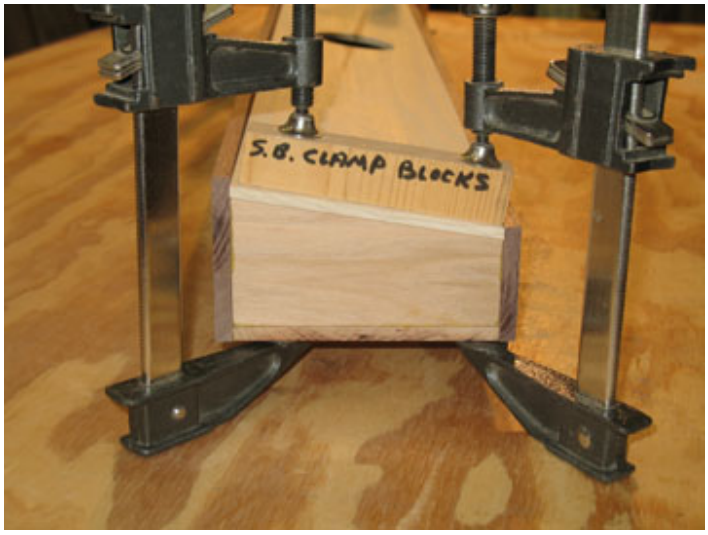
Chapter 12
Cover Locating Pins

If the bridges were the most difficult component of a harp to produce, the cover locating pins have to be the easiest. They are merely 4 dowels of maple, one inch long, with a bullet nose shaped on one end. I start by cutting 2 pieces of ¼" dowel (Maple) each piece 2 & 1/8" long. Take these two pieces to the belt sander and while holding them against the belt, spin them round and round between your fingers to shape each end. Nothing critical here, you can make them spherical, or you can just chamfer them if you prefer. I think the bullet nose shape looks better on the finished harp, but you are welcome to treat these pins any way you choose. When you have them to the shape you want, take them to the band saw and cut each one exactly in half. This will give you your 4 dowels, each 1" long. It is a good idea here to lightly chamfer the bottom ends of the pins on the belt sander. Grab a piece of scrap wood and drill 4 shallow holes in it, only about ¼" deep. Use a drill bit that is slightly larger than ¼". This is a handy holder for the pins while you dye them to match the bridges, and clear coat them as well. Only the top half of the pins will be seen, the end with the bullet nose shape, so you do not have to worry about dying or clear coating the lower half of the pin. That end of the pin is going to be inserted into the harp, below the soundboard.

Chapter 13
Gluing Down the Soundboard

After doing all of that work creating the bridges and cover pins, by now you should have enough coats of your finishing product of choice on the inside surfaces of the soundbox, and on the bottom side of the soundboard. Now we can actually glue the soundboard in place and start finish shaping the harp body. For this operation, I collect all of the clamps I am going to use, and a variety of job specific pieces of wood to act as clamp blocks, or cawls, as I glue this up. Before opening the glue bottle, I once again inspect the corners where the soundboard has to locate. I am looking for any glue squeeze out that I might have missed before. Little gobs of hardened glue hiding in the corners could interfere with the soundboard locating properly. If I find any, I carefully pare them out with a knife or chisel. Now I also turn the soundboard over, and using a hand pad of 150-grit sandpaper, I sand a slight glue relief chamfer along the front and back inside edges of the soundboard, stopping one inch from either end. This slight chamfer provides some glue relief in those corner joints, and also allows some clearance for any tiny glue gobs that I might have missed. I stop one inch from each end so that this chamfer will not be visible on an end view of the harp. The ends will still have sharp, crisp corners that nest perfectly into the corner between the pin block and the front and back.

Start with a bead of glue all around the perimeter of the soundbox. I usually begin at the front left corner, and squeeze a bead of glue across the top of the left pin block, then along the back of the harp, on top of the support rail that I glued there before, and then down across the right pin block, and all along the support rail on the front of the harp. Using your fingertips to make sure the soundboard is centered above the end blocks, insert the front edge down into position, and then lower the back of the soundboard in place. I use two blocks of wood on the top of the soundboard to protect it from the clamps (2 on each end) that clamp the ends of the soundboard down on to the top of the pin blocks.



Next, I lay 2 long pieces of wood along the front and rear edges of the soundboard, just inside of the front and black. I use large spring clamps to make sure the soundboard is firmly down on the support rails the length of the harp.

Now I use two more long pieces of wood, one along the front of the harp and one along the back, as I use clamps to pull the back and the front in securely against the soundboard. Closely inspect these glue joints all the way around to make sure that there are no major gaps or miss-alignments. Re-adjust your clamps where necessary, or add more clamps if you have to. Once you are satisfied, set it aside to dry.

Chapter 14
Finish Shaping and Sanding the Cover Supports

In chapter 5, we cut the cover supports from the pin blocks and used the drill press and band saw to cut out the rough shape of the cover support blocks. If you have not sanded smooth the inside surfaces of the cutout portion, do that now while the 2 blocks are still stuck together with carpet tape. Smooth the radiuses and the inside faces of the legs so they are tangent to the corners. Also, smooth the top of the cut out so it is also smooth and tangent to the corners. We do all of this work while the two pieces are still joined so that they will be identical in size and shape. You can now pull them apart and start the finish sanding on them independently. Every surface on these blocks will be visible with the exception of the top where you drew those two alignment arrows. It will glue to the cover piece. I begin preparing these pieces by flat sanding them on a smooth work surface with a full sheet of 80-grit sandpaper. I like to use a technique I learned in my years of building molds for the plastic industry. When we had to polish the inside faces of a mold smooth, we would start with a coarse abrasive, and go over the whole cavity, always working in one direction. When we had polished out all of the machine marks, and all of the scratch marks from the coarse abrasive were all going in one direction, we would then switch to a finer grade of abrasive, but this time we would work in a direction 90 degrees to the direction we were taking before. By changing direction with each successive grade of abrasive, it was easy to see when you had removed all of the coarser scratch marks from the previous grade. I use this same technique when sanding small parts down to a fine, smooth finish. I will start with one of these cover supports, and holding it flat on one side, I'll rub it back and forth, going from corner to corner of the work piece, until the surface only shows the marks from the 80 grit sandpaper, and they are all going across the piece

diagonally. Turn the piece over and do the same to the other side. On the end grain front and rear faces of the legs, I still have the circular swirls from the disc sander. I sand these out, again working from corner to corner. Treat the other support block the same way. Do not forget to lightly sand the bottoms of the legs, or the feet, the same way. Blow or vacuum the dust and abrasive off of these pieces, and switch to 100 grit. Go through the same steps, but this time, rotate the part 90 degrees to the direction you were sanding before. You can hold the piece up to the light, looking at the surface you just sanded at an oblique angle, and the scratch marks on the surface will tell you when you have sanded out all of the 80 grit marks, and only the 100 grit marks remain. Continue this way through 120 and 150 grits. When I have sanded all of the sides and faces with 150 grit, the corners have gotten fairly sharp.

This is a good time to locate the holes that will receive the cover locating pins. Turn the two cover support blocks upside down on your workbench, and use the corner-to-corner method with a scale and a sharp pencil to locate the center of each of the four feet. Dimple these four locations with an awl so your brad point drill bit can center on this location. These four points are where we will drill clearance holes for the cover locating pins that we made earlier. However, we cannot drill them out to size yet. First, we have to transfer these locations to the soundboard so we know where to drill for and install the ¼" X 1" bullet nosed pins. And of course, we cannot do that until the cover has been assembled.

Here you will have to plan your steps according to what tooling you have at hand in your own shop. The first obvious thing that comes to mind is dowel centers. You could drill ¼" shallow holes on these locations, but there is a problem. Most dowel center sets I have ever seen only have 2 centers of each size. We need 4. You could drill 2 of the feet for ¼" dowel centers, and then drill the other 2 feet to accept 3/16" dowel centers, or even 1/8" centers, if that's what you have. All four of these holes will be drilled out to 9/32" later, so any size ¼" or less will do. One other slight problem with using dowel centers that you will have to keep in mind. The holes that we drill in the feet will be at an angle to the surface we are drilling into. That same 9 degree angle is coming back to haunt us. If you use dowel centers with a shoulder on them, like the ones I have, you will have to make sure that the dowel center is registering on the sides of the hole you drilled, and not on the bottom face of the feet. Otherwise, this angle will throw the transferred hole location off.

There is a really handy tool I have left over from my days as a tool and die maker in the manufacturing industry. With this tool, I avoid these problems altogether, and I can easily locate all 4 pin locations at once. It has called a set of transfer screws. It is a little steel tube, with a hex shape on the outside. Unscrew the end cap, and out slide (usually 6) little screws. Each screw has a point in the center, and a hex that fits a hex recess in the front end of the container tube. They come in all standard screw sizes, and I use my ¼-20 set

for this job. That is ¼" diameter, and 20 threads per inch. Of course, we are not cutting any threads here, but when I drill the holes in the feet of my cover supports, I use my ¼" brad point drill bit, and set the depth at ¼". These little transfer screws screw right down into the ¼" hole, and you can feel them hit the bottom of the hole. They are just long enough that only the very point, the "center point" of the screw is protruding above the surface of the wood. I have seen these transfer screw sets on sale for as little as $6.00, and it is a very handy tool to have in the shop.

This is a photo of my set of screw centers. I have one stuck into the nose of the cylinder, which also acts as an insertion tool.

Having thoroughly confused you with all of that, drill a hole in each of the 4 feet that is going to work with whatever tooling method you choose to utilize. When you have drilled these holes, lightly break the edges of the cover support blocks all around the foot surface and in the cutout area. Do not break the edges that are going to glue to the cover, or the vertical corners running from the feet to the top surface of the blocks. We will break these edges and corners after assembly.

Set these 2 support blocks aside now, and return to your soundbox. By now, all of the glue should be dried, and you can remove the clamps and clamp blocks.

Chapter 15
Sanding the Soundbox

The first thing I do now is turn the soundbox upside down on a towel, on my workbench. The towel is just to protect the outside of the soundbox from any dings or scratches while I work with it. Using my palm sander with 80 grit abrasive, I sand the bottom smooth. With a little luck, the bottom edges of the front and back will clean up nicely when I sand off any glue squeeze out on the

bottom of the harp. Turn the harp over and examine how much material you have sticking up above the soundboard on the front and back pieces of the soundbox. There should be enough that when you sand it down flush with the top of the soundboard, the angle of the soundboard will continue to flow right to the outside edges of the front and back. If it looks like more material than I really want to sand off, I will take it over to the table saw and rip off the excess. Once again, tip the blade over to that 9-degree angle, and raise the blade just enough to cut through the thickness of the front and back. Use the rip fence first on one side of the blade, and then on the other, to trim off most of the excess wood, cutting close to the soundboard. Take the soundbox back to the towel, and sand the top edges of the front and back down until they are flush with, and at the same angle as the soundboard. Take a seat in your shop chair, and put one end of the harp on your feet while holding the soundbox between your knees. Sand the ends of the harp down smooth and flush with the outside face of the pin blocks. After I have gone over the whole harp body with 80 grit on my random orbit palm sander, I do it again with 120 grit. Take a break from that here, and go over all of the outside edges with your 150 grit hand pad, just enough to soften the corners as we did when we were sanding the cover support blocks. Now go over the whole thing again with 180-grit paper in your palm sander. The harp body is almost ready to go into the finishing room. We have to locate and drill no less than 32 holes in the soundboard first. One thing we have to do before we can do that is put the cover pieces together, so set the soundbox aside for now.

Chapter 16
Prepare the Cover Piece

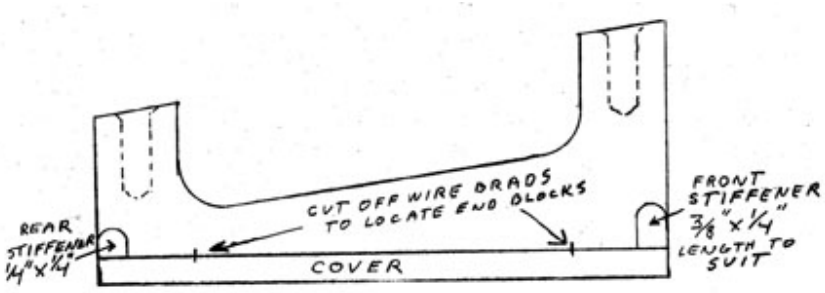
You should still have one plank of stock left over, preferably of the same wood that you made the front and back of the soundbox from. Sand this piece on both sides, all the way up to 220 grit. Go ahead and make this piece nice and smooth. It is a lot easier to do this now, than it will be later after we have glued four more pieces to it. Taking it to the table saw, clean up the long edges so that they are parallel. You are going to rip this piece so that it is just slightly wider than the cover support blocks. Before you do that, you are going to rip two narrow strips that will become the cover stiffeners, glued to the bottom face of the cover. Run each edge of the cover over the jointer set at 90 degrees, so the edge is very smooth and square. Put a small pencil X on each of these jointed edges so you will know where the glue goes later. Now rip these edges off, creating one long strip that is about ¼” wide, and one long strip that is about 3/8” wide. Their purpose is to add some rigidity to this long piece of thin stock that is going to span from end to end of your harp. Now you can go ahead and

rip the remainder of the cover piece down to about 1/16” or less **wider** than the support blocks. I leave this little bit of material so that I can sand the cover just down to where it becomes flush with the end blocks. It is a lot easier to sand the edges of this thin stock down to the end blocks, than vice-versa. Now, use your crosscut slide again to clean up one end nice and square, and then cut the other end to length. You will want to cut this cover 1 & ½” **shorter** than the length of your harp. The photo below shows that the ends of the cover assembly stand ¾” inside the ends of the harp body.

Now examine the piece, and decide how you want to orient it on the harp. Which side is nicer? You want that to be the top, and then which edge do you want at the front, and which at the rear. Turn it top side down on your workbench, with the front of the cover towards the front of your workbench. Now get those two support blocks that are going to glue down on to the bottom side of the cover piece. Before we try to glue them down, let’s do something to make locating them a little easier. Take a small wire brad nail, the smaller the better, and use a hammer to drive it 1/8” deep or so into the top of the support piece, near one end. Using side cutters, or wire cutters, cut it off as close to the wood as you can. The idea is to leave just a small sharp point of wire sticking up out of the top of the support block. Do the same on the other end of that support block, and then repeat the process on the other end block. Hold these two pieces together, side by side, so that the arrows on the top are once again point-to-point, and the long legs are facing towards you. Remembering that the long legs are at the front, flip these pieces over upside down by rotating them sideways. Now they are in the proper position relative to each other and to the

cover piece. Separate them and put one on each end of your cover piece. Carefully position one at the end of the cover piece, make sure it is centered front to back, and on the end of the cover. Now use a mallet to drive those sharp pins down into the surface of the cover. Do the same on the other end, with the other block. Now, when you apply glue to the top of the support blocks, and position them on the cover piece, you will be able to feel the pins fall into the little holes they made, and the piece will not slip around and become miss-aligned as you apply clamping pressure. Glue both support blocks down, and clamp them securely in place.

The drawing below shows the approximate locations of the wire brads that help locate the cover support blocks while they are being glued in place. It also shows where the cover stiffening rails are glued to the underside of the cover.



While the glue is setting up on those pieces, you can start the preparation of the cover stiffeners that we cut from the edges of the cover. Take the wider of the 2, the one that is about 3/8” wide, and locate the good surface that you ran over the jointer and marked with an X. This will be the surface that glues down to the underside of the cover, running from support block to support block. I like to give the exposed edge of these stiffener rails a full radius. I think it just looks nicer that way, but you are welcome to treat these edges any way you like. A person could get really involved here and set up a router table with a small radius round over bit to cut these edges, or there are any number of ways that this operation could be done. But I usually have my router table set up for another job, and when I consider the set up time, tearing down one set up, setting up this operation, and then having to take it down again - - - - - It’s just not worth it. I can put this full radius on these rails faster by hand with sandpaper. This is how I do it. I begin by running these corners across the belt sander, roughing a chamfer on both edges. Then I take them to my work bench, and just sand the radius by hand, starting with 40 grit, 80, 100, 120, 150, and 180, rolling the rail back and forth as I sand along it’s entire length. It really only takes me about 10 minutes to sand this full radius on a rail that is about 3 feet long. I would spend at least that much time trying to set up a machine tool to do the same job, and it would probably still need some sanding anyway. Shape the wider of the two rails, and then cut a little bit off of one end to eliminate any round over at the end. Touch this end on the disc sander just enough to make sure it is square. Now take it to the cover piece where the support blocks have been glued down, and

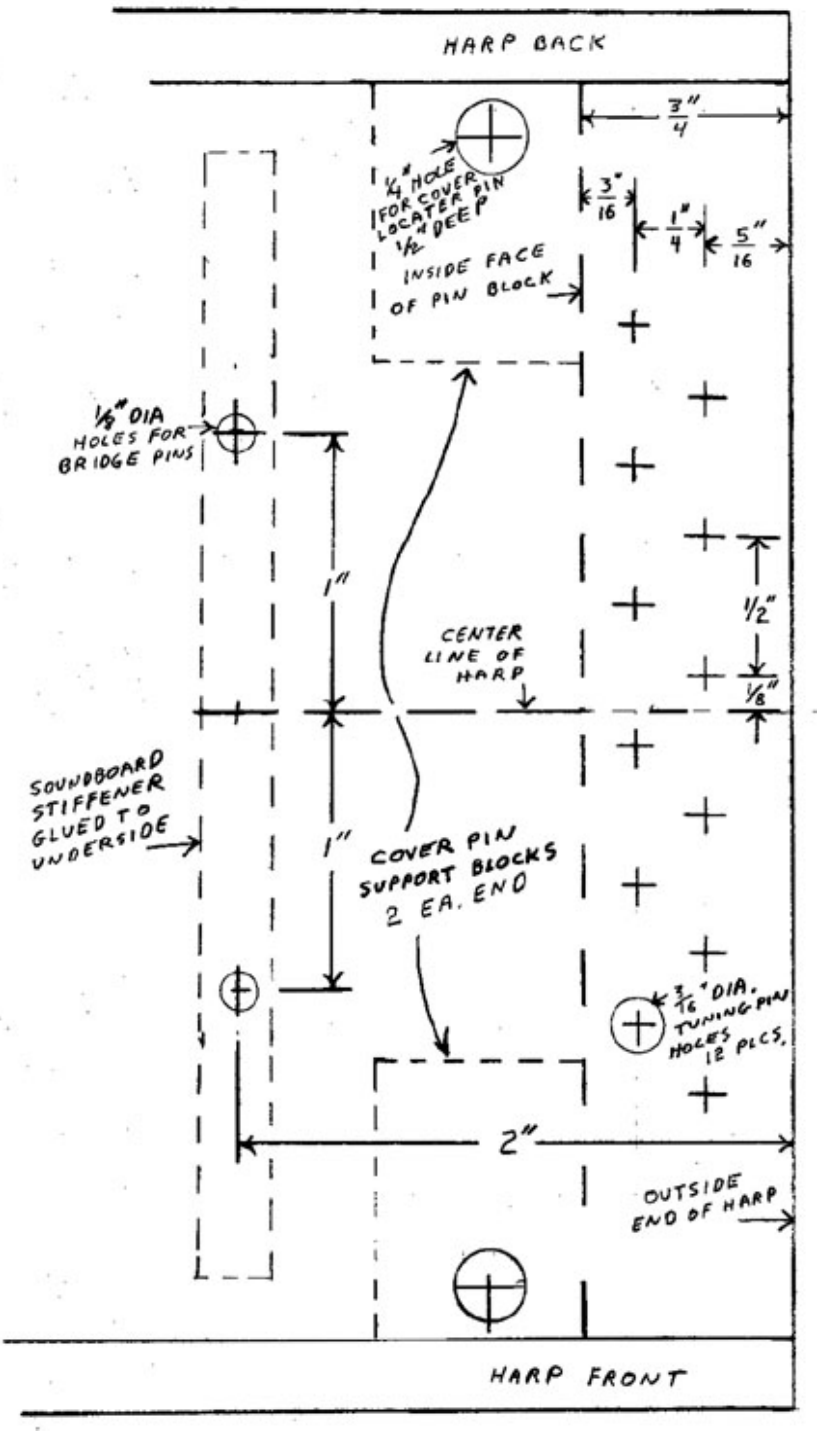
position it against the inside face of the block on the left. Make a pencil mark on the right end of the rail, at the inside face of the right hand support block. Cut off the excess, but be careful not to cut too much off. You want this rail to fit very closely between the two support blocks. Therefore, when I cut it, I cut on the waste side of the line, and then take a little bit off at a time on the disc sander until the rail will just fit between the support blocks. Before I apply any glue to this rail, I loosen the clamps that are holding the support blocks to the cover piece. Scoot the cover forward so that about ½" of the front of the cover is hanging off the front of the bench. Snug the clamps back up enough that the piece will not move. This is so that I can get some small clamps on there to hold the rail in place. Now you can apply a very thin bead of glue to the jointed edge of the rail, and clamp it in place. I use half a dozen 1" spring clamps, evenly spaced along its length to get the rail located, and then I follow this up with spring type clothespins all along its length. While the glue is drying on that, I start the same shaping process on the rail that will glue to the back of the cover. When you have the rail shaped, reverse the position of the cover on the workbench, and glue the back rail down just as you did the front one.

This is a photo of a finished cover assembly, turned upside down. If you look closely, you can see the two cover stiffeners, one on the front edge and one on the back edge. You can also see how their length allows for a tight fit against the support blocks.

Chapter 17
Laying Out the 32 Holes in the Soundboard

While the glue on the cover assembly is drying, we can start on all of the holes we have to drill in the soundboard. We will locate and drill the easiest four holes first. Measure in two inches from each end of the harp body, and using a square, mark a vertical line across the soundboard. Now place a scale along this line and find the center of the soundboard between the front and back, and make two marks, 2" apart, each one 1" from the center point. This is the same spacing that we used on the bottoms or bases of the string bridges. We will drill these four locations with an 1/8" brad point drill bit to accept the 1/8" dowels that will be in the bottoms of the bridges. Use an awl to dimple these locations, and then using a hand held electric drill, drill these holes perpendicular to the top surface of the soundboard. As you drill through, you should also be drilling through the small stiffeners that we previously glued to the back of the soundboard.

Examine the drawing below, and lay out the locations for the tuning pins. Here again, try to be as accurate as you can in laying out this hole pattern, and then use your awl to dimple each location so your 3/16" brad point drill will not wander off of location. This drawing also shows the locations for the bridge pin holes, which we just located. The cover support pin holes are also shown, but do not worry about laying out these holes, we will use the cover itself to locate these holes later.



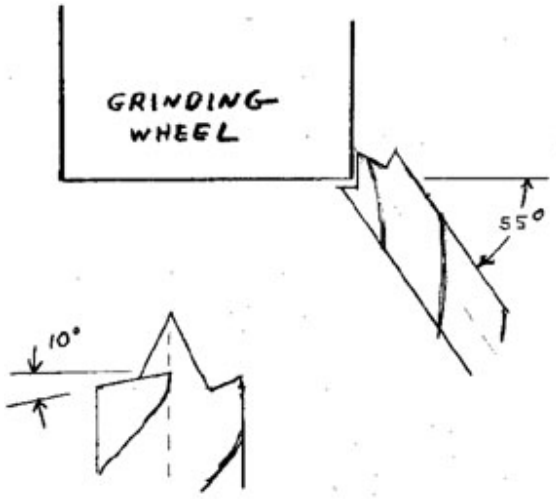
Before you dive into drilling these 24 tuning pin holes, (12 on each end of the harp) you should check the fit of the tuning pins in the holes. This hole diameter is critical. If the hole is drilled too big, the pins will fit loosely, and the string tension will tend to unscrew the pins, making it impossible to tune the harp.

If the hole diameter is too small, the pins will be difficult to install and turn. Also, if they are too tight, you may risk creating small splits in the soundboard from the holes that are closest to the end of the harp. This tendency for the soundboard to split at these location is also why we have “cheated” the hole pattern 1/16” off center, towards the inside of the harp.

Take a scrap of wood, the same wood you used for your pin blocks, and drill a test hole with your 3/16” brad point bit. Use one of your tuning pins, and see how easily it threads into the test piece. It should be tight, but not difficult to install. If you feel the fit is not quite right, try speeding up or slowing down the RPM of the drill bit. This will alter the finished diameter of a drilled hole. If the diameter of the drilled test holes continues to be too big at any speed, then the brad point of the bit is off center, and you will need to adjust the drill bit itself.

In addition to my 45+ years of woodworking experience, I also have over 25 years of machine shop experience in the machine tooling trade, so when I need a brad point bit of a particular size, I just grind my own. And it is not difficult at all.

The following drawing shows how I grind my own brad point bits on a standard bench or pedestal grinder. Dress the face of the grinding wheel to get a crisp, sharp corner. Try to get the brad point on center, test the drilled size frequently, and keep adjusting the grind until you get the fit you need. Remember the clearance angle ground on the bit behind the cutting edge. The angle values represented here are not critical, “eyeballing” it will get you close enough with a little practice.



Once you are satisfied with the fit of the pin in your test block, you are now ready to go ahead and drill the 24 holes for the tuning pins. Drill these holes about 1 & ¼” deep, and perpendicular to the bottom of the harp. Because the

soundboard is on that 9-degree angle, I use a bit of masking tape wrapped around the drill bit for my depth indicator.

By now, the glue on your cover assembly will be dry, so you can take it out of the clamps and use it to mark the locations of the cover locating pin holes. Insert your transfer screws or dowel centers into the four holes in the feet of the cover assembly, and set it in place on top of the harp body. Center it from front to back, and use a scale to center it from side to side. The distance from the outside edge of the cover support to the outside edge of the harp should be ¾". A slight variation here is not critical, just make sure that the cover is centered, and then push down on the cover enough to drive the points into the soundboard well enough to mark the locations. Drill these four locations with a ¼" brad point bit, and drill each one ½" deep. Here I do use the depth stop on my drill press, drilling the 2 holes at the back of the harp first, and then re-setting the depth stop to drill the 2 holes at the front of the harp. You should feel the drill bit break through the bottom of the soundboard, and then enter the end grain of the cover support blocks that we glued into each corner on the inside of the harp body.

Chapter 18
Re-drilling the Holes In the Feet of the Cover Assy.

At this point, you can remove the centers from the four holes in the feet of the cover assy. and drill these holes out. I use a single fluted countersink tool to chamfer the edges of these holes first, and then I use a standard 9/32" twist drill and drill these holes each ¾" deep

Chapter 19
Finish Sanding the Harp Body and Cover Assy.

Finish sanding the harp body and the cover piece so that all of the edges and glue joints blend smoothly. Lightly break any sharp edges or corners, and remove any pencil marks that may still be visible. Go over both assemblies with 150, 180 and 220 grit sandpaper. Now it is time to take these into the finishing room and start applying your finish coats.

Chapter 20
Apply the Finishing Coats

Here is a handy hint. I cut four pieces of 2X6 lumber, each piece about four inches long. Into the face of each of these, I drilled two 3/16" diameter holes about one inch deep, and these holes are spaced at 4 & 1/8" apart. Into these holes go pieces of that left over 1/8" dowel. One piece of dowel is 2" long, and the other is 2 & ¾" long. When I am applying the poly to my harp, I coat the soundboard first, and then set it upside down on these dowels. The dowels go into the holes I drilled for the cover locating pins, and because the 1/8" dowels in the back are shorter than the dowels in the front, they suspend the harp above the 2X6 blocks, and hold it relatively level. Now I can finish coating the sides, ends and bottom of the harp. I treat the cover assy. the same way, first coating the underside and end blocks, and then positioning it on more 1/8" dowels to coat the rest of the assy.

As mentioned earlier, I like to use a wipe-on polyurethane to finish my harps, and I rarely ever use any stain. Use a tack rag to remove any residual dust on the assemblies and apply the first coat. This first coat will soak right into the wood quickly, and dry within an hour or two. I will apply a second coat and then a third, allowing 3 to 4 hours of dry time between each coat. After the third coat, I will take the harp assemblies out to the shop and buff all surfaces down with extra fine #0000 steel wool. Remove all of the steel wool from the surfaces, and use compressed air to blow any steel wool residue out of the holes in the soundboard. Back to the finishing room, and go over everything with the tack rag again. When you apply the next coat of poly, you will notice how much smoother and easier it applies. Let that coat dry, and apply another. Now it is

back to the shop to go over everything with the same steel wool again, blow everything off, tack rag, and more clear coats. This process is repeated again and again until the finish looks satisfactory to me. How many coats depends a lot on the species of wood I am working with. Tightly grained woods like Maple will finish up with less coats than an open grained wood like Walnut. Just continue this process until the finish on your harp meets your satisfaction. On some harps, I will build up six or eight coats of poly, and then lightly go over all the surfaces with my palm sander and 320 grit sandpaper. This flattens the finish nicely, but then the harp will require 2 to 4 more coats of poly to bring back the gloss.

The wipe-on poly will run if you apply it too heavily, especially on vertical surfaces. Sometimes it will seem to form thick ridges at the bottom of vertical surfaces. If this does happen, let the poly dry thoroughly, and then go over these areas with 300 or 400 grit sandpaper on a flat sanding block to remove the excess buildup. Then 2 or 4 more light coats of poly will finish the project nicely.

While you are finishing the harp assemblies, treat the bridges and cover locating pins the same way. A couple light coats of clear poly, steel wool buffing, and then more coats of clear. When the finish on the harp assemblies, bridges and pins is satisfactory to you, pat yourself on the back and breathe a sigh of relief. All that is left now is the final assembly, stringing and tuning.

Chapter 21
Final Assembly of Your Harp

The final assembly is fairly easy, and will not take long at all. First, take the four cover locating pins. Use a pocketknife to whittle down the bottom 3/8" of these pins so that they will start into their receiving holes easily. Get a small block of soft wood, like Pine, and put a small dimple on one surface of this block. I use a 3/16 standard twist drill bit, and drill just past the point grind of the bit. This makes a little "pocket" that the bullet end of the cover locating pins can nest in. Apply one drop of glue into the hole, insert the bottom end of the cover locating pin, and then put the dimple in the soft wood block on top of the pin. Gently drive the pin home with a hammer. If you listen to the sound, you can hear when the bottom of the pin hits the bottom of the hole we drilled. We made those pins one inch long, and drilled their corresponding holes ½" deep, so there should be ½" of pin protruding above the soundboard. We drilled the holes in the cover assembly ¾" deep, so if there is a little variation here, it should not

affect the cover's ability to sit down on the surface of the soundboard. When you have all four pins installed, you can experience your first "moment of truth". This will tell you how carefully you located and drilled these holes. Test the fit of the cover on these four pins. It should just snug down in place with very little slop or wiggle. If there is just a little slack, and the cover moves back and forth just a little bit, that is a good thing. Remember that wood moves slightly with changes in humidity, and this little bit of slack gives the relationship between the pins and the holes they fit into a little bit of flexibility. If the cover will not go down on the pins, or goes down very tightly, do not worry, we can fix that. See if you can determine which pins are hanging up, or fitting tightly. It might be a tightness front to back, or a tightness from side to side. When you have determined which pins are fitting tightly, take the cover assembly back out to the drill press, and open up the corresponding holes to the next drill size. Re-try the fit, and see if the cover will go down easily without any interference. If you are still getting a tight fit, repeat the process, stepping up one drill bit size at a time, until you achieve a comfortable fit.

Now we must install the string bridges. If you have not already done so, cut four lengths of that 1/8" dowel, each about ½" long. Put a light chamfer on each end of each of the four dowels. Try the fit of these dowels in the 1/8" holes we drilled into the base of the bridges. If the fit is loose, you might want to glue them in place in the bridges. If they are snug, just drive them in until they bottom out in the holes, and call that good enough.

After 6, 12 or 20 coats of clear poly on the harp body, rest assured that those 1/8" diameter holes we drilled in the soundboard to accept the bridges will have closed up. No worries, I just use my hand held drill and open them up again with a 1/8" drill bit. Now test the fit of each bridge. This is your second moment of truth. How much you have to open up these holes in the soundboard is a direct indicator of how carefully you laid out the hole patterns in both the bridges and in the soundboard. I use my numbered drill bit set to drill out, or bigger, the appropriate holes, one at a time, until the bridges will just push down in place on the soundboard. These bridges should never move, and there should never be any reason to move them. The 1/8" dowels that pin them into place just ensure that they never will move. Now you are ready to move on to stringing and tuning this harp.

Chapter 22
Stringing Your Harp

I would imagine that at least once or twice by now you have wondered about that hole pattern you drilled in your harp. You drilled twelve holes in each end of the harp. Twelve holes, twelve pins, twelve strings. Right? But all along, I have been referring to the 16 strings on this harp. There are also 16 string notches in your string bridges. So how are we going to string 16 strings with only 12 pins? Well, this is what you spent your money on. Now you are going to learn how to string 16 strings with only 12 pins on each end of the harp. This is a stringing method I developed myself, especially for these harps. It probably would not work on any other kind of instrument except my door harps. I do string them using the same method, and all of my Aeolian harps are strung in this manner.

At the beginning of this book, I discussed the technical definition of an Aeolian harp. That all of the strings, however many there are, are all the same length, different diameters, and tuned in unison. We are going to use 8 different diameters on this harp, so there will be 2 strings of each size. They will be strung in pairs, with 2 strings of each size running side by side across the harp. I start with one end of a long string wrapped around the tuning pin in the upper right corner of the harp. That string then runs across the length of the harp, in the first string notch from the back, and through the first tuning pin on the left end of the harp (this tuning pin has now become a “bridge” pin), and then back across the harp to the second tuning pin on the right end of the harp. I have installed 2 strings on the harp, and I have used only 3 of my tuning pins.

Think of the math. 3 tuning pins for 2 strings. 24 total tuning pins, divided by 3 equals 8. I mount 2 strings for each 3 tuning pins, and I have 8 groups of 3, so 8 X 2 = 16. Simple! Right? Trust me, it works.

The string schedule table listed below is the one I use with satisfactory results. This string schedule is not etched in stone. Feel free to experiment with different variations of this pattern, and different diameters of the strings you use. If you cannot obtain monofilament nylon of a specific diameter in your locality, go ahead and use a different diameter that is close to the one specified. Just be sure that you are using round, monofilament nylon. Slight variations in the string diameters from this list will not affect your harps ability to sing, though it will affect the apparent voices you will hear when it does sing. A local sporting goods store should be able to supply you with the strings you need. Look for a store that does custom winding on fishing reels. They usually have a great variety of line diameters, and should be willing to sell you just the lengths of each size you need for a nominal charge by the foot.

The diameters you need to obtain are:

.044”
.035”
.028”
.024”
.018”
.026”
.030”
.039”

One word of caution here. When you purchase your strings, make sure that the largest diameter string will pass through the small hole drilled in your tuning pins. I have seen minor variations in these hole sizes from one manufacturer to the other. It is not an easy task to drill these holes out to a larger diameter when your larger strings will not pass through the holes. It is possible, but not easy.

You will need a length of each string that is twice the length of the harp you are building, plus 4 inches. In our example, we are building a harp that is 32” long, so we will need strings that are 68” long, minimum. Chances are good that you are going to break a string or two learning how to do this, so you might want to buy extra string of each size to begin with.

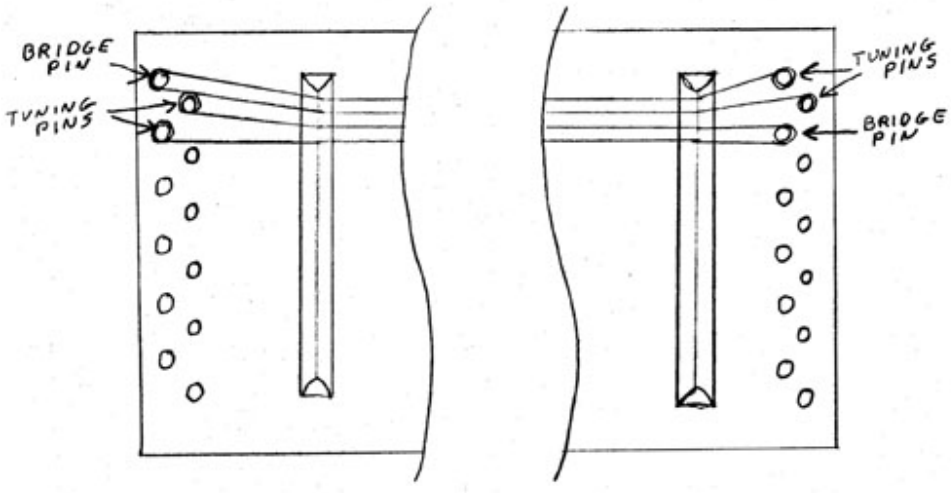
Begin by installing all 24 tuning/bridge pins in the 12 holes on each end of the harp. Turn each pin 3 or 4 full turns down into the holes, leaving most of the tuning pin protruding from the soundboard for now.

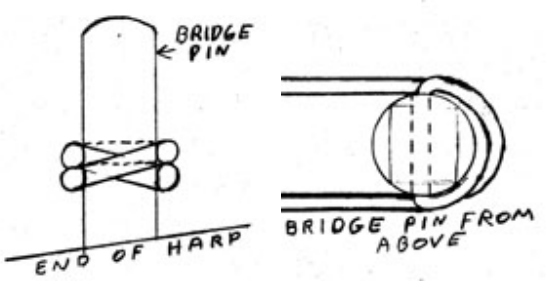
I start with the largest string, .044”. Lay the coil of string at the right end of the harp with one end of the string in your left hand. Pull that end across the length of the harp until the end is about 2 inches beyond the tuning pins on the left end of the harp. Now pinch the string in your right fingers at the tuning pins at the right end of the harp, and fold it back on itself, creating a bend in the string. This bend is the center point of this pair of strings. Holding the bend in your left hand, pull the string back along the rest of the string, and cut off the excess at the same length. Now you have one string that has a bend in the middle, and each half of this string is about 2” longer than the length of your harp.

This pair of strings will wind around and be tuned with the 2 tuning pins that are closest to the back of the harp on the right end. The tuning pin closest to the back of the harp on the left end of the harp is going to become the bridge pin for this pair of strings. Use your tuning key or wrench, and run this bridge pin all the way down to the top of the threaded portion of the pin. Stop turning when the little hole in the pin is aligned with the lengthwise axis of this harp. This makes it easier to insert one end of the string through the hole, and pull it through to the center point, or the bend that you put in the middle of its length.

Now use your tuning key, and rotate the bridge pin one-quarter turn, so that the string hole in the pin is now perpendicular to the lengthwise axis of the harp. Take the half of the string that is coming out of the hole towards you, and wrap it around the outside of the pin, towards the left end of the harp. Pass it underneath itself on the other side of the pin, and pull it across to the first tuning pin. Poke the end of the string through the first tuning pin far enough that you have about ¼" sticking through the pin. Now, using your fingers, wrap the string around the tuning pin in a counter-clockwise direction. Remember that these pins are turned clockwise to screw them into their holes, and you will be turning them clockwise to tighten the strings, so as you are looking at the pin, the string should come off of it on the far side, or the side of the pin that is closest to the back of the harp. You should be able to wrap the string one or two full turns around the pin before you start to run out of slack. Keep light tension on the string with one hand, and put your tuning key on the pin and turn it enough to pull the rest of the slack out of the string. Do not try to make the string tight at this point, you only want to turn the tuning pin enough to hold the string in place, and make sure that the string rests in the first notch in each bridge. If you turn it too tightly, you will begin to pull the other half of the string through the bridge pin, loosing your middle of the string location.

Now take the other half of the string and install it the same way into the second tuning pin from the back of the harp. As you begin to pull it snug with your tuning key, make sure that the string crosses over itself at the outside of the bridge pin, so that it is located underneath where the first half of the string exits the bridge pin. Once you have both ends of this first pair of strings secured, you can go ahead and tighten them just enough to ensure that they will stay in place while you install the rest of the strings. The drawings below will clarify this procedure.



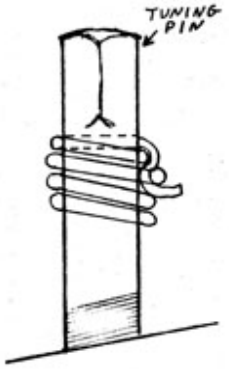


Follow the same procedure for the next pair of strings, but this time the tuning pins will be on the left end of the harp, and the bridge pin will be on the right end of the harp. Each pair of strings is installed the same way, but each pair alternates from end to end, so you are generating what I call an “Alternating “V” pattern” Each pair of strings forms a V, but each time the point of the V alternates from one end of the harp to the other.

Below I have included an extremely close-up photo of one bridge pin with a couple of the tuning pins to the right of it. In this photo you can see how I have wrapped the string around the bridge pin in such a way that it cannot ride up on the pin. Each half of the string is trapped underneath the section of string that goes through the hole in the bridge pin.

The very small diameter strings located in the center of the soundboard will pull through the tuning pins more easily than the larger diameter strings will. This can be a great source of frustration when you are trying to tune the harp,

and the string keeps coming loose from the tuning pin. I have learned to cut the smaller diameter strings a little bit longer than I cut the large diameter strings. This gives me more slack to work with, and having more winds of string around the tuning pin helps keep it in place by the increased friction. Sometimes it is necessary to trap the loose end of the string under one of the string wraps to hold it in place as in the drawing below.



Do not worry about having an unsightly loose end of string protruding from the tuning pin at this point. There will be many opportunities to trim this off later. As a matter of fact, before you are through tuning your harp, you will probably have to cut an inch or so off of each string, and then re-wrap them around the tuning pin.

Chapter 23
Tuning Your Harp

When these nylon strings are tuned tightly enough to sing, they are stretched almost to the breaking point. This high degree of tension stretches the nylon. Fortunately for us, the nylon will reach a point of equilibrium, where it has stretched as much as it is going to without breaking. At this point, the string will hold its tune very well. However, you cannot exert that much tension on the string all at once, or it will break. You have to bring these new strings up to full tension gradually, over several days. When you have installed all of the strings on your harp, go over each tuning pin and tighten each string to a point where it

will sound with a clear tone when plucked. Be careful not to accidentally try to turn a bridge pin. Tune each string this way, and then set the harp aside for a day. On the following day, strum across the strings, and you will hear how the tuning has changed with the stretching of the strings. Larger diameter strings will stretch at a different rate than narrower strings. The length of the strings will also effect how much the strings will stretch. There are many variables here to consider, so it is hard to say just how long this tuning process will take for your harp. I will typically tune a new harp once a day, every day, for a week or two. Gradually, the difference in the stretch from string to string gets less and less, and the strings get closer and closer to holding their tune for longer periods. During this process, you will be putting more and more wraps of string around each tuning pin. Between putting more and more wraps around each pin, and the pin being screwed deeper and deeper into the end blocks, you are going to reach a point when the string wraps are touching, or crowding the soundboard. At this point, you have to get rid of some of that excess string.

Remember that these strings are in pairs, and if you have extremely uneven tension on one half of the pair, the string could slip through the bridge pin. When you need to loosen a string to cut off the excess, you have to back the tension off of both halves of the pair. Back each tuning pin off one-half turn at first, and then back off each tuning pin one whole turn. These nylon strings are not like a rubber band. They will not snap back to their original condition when you loosen them to adjust the wrap. You will have to unscrew the tuning pin that has too many wraps of string around it, pull more of the string through the hole in the pin, and then re-wrap the string just as you did when you first installed it. The larger diameter strings on a 36” harp will stretch at least an inch for each half of the string over the course of this tuning procedure. The smaller diameter strings often do not pose this problem because the length of the tuning pin can accommodate many more wraps of small diameter string than the larger diameter strings.

As these strings reach equilibrium, you will find that your harp needs tuning less and less often. Our favorite old harp, built in the spring of 1994 (over 13 years ago), is tuned each spring but rarely needs it. The strings have stabilized so well that they will hold their tune over the winter when it is too cold to have any windows open. I have had to replace 2 strings on this harp in the 13 years that we have been enjoying its song.

When your strings seem to be reaching that point of equilibrium, they will need adjustment less and less each day. This is the time to start bringing the string tension up to its final target. I wish it were as easy as just telling you to “tune the harp to Middle “C””. It would be nice if life were that simple. These harps work on the principal of “sympathetic harmonics”, which is why all of the strings must be tuned to the same note. If you had the opportunity to walk up to a big concert pedal harp and pluck one of the A strings, you would be able to visually observe that each A string on the whole harp would begin to vibrate in

sympathy to the one you plucked. Assuming the harp was in perfect tune, you would be able to observe the same effect for each string on the scale. This is a demonstration of “sympathetic harmonics”. With an Aeolian harp, not only must each string be able to vibrate in sympathy with all of the other strings, but the harmonics must also be in sympathy with the harmonics of the soundbox you have built. Just as Mother Nature never grows two trees exactly alike, no two pieces of wood are ever going to have exactly the same harmonic properties. I have been able to generate rough target points for you to start at, but I encourage you to experiment with the tuning of you harp. Yes, your harp will begin to sing in the proper wind conditions if you are even close to the ideal tuning. But the closer you are to that perfect sympathy of harmonics between the harp strings and the harp soundbox, the more magical the sound of your harp will be.

Generally speaking, a harp in the 2 foot length range will need to be tuned to a note somewhere just above Middle “C” on a piano scale. Harps around 30” long will sing when tuned close to Middle “C”, and harps closer to 36” will be tuned below Middle “C”. Our old Walnut harp, 36” long, does quite well tuned to F below Middle “C”.

Chapter 24
Placement of your Harp

When you feel your harp is tuned and ready for a test, it is time to put it in your window and hope for some wind. Raise the window about 6” and set the harp into the window. Our windows have bug screens on the outside of the window frame, so I gently push the harp back until the back of the harp is up against the screen. Now bring the window down on top of the cover piece and gently pull the window down so that it is snug against the top of the harp. There are two very good reasons for trapping the harp tightly in the window this way. The first reason is that a strong gust of wind could possibly dislodge the harp from its placement and send it crashing to the floor. This is **not** a good thing. The second reason is that with firm contact between the harp and the window frame, some of the sounds produced by the harp will be transferred into the window frame and the wall, essentially turning the wall and the window into a large sounding board and increasing the volume of the harp.

Ultraviolet light is also a concern. Even though the clear polyurethane I like to use contains UV inhibitors, many years of exposure to strong sunlight will eventually degrade the finish as well as the integrity of the hardwoods you have used to build your harp. If you can, choose a window on a side of your home

that is protected from direct sunlight for placement of your harp. Reducing the amount of time your harp is exposed to direct sunlight will extend the lifetime of your instrument.

Photo of harp in window.

Now that your harp is in position, you may need to generate a cross draft. Open a window or two on the opposite side of your home to encourage the available breezes to blow through your home. It will not matter if the wind is blowing in, across your harp strings, or out. These harps do not seem to be too fussy about wind direction. One thing they are fussy about is having a smooth, laminar airflow. The wind coming out of a fan is very turbulent, and prevents or interferes with the Aeolian effect discussed in chapter 11. I have had satisfactory results in generating wind on an otherwise calm day by placing a window fan in a window on the other side of my home, away from the window that my harp is in. If the window fan (sometimes called a box fan) is blowing out of the secondary window, it is pulling a smooth laminar flow of air in through the window that the harp is in. If the fan is blowing into the house, it is forcing an exhaust of air through the window that the harp is in, and by the time this air travels through the house, it has lost its turbulence and has become a smooth airflow once again. I have seen demonstrations by other harp makers where they have successfully used fans and shrouds to force their harps to sing, but the sound produced by the harp is unnatural and not necessarily pleasing at all. When I was first researching these harps almost 20 years ago, I built a wind tunnel in my shop to test different string materials. I had very little success until it dawned on me to reverse the airflow by turning the fan around so that it was pulling smooth air into the tunnel and across the strings, rather than blowing turbulent air across the strings.

Once your harp is fully tuned, you may find that you do not necessarily need to worry about that cross draft. Once again, using our old 36” Walnut harp as an example, there are days when it will sing, and there seems to be no wind outside at all. I can place this harp in its window, and it will play with no other windows or doors open. I suspect that the slow air movement created by natural convection currents in our home is sufficient to set the strings vibrating.

It may be necessary to try different locations or windows in your home to find out where the harp will sing best for you. I encourage you to try different

locations for your harp, and with each test location, vary the other windows or doors you open to create the cross draft. There is a lot of hit-and-miss, trial and error here in finding the ideal location for your harp and where it will sing best for you. It has happened on very rare occasions that a harp will sing very well in one location, and yet never utter a sound in another. I cannot explain this, and will not even attempt to. I just do not know. I do know that Athanasius Kircher experienced this same phenomena during his research into these harps in the 1600's. This problem seemed to perplex him to distraction, and after much research into trying to explain it, he finally gave up, and resorted to his Jesuit teachings to state, "The harp will not sing for a man who is not true of heart."

Kircher originally designed this type of harp to take full advantage of this new invention that was becoming so popular all across Europe, the "sash window". By placing the harp in a sash window, and closing the window down on top of the harp, one could force all of the available breezes across the harp strings. The reason for the slanted soundboard was that Kircher thought he could direct more of the sounds created into the living area by tilting the soundboard inward. But these harps do not necessarily have to be installed in a window to sing well. I have one customer who lives on a hill above San Francisco Bay. He commissioned a 36" harp for placement on top of the wall that surrounds his garden overlooking the bay. He reports that the breezes coming up the hill from the bay are more than sufficient to make his harp sound beautifully. Many times, I have had one or more of my harps out in an open field, and have been able to demonstrate and enjoy their beautiful song by just orienting them across the breezes blowing through the field.

Chapter 25
Horizontal Slider Windows

I mentioned in the previous chapter that these harps do not care if the wind is blowing in or out across the strings. They also do not seem to be effected by their orientation in a window. Stand one up on end in a window that slides open on the horizontal, and it will sing just as well. You would still be wise to slide the window closed, up against the harp to help hold it in place, and force the breezes across the strings. There is another alternative to the construction of your harp that you may want to consider. If your home is equipped with these horizontally sliding windows, you have an advantage. Generally speaking, most of these sliding windows are taller than the average sash window is wide. So by standing the harp up on end, you can generally

allow for a longer harp than one made to lie down horizontally in a sash window. This is good because as I have mentioned before, longer harps will sing more often in light breezes than a shorter harp will. The only problem that arises with this scenario is that the harp, standing on its narrow end, is less stable in it's mounting than one lying down horizontally. It would be easier for a strong gust of wind to dislodge the harp. However, there is an easy fix. If you do have this type of window, and anticipate that most of the time your harp will be located in one of these sliders, you have the option of attaching feet to the bottom of your harp. Make four small blocks of hardwood that will compliment your harp, and attach one to each corner of your harp where they can be screwed into the end blocks from below. Make these four feet to a size that will enable two of them (either the front two or the back two) to fit into the channel of the window frame. Then, when you slide the window up against the harp, the "feet" will be locked into the window frame channel and this will prevent the harp from being blown out of the window by sudden, radical gusts of wind. With just a little bit of imagination and ingenuity, you could also size and locate these four feet so that they will not interfere with the placement of the harp in a standard sash window. This way you could put the harp in one window on one occasion, and in another window at some other time.

Have fun building your harp, be careful with your power tools, and good luck.

Sources of Hardware

The tuning/bridge pins and the wrench to install and tune them are the only components that you may have trouble finding locally. I have listed a couple of sources below where you can purchase these items either on line, or by mail order.

Musicmakers Kits Inc.
14525 N. 61st Street Ct.
P.O. Box 2117
Stillwater, MN 55082
www.harpkit.com

International Piano Supply
88 NewOctave Loop
P.O. Box 1005
Astoria, Oregon 97103-1005
www.pianosupply.com