FOLK HARP DESIGN AND CONSTRUCTION

by
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Fourth Printing, March 2008

CHAPTER 5 - SEQUENCE OF ASSEMBLY

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CHAPTER 6 - STRINGS

STRINGS

CARE AND FEEDING OF THE HARP

Glues

Aliphatic resins are the most common woodworking glues available (such as Elmer's or Titebond). They work very well for most joints on a harp. If you live in a hot humid climate (Hawaii, for example), it might be advisable to use a more water-resistant adhesive. I remember a powdered glue called Weldwood that my Dad used for canoe-making. It would be excellent for resisting humidity and heat. High-grade 8-hour epoxies could also be well utilized.

Established luthiers use hide glue very successfully for guitars, violins, and such, but they never purchase the liquid version sold in bottles. Hide glue must be purchased as fresh granules (shelf life is a year or less) that must be cooked to the proper consistency just before use, discarding the leftovers. It is not easy, and it is no better than Elmer's, in my opinion, unless you really know what you are doing.

I've not used Gorilla Glue, nor any of the other more recent innovations on the market, so I cannot give advice except to read the instructions carefully and make sure the adhesive you choose is meant for woodworking.

Golden Rules

I've capsulized what I believe to be the most important guidelines in harp-making into my "Twelve Golden Rules", shown on the Chapter One divider.

You'll find further explanation/justification for these principles in the first three chapters of the manual. I believe that if you follow these rules, you will end up with a useful harp. If you disregard them, you may experience breakage, warping, cracking, creeping joints, and/or negative feedback from experienced harp players who try your finished instrument.

As I mentioned in the Forewarning, however, you should take these "rules" with a grain of salt. Some people will successfully break some of them with new techniques that I don't know about.

Tuning Pins

This is a good time to determine what type of tuning pins you plan to use on your harp, if you have not already decided. Here are some options:

ZITHER PINS, often called “standard” tuning pins, or “harpsichord” pins, are short enough that they usually do not pass through the entire thickness of the harp neck. They are easy to install and use because they require only a straight hole in the wood, no taper. Typically, a sharp (new) 3/16” twist drill bit will give you a perfect fit for these pins. Don’t use a brad-point bit of that size -- it will bore a cleaner (thus larger) hole.

Notice that the zither pin has a fine thread, so it will automatically drive itself deeper into the wood as you turn it clockwise to tighten the string. You’ll need to drill the hole deep enough so the pin will never reach the bottom of the hole (about 1-1/4” deep).

Be sure to test the fit of your pins in scrap wood first. You should have to pound them into the wood with a hammer, and then turn them with a tuning key to install the strings and tune them to pitch. Generally speaking, they give excellent service for the life of any small harp with low or medium string tension, but they are not considered durable enough to handle high tension harps or heavy wound strings.

The advantage of zither pins is the low price and simplicity of fitting. If they become loose in the wood, however, it will be necessary to either replace them with oversized pins or add some sort of shims inside the holes to firm them up.

TAPERED THROUGH-PINS are long enough to pass through the neck of the harp so that you attach the string to one end and use your tuning key at the other end, on the opposite side of the harp neck. These are available in different size tapers, usually #4 or #5 Morse tapers, and they require a tapered hole to match the pins. That means you will need to acquire a reamer to taper the holes in the neck to fit the pins.

The main advantage of tapered pins is the ability to push them deeper into the wood to tighten them, as needed. You should be able to keep these pins as tight in the harp neck as you like, but beware that they will loosen of their own accord over time, due to humidity changes and normal use, so you must occasionally push them back in to keep them tight.

THREADED THROUGH PINS are the latest concept, developed by the folks at Dusty Strings in Seattle. These pins combine the best features of zither pins (easy installation and trouble-free use) with the best features of tapered pins (through-the-neck support and greater strength).

No need for a tapered reamer with these pins, but you must find exactly the right size drill bit for the type of wood you are using for the neck. We drill with a letter “D” drill for harp necks made of cherry, walnut and maple. Then we turn the pins slowly with a drill as we press them in to the desired depth.

Golden Rule #3

DON'T LET THE STRINGS EXCEED 70 PERCENT OF BREAKING POINT TENSION

MONOFILAMENT WINDOW FOR NYLON, GUT & STEEL
(length in inches)

Note	Max length (70%)	Min length (30%)	
C7	4.2"	2.8"	
B6	4.5	2.9	
A6	5.0	3.3	
G6	5.6	3.7	
F6	6.3	4.1	
E6	6.7	4.4	
D6	7.5	4.9	
C6	8.4	5.5	
B5	8.9	5.8	
A5	10.0	6.6	
G5	11.2	7.4	
F5	12.6	8.3	
E5	13.4	8.7	
D5	15.0	9.8	
C5	16.8	10.5	
B4	17.8	11.0	
A4	20.0	11.5	
G4	22.5	13.0	
F4	25.2	14.0	
E4	26.7	15.0	
D4	30.0	17.0	
Middle C4	33.7	19.0	these numbers are below 30 percent
B3	35.7	20.0	
A3	40.0	22.5	
G3	44.9	24.0	
F3	50.5	26.0	
E3	53.5	28.0	
D3	60.0	30.0	
C3	67.4	32.0	
B2	71.4	34.0	
A2	80.1	36.0	
G2	89.9	39.0	
F2	100.9	42.0	
E2	106.9	44.0	
D2	120.0	47.0	
C2	134.7	51.0	

In lieu of purchasing the computer program for string analysis, you can either "borrow" the measurements from a successful harp that you like, or make use of this chart showing the "Monofilament Window" of acceptable string lengths for each pitch, from C2 (two octaves below Middle C) at the bottom to C7 three octaves above Middle C) at the top. I have not proceeded beyond that 36-string range, but you could fairly easily extend the chart by simple logic if you desire to make a harp with a wider range.

Notice that the highest strings have a narrower window of acceptable lengths than the lowest strings. This is quite important. If you are not careful at the top of the range, you will end up with strings that break because they are just an inch too long, or sound dead because they are an inch too short for the assigned pitch.

You have more flexibility in drawing your harmonic curve as you come down the scale. You can, for example, have a successful monofilament string tuned to middle C that is 33" long, or one that is only 19" in vibrating length.

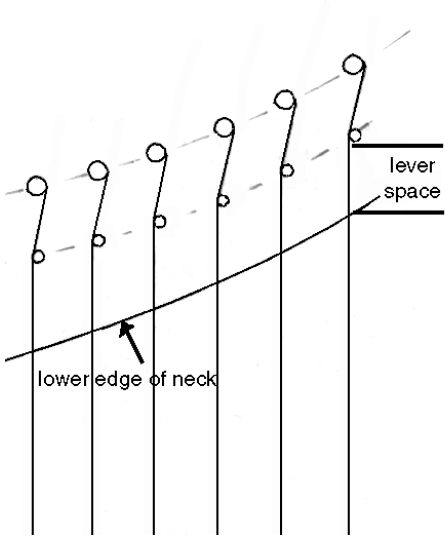
Notice, however, that the maximum lengths become ridiculously long toward the bottom of the musical scale. You will obviously not build a harp with strings having a 10 foot vibrating length! What most builders do is hug the maximum line in the upper range and shift closer to the minimum line at the bottom of the harp.

Note to the Math Guys: If you do the calculations yourself, you will find that my minimum string lengths for the notes below Middle C are considerably less than the 30 percent calculations. I have done this to give a more realistic picture of common string lengths in that range. Most builders do not use monofilament strings below C3 anyway, so there is no point in adhering to the 30 percent rule in the bass range.

Golden Rule #5

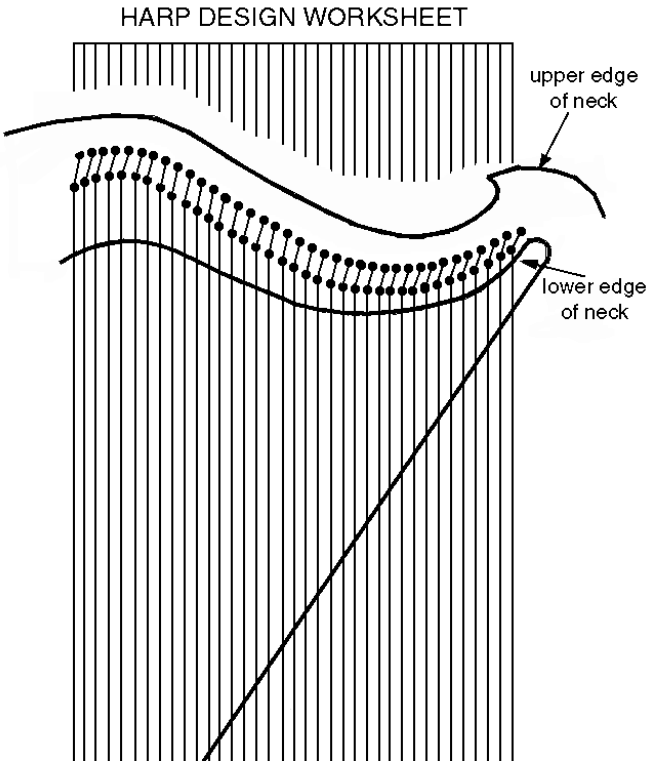
LEAVE ROOM FOR SHARPING LEVERS

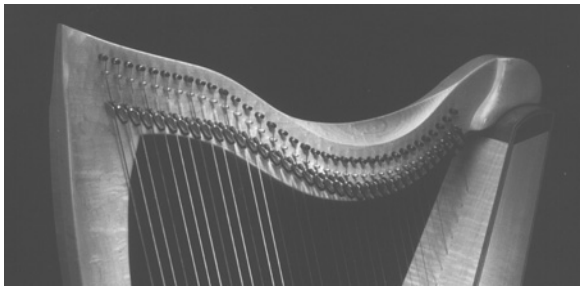
Sharping levers are an important accessory to any harp, making it quick and easy to change keys. Be sure to leave room for sharping levers below the guide pins. Sharping levers will be mounted so they can shorten the vibrating length of each string by about 7 percent. You need to leave enough room for mounting these brackets below the guide pins. You will need to have solid flat wood available for mounting the lever brackets, so we usually caution builders against rounding over the lower edge of the neck on the side where the strings will be attached. Here are some minimum measurements at each C string to help you draw that lower edge of the neck:



C7 = 3/4”	Middle C4 = 2"
C6 = 1"	C3 = 2-3/4"
C5 = 1-1/4"	C2 = 3-1/4"

The upper edge of the neck can be pretty much any shape you like. This is often where a builder will add some decorative design element such as a cap, finial, or crest. I often suggest that people look at the neck shapes used by Dusty Strings (below), because they incorporate a sort of "bridge" across the deepest valley of the harmonic curve. This excess wood serves as both a nice design element as well as a method of reinforcing the neck where it needs it most, by simply enlarging the profile.





METRIC CONVERSION CHART

If you need to convert the calculations in this manual to metric measurements, use this chart for rough calculations only. For better accuracy, find a metric conversion chart on the Internet.

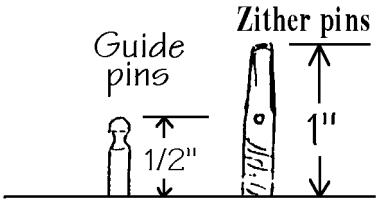
If you know:	Multiply by approx:	To calculate:
inches	25	millimeters
inches	2.5	centimeters
feet	30	centimeters
yards	0.9	meters
miles	1.6	kilometers
centimeters	0.4	inches
millimeters	0.04	inches
meters	1.1	yards
kilometers	0.6	miles
ounces	28	grams
pounds	0.45	kilograms
short tons	0.9	metric tons
grams	0.035	ounces
kilograms	2.2	pounds
metric tons	1.1	short tons
fluid ounces	30	milliliters
pints (US)	0.47	liters
pints (Imperial)	.568	liters
quarts (US)	0.95	liters
quarts (Imperial)	1.137	liters
gallons (US)	3.8	liters
gallons (Imperial)	4.546	liters
mililiters	0.034	fluid ounces
liters	2.1	pints (US)
liters	1.76	pints (Imperial)
liters	1.06	quarts (US)
liters	0.88	quarts (Imperial)
liters	0.26	gallons (US)
liters	0.22	gallons (Imperial)

Installing Hardware

If you are using brass **eyelets** in the soundboard, push them into the holes from the front side. Builders do not usually place eyelets inside the the soundchamber.

Install all the **guide pins** into the lower row of holes drilled in the neck while the neck/pillar is still disconnected from the body. Be careful to put some cloth padding under it (such as a towel) so you don't scratch or dent the back side as you pound the hardware in. Pound these pins in with a hammer, holding a scrap of 1/2" thick wood next to them as you pound, so they all stand at the same height. If you have **threaded guide pins**, you can start them with a hammer and then switch to the proper driver to turn them the rest of the way down to the proper depth.

If you are using standard tuning pins (**zither pins**), you can install those next, using either a hammer or an arbor press. Notice that these pins are lightly threaded, so they can be screwed deeper into the wood or unscrewed back out again with your tuning wrench. These pins should be set to about 1" height.



If you are using the newer **threaded through pins**, you can flip the neck over and use an electric drill to turn each pin SLOWLY as you press the pins in to the desired depth. Don't rely on the threads to draw the pin into the wood -- that takes too long and generates too much heat from the friction. Just push hard as you let the drill turn slowly and the pin will slide into place nicely.

If you are using **tapered through pins**, you'll find it easier to install those after the neck and pillar are put in place on the body of the harp. Push the pins into the upper row of holes in the neck, from the back side of the neck. Note that these pins fit to a certain depth in the tapered holes drilled through the NECK.

Finish pushing the tapered pins using the tuning wrench until they fit tightly. If they ever become loose in the future, all you need to do is push them in further -- that's the beauty of having tapered pins -- you can make them as tight as you like.

HINT: I find it best to turn the pin back and forth as I push it in. This takes a little muscle power. Grip the harp neck with one hand and use the tuning wrench in the other hand to push the pins until they are firmly seated.

Now your harp is ready for stringing and tuning (see next chapter).

FLAPJACKS

This recipe comes from Haydon Cardew, a harp builder in Great Britain

Ingredients:

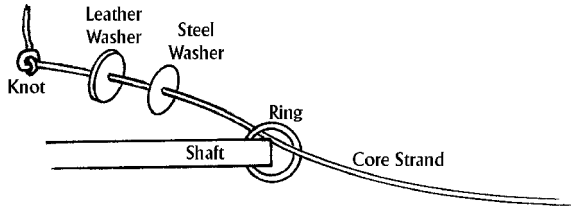
1/2 lb butter (2 sticks)
1/2 lb brown sugar (1-1/4 cups)
10-12 oz Rolled Oats or Meusli
Dried fruit

Baking Instructions:

Gently melt butter and brown sugar together until smooth. Add enough rolled oats (or muesli) to soak up the mixture (about 10-12 oz).

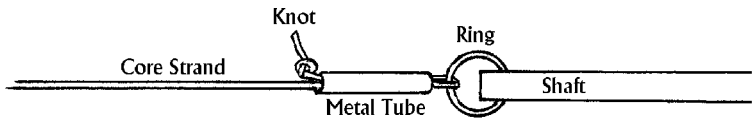
Spread mix into greased baking tray and bake until crisp and golden. Cut it up as it cools. Try rubbing a chocolate bar over the top while it is still warm. Add dried fruit for variety.

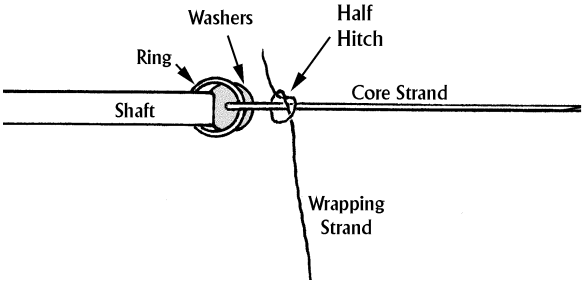
You need to devise a method for attaching the core strand to the spinning motors or shafts, and it must be firm enough to withstand this tension. John's system calls for drilling a hole through each motor shaft and bending a stiff wire to form a small "hog ring" at the end of each shaft. He then ties a knot in one end of his core string and slides a leather washer and a small metal washer onto the string next to the knot. When he threads the string through the hog ring, the washers prevent the bottom end from pulling through the ring.



At the other end, John slips a small piece of metal tubing over the string and then loops the string through the ring and back into the metal tubing. After drawing the string taut, he ties a bulky knot to prevent the end of the string from slipping back through the metal tube.

Once the core is suspended firmly, you can tie the wrap material near the bottom end of the string, using several half-hitches. Coat those knots with a little superglue to make sure they don't untie themselves or slip around on the core strand.





John says, "You need to develop a knack for the wrapping. If the wrap doubles back on itself, you either have to start over, or reverse the motor direction and carefully unwrap it. If the wrap moves ahead too fast, you won't have a nice tight winding."

When you have wound a sufficient amount of wrapping strand onto the core strand, tie it off with several half hitches, and apply superglue to hold it securely. Keep in mind that the wrapped portion of the string should not reach much above the guide pin (bridge pin) when installed on your harp. The reason for this is that compound strings are too bulky to wind onto the tuning pins in full thickness. Be sure to leave a sufficient "tail" of core strand material long enough to reach through the tuning pin.

Making Your Own String Winder

Most amateur harp builders purchase compound (wound) strings from an expert string supplier, such as those mentioned in the Appendix of this manual, but some adventurous folks enjoy "doing it all", so they make their own device for wrapping one size material around a core of a different size material. This is most easily done using a thick monofilament nylon strand for the core and a thin monofilament nylon strand for the wrap. Nylon core diameters generally range from .036" to .060", and nylon wrappings vary from .008" to .025" in diameter. Dupont Tynex makes a good springy core strand, but the wrapping material can be ordinary fishing line, as it is more limp and easy to wind.

The basic challenge is to stretch the core monofilament between two points, tie the wrapping strand at one end, and then spin the core fiber while guiding the wrap with your hands until you reach the desired length where you tie off the wrap again.

It sounds easier than it is, but John Lozier, from Morgantown, West Virginia, has sent me the details of how he set up his string winder, and it is quite a neat device. He said he learned the technique from John Kovac, who learned it from a Paraguayan harpmaker by the name of Geronimo Morinigo.

John uses two DC motors that run off a 12 volt car battery. He wires them up to rotate in opposite directions, so when they face each other, they spin the string in the same direction. You don't want the core material to twist as you are winding the wrap.

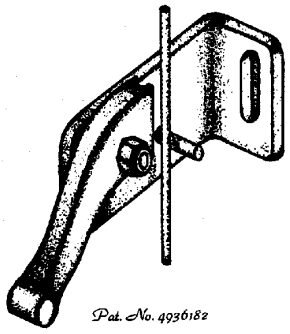
Tony Souza, from Otisville, Pennsylvania, uses a different system, powered by a single motor. He set up a steel channel (square tube) long enough to accommodate his longest strings, attached pillow blocks at each end to hold short steel shafts aligned with each other, and then he uses bicycle chains from a single jack shaft to turn the short shafts. His motor is just an electric hand drill, but I've heard of others who used an old sewing machine motor complete with a variable-speed foot pedal.

It is advisable to add some method of stretching the core material with about the amount of tension it will have when the finished string is tuned up on the harp, although John Lozier says he does not worry about precision in this detail. Some people fasten a spring to one shaft and tie the core strand to that spring. The string can either be pulled tight enough to stretch the spring when tying it in place, or the shafts can be moved apart to exert the desired tension after tying the core strand in place.

Sharping Levers

Sharping levers are used on folk harps to facilitate key changes. Installing a lever over a string allows you to raise the pitch of that string one-half step by engaging the cam against the string. Thus an F-string can be raised to F# by a simple flick of the lever. Similarly, a B-string may be tuned to Bb so that the lever will raise it to B-natural and release it back to B-flat, as needed.

Most folk harp players set the key signature (sharps or flats) on the harp before starting each piece of music. For the key of G, you would engage the levers on all the F strings to produce the F# notes needed for that key (making sure all other notes on the harp are natural). If the following piece were to be played in the key of F, you would then release the levers on all the F strings to produce F-natural, and also release all the B-string levers to produce Bb.



Loveland lever

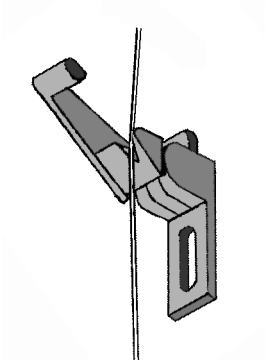
KEY OF E:	requires F# and C# and G# and D#
KEY OF A:	requires F# and C# and G#
KEY OF D:	requires F# and C#
KEY OF G:	requires F#
KEY OF C:	requires no sharps or flats
KEY OF F:	requires Bb
KEY OF Bb:	requires Bb and Eb
KEY OF Eb:	requires Bb and Eb and Ab

You may install a lever over every string on the harp, or, if you think you won't use all of them, it would be more cost-effective to select which keys you think you are most likely to use, and then install only the levers necessary for those keys.

Truitt lever

Most sharping levers come with installation instructions, and sometimes special tools. Generally speaking, you cannot install the levers until the harp is strung and tuned because each lever must be carefully aligned with its assigned string. The height of the strings from the wood surface will also affect the position of the levers. That is why Golden Rule #4 is so important. It allows you to adjust the string height.

The most commonly used levers at this date are Loveland brand and Truitt brand, although there are some harpmakers who use the older designs like Robinson levers, or even brass blade-type levers. Two interesting newcomers to this market are the Jordan and the Camac levers.



Jordan lever

ROCK CAKES

Another winner from Haydon Cardew, in Great Britain. He makes these with his students at a special needs school.

Ingredients:

3 oz butter
8 oz flour
3 oz sugar
4 oz raisins
pinch of mixed spice
1 egg (beaten)

Baking Instructions:

Rub together the butter and flour until it looks like bread crumbs. Add sugar, raisins, spice, and egg. Mix gently with your hands - lovely stuff.

Form rocky shapes - about 8 to 12 on a greased cookie sheet, and bake in a medium hot oven til they smell done - about 15-20 minutes.

TROUBLESHOOTING

CHAPTER SEVEN

Engineering “Dances”

Now that your harp is designed and built, you'll have the opportunity to watch what happens to it under the constant tension of the strings. This is the test of your designing and woodworking skills, and it may take several years to discover the results. I call this exercise learning the engineering “dances" of harp making. I've listed a number of the common dances here, along with a few hints on how to step through them successfully.

The “Turn”

They say “One good turn deserves another”, but you won’t like it when a tuning pin turns backwards of its own accord after you carefully tuned a string up to pitch. There are several ways to master this dance, depending on the type of tuning pins you are using:

For **Zither Pins**:

1) First try to simply pound the pin more deeply into the wood so more of the threaded section is seated in the hole.

2) If that does not help, you can remove the pin and insert a thin shim of wood along one side of the hole to take up some space. Wood veneer works well for this, but I’ve heard of some people even using a narrow strip of thin cardboard from a matchbook cover. Usually you can hold the strip in the hole while pounding the pin back in, and the pin will be tight again, but it may take a few tries to get it to work.

3) Another option is to soak the wood with a wood-swelling liquid. Piano technicians use a product called “Pin Tite” for swelling and restoring the wood fibers in the tuning pin hole. You can even try mixing up your own brew by combining alcohol and glycerin in equal amounts. If you remove the pin and let the liquid soak into the hole overnight, then clean out the excess solvent with a Q-tip before inserting the pin again.

4) If the above efforts fail, the final solution for this problem is to simply purchase an oversize tuning pin. Musicmaker’s carries pins that are .010” larger than normal.

5) One other suggestion would be to upgrade the harp to through pins, either tapered or threaded. These take larger holes than zither pins, so you would be re-drilling all the way through the harp neck.

For **Tapered Through Pins**:

It is quite easy to solve this problem for tapered pins, simply because they are tapered. All you need to do is push them deeper into the wood. I use a tuning wrench and push while twisting the wrench back and forth slightly as I push. You should be able to get these pins as tight as you want.

For **Threaded Through Pins**:

The solution for these pins is the same as with zither pins. I recommend not removing the pin unless absolutely necessary, however, because the act of screwing it out of the hole will likely enlarge the hole even more and make the problem worse. Try a wood-swelling solution first and see if that takes care of it. If not, then remove the pin and try a shim. If all else fails, you can always ream the hole for a tapered pin and replace the pin altogether.

The "Slip"

This is a common dance step that every harp maker and harp player needs to learn quickly. It concerns string slippage at both the tuning pin and inside the body at the knotted end of the string. Rookies are easy to spot on the dance floor, because their harps simply cannot be tuned up to concert pitch.

It happens when the strings are either slipping around the tuning pin or the knots are slowly untying themselves at the other end, behind the soundboard. Monofilament nylon strings are the main culprit here, because shiny nylon is very slippery stuff! You'll want to make sure to anchor each end of every string securely to prevent this from happening. Here are some hints:

Don't rely on the little hole in the tuning pin to grip your string firmly - that hole is only there to assist you in starting to wind the string onto the pin. For complete security, you should cross some of the string windings over each other on the pin, so that one winding jumps over at least one other wrap. This cinches the string to the pin. It is amazing how effective this simple little trick is in anchoring that end of the string.

The same shiny nylon can literally untie itself behind the soundboard too. I've seen various complex knots that help secure this end of the string. Some are quite elegant and professional, and others are bulky clumps that are obviously tied with great frustration.

You can refer back to Chapter 6 to learn a better knot, but if you are no seaman when it comes to knot-tying, then I recommend simply adding a drop of Superglue to each knot. When that soaks in around the twists of nylon and dries, it freezes the knot right where it is. Don't use too much glue - you don't want to adhere the knot to the soundboard. Just get some glue into the knot itself.

Harp String Suppliers and Analysts

Markwood Strings (Laurie Hill)
809 W 1st Street
Phoenix, OR 97535
(541) 535-7700
Web site: www.markwoodstrings.com
email: mwstrings@aol.com

Robinson's Harp Shop (Sue Raimond)
33908 Mount Laguna Drive
PO Box 161
Mount Laguna, CA 91948-0161
(619) 473-8556
email: robinsonharp@sciti.com

Vermont Strings (Skip & Joan Lamere)
68 Shaw Hieghts
Waterbury Center, VT 05677-8790
(802) 244-8564
email: vtstrings@vtusa.net

Computer String Analysis Software

String Band Manager (DOS based program)
Joseph Jourdain
Box 44
Wells, BC V0K 2R0
CANADA
email: mrummel@goldcity.net

Free On-line string Analyisis for Windows

A String Analysis program is now available for free on the Musicmaker's Kits web site <www.harpkit.com>. You can download an Excel Spreadsheet that allows you to type in the string diameters, type of fiber, and vibrating length to calculate string tension, breaking point, and tension/length (T/L) ratios. It even shows your data in graph form when you click on the "charts" at the bottom.

This spreadsheet was programmed by Walter Cowart, a retired engineer and hobby instrument-maker.