1980

UA37/2 The Haile Method of Classical Guitar Instruction (Outline)

Frank Pittman

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THE HAILE METHOD OF CLASSICAL GUITAR CONSTRUCTION
(outline)

Introduction:

The modern classical guitar evolved from a variety of string instruments played in medieval Europe. Spain became the leading country for guitar making in the sixteenth century and continues today as a leader in this field.

Antonio de Torres Jurado (1817-1892) is said to have done more than any other luthier to develop the modern classical guitar. He was an active Spanish luthier from 1850 until his death. Torres guitars were quite different from those of his predecessors. His guitars were generally larger than earlier instruments but more importantly he developed and used a fan strutting pattern for the top which is still widely used today.

There were several other early luthiers who contributed to the development of the classical guitar after Torres' death. These include makers such as Vincente Arias (1840-1912), Jose Ramirez I (1857-1923), Manuel Ramirez (1866-1942), and Santos Hernandez (1873-1942).

Even though Spain is still considered the center of classical guitar construction, there are luthiers in other countries who ~~constributed~~ contributed to the instruments development. Hermann Hauser (1882-1952) a German, was one of the most influential makers of the twentieth century. Robert Bouchet, a French maker; Masaru Kohno, a Japanese maker and Hascal Haile, an American are ~~active~~ RECENT makers of prominance.

Hascal Haile ~~has been~~ was a master wood craftsman for over 50 years. He worked primarily in furniture and cabinetmaking until 1968. Since 1968 (at the age of 58) he began to hand make classical and steel string guitars as a full time occupation. Mr. Haile ~~has~~ made over 400 guitars since 1968 and a list of his customers reads like "Who's Who of Guitar Playing". He ~~has~~ made instruments for such players as Chet Atkins, Roy Clark, Bobby Goldsboro, Porter Wagoner, Dolly Parton, Hank Snow, Waylon Jennings, Jerry Reed, Tom Jones, John Johns, Paul Yandell, Ray Cummings, and John Knowles. MR. HAILE DIED AT HIS HOME DURING THE MONTH OF OCTOBER 1986.

Mr. Haile works with his wife in a relatively small basement shop in his home in Tompkinsville, Kentucky. He developed his guitar construction techniques largely on his own. He did not work as an apprentice or have a teacher. He had to rely upon his woodworking and musical judgement, what he could read, and what guitar players had to say about his products. He attributed much of his success in guitar making to the help and advice given him by Chet Atkins and Basil Gural. Mr. Haile's guitars ~~have~~ evolved since 1968 to be comparable to the very best in the world in the judgement of many. He continues to seek ways to improve his instruments and his guitars ~~are still evolving~~. ~~The construction methods presented in the pages that follow are the methods he was using in 1979. He has, no doubt, changed his techniques somewhat since this material was written.~~

were still evolving at his death.

CLASSICAL GUITAR DESIGN

The basic parts of a classic guitar have not changed significantly since Torres introduced fan strutting in the later part of the ninteenth century. The drawing on page 3 identifies the basic parts of a modern classic guitar. Over the years luthiers have experimented with many subtle modifications in guitar parts in an attempt to improve the instruments quality.

The ultimate goal of a luthier is to make an "excellent" guitar. If you attempt to explain the characteristics of an "excellent" guitar you will soon realize that it is difficult to do. Such variables as loudness, projection, sweetness of tone, balance, sustain, noting accuracy, action, craftsmanship and beauty may all enter into ones definition. We must also remember that judgements about the sound quality of a guitar are based upon the sensitivity of human hearing, and how well the output of a particular guitar matches or mismatches with human hearing over the frequency band of its output.

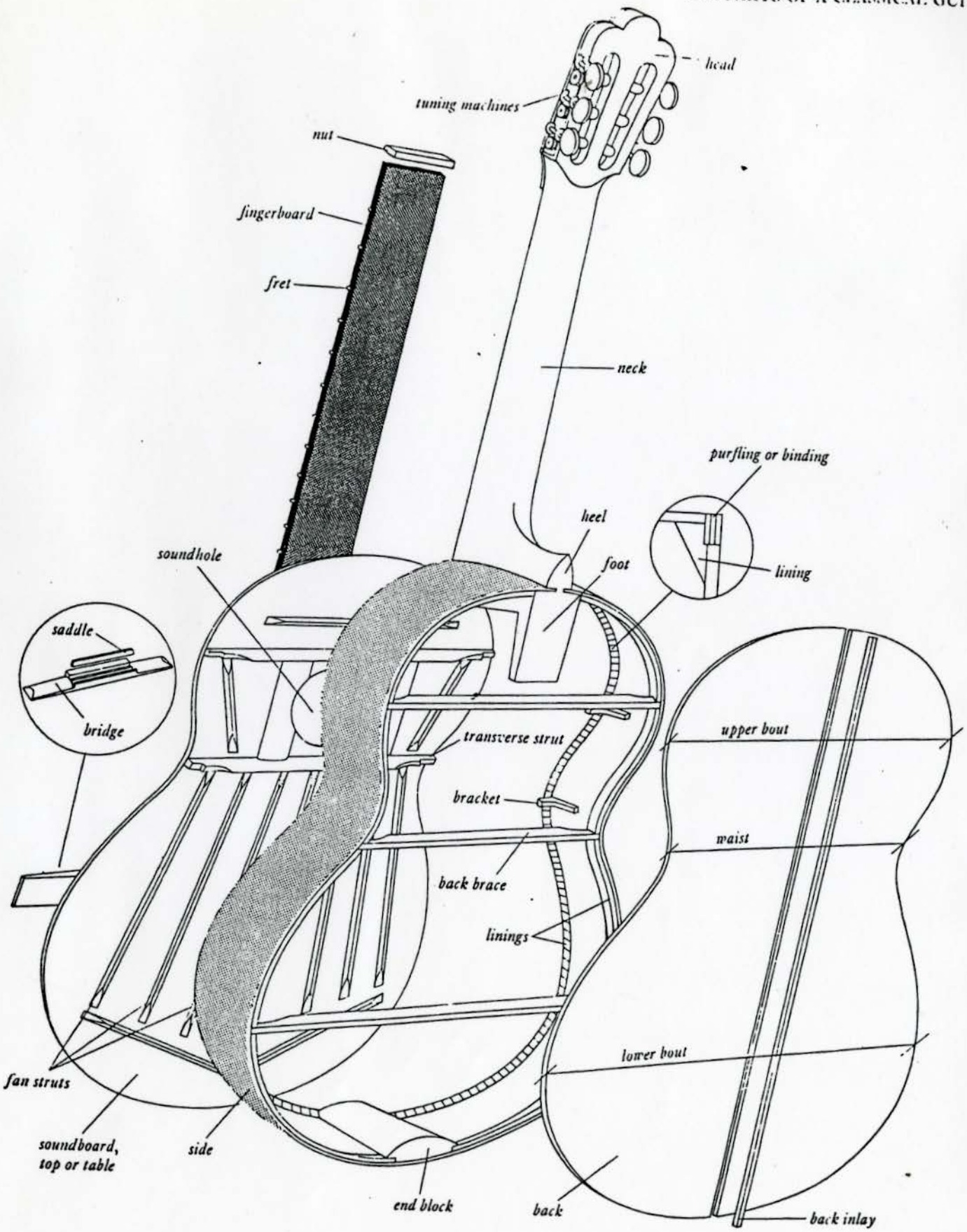
The playing conditions into which a guitar is placed also influence evaluations of quality. A guitar player with powerful fingers can bring out sounds from an instrument which would be impossible for other players to achieve. Some instruments may be excellent for recording and close intimate performances while others are well suited for large concert halls or group performances. Therefore, it is safe to say that guitars may be excellent for some situations and not so good for others, and there are some guitars that are not much good for anything.

A good luthier is one who can produce a guitar that will fit a particular musicians style of playing and at the same time respond well in the playing situations it will most often be placed. Good luthiers can control and modify many of the variables which effect sound and they do this in a variety of ways.

An acoustic guitar's body is its amplifier. This fact can be easily observed if you pluck the strings of a solid body electric guitar without an amplifier, you will barely be able to hear the notes. If you place the same strings on an acoustic guitar and tune them properly you will be able to immediately notice an increase in amplification when the strings are plucked or strummed. The sound which is emitted from an acoustic guitar is a function of the main wood resonance which is determined by the structure of the guitar body, mainly the top; and the Helmholtz resonance which is determined by the internal volume of the guitar body coupled with the area of the sound hole. The structure of the guitar body, particularly the top, has been the area of most experimentation by luthiers over the years.

Since the body size of an acoustic guitar is an important variable in determining the sound of a guitar it is interesting to compare a sample of 24 modern classic guitars with Haile guitars in terms of body size.

THE PARTS OF A CLASSICAL GUITAR



I. Design and construction (general information)

A. Modern classic guitar sizes

1. Body size ranges: Data compiled from a study of 24 modern classic guitars.

(a) Upper bout: 24 cm (9.448") to 29cm (11.417")
average upper bout 27.525cm (10.836")

(b) Waist: 20.5cm (8.07") to 24.3cm (9.566")
average waist 23.404cm (9.214")

(c) Lower bout: 34.5cm (13.58") to 38cm (14.96")
average lower bout 36.18cm (14.245")

(d) Depth range:

(1) Upper bout: 8.3cm (3.26") to 10cm (3.937")
average 9.258cm (3.64")

(2) Lower bout: 9.2cm (3.62") to 10.7cm (4.212")
average 9.975cm (3.927")

2. Overall length range:

96cm (37.795") to 104cm (40.94"), average 99.054cm (38.997")

3. Scale length range:

64cm (25.197") to 67cm (26.378")
most common scale length: 65cm (25.59")

B. Haile classic guitar sizes

1. Haile standard classic:

(a) Body size:

(1) Upper bout: 27.94cm (11")

(2) Waist: 24.13cm (9.5")

(3) Lower bout: 37.98875cm (14.5625")

(4) Depth upper bout: 9.52cm (3.75")
Depth lower bout: 10.79cm (4.25")

(b) Overall length: 99.695cm (39.25")

(c) Scale length: 65.0875cm (25.625") or 66.04cm (26")

2. Haile small classic:

   (a) Body size:

      (1) Upper bout: 27.30cm (10.75")

      (2) Waist: 22.86cm (9")

      (3) Lower bout: 36.195cm (14.25")

      (4) Depth upper bout: 8.89cm (3.5")
      Depth lower bout: 10.16cm (4")

   (b) Overall length: 98.425cm (38.75")

   (c) Scale length: 65.0875cm (25.625") or 66.04cm (26")

CLASSIC GUITAR CONSTRUCTION MATERIALS

The species starred below (*) are the ones used most often by Mr. Haile.

BACKS:

Species: *East Indian rosewood, Brazilian rosewood, maple

Grain: Quarter sawed vertical grain, book matched

Rough Size: 5/32 x 8 x 22

SIDES:

Species: Same as backs

Grain: Quarter sawed vertical grain, book matched

Rough Size: 5/32 x 4 3/4 x 30

TOPS:

Species: *European white spruce, Sitka spruce, Western red cedar

Grain: Quarter sawed, book matched, 12 to 16 growth rings per inch

Rough Size: 5/32 x 8 x 22

NECKS:

Species: Brazilian or *Honduras mahogany, hard maple

Grain: Quarter sawed, straight grained

Rough size: Neck & peg head, 4/4 or 5/4 x 3 1/4 x 30
Heel blocks, 4/4 or 5/4 x 3 1/4 x 32

BRIDGE:

Species: *East Indian rosewood, Brazilian rosewood, ebony

Grain: Straight, quarter sawed

Rough Size: 3/8 x 1 3/8 x 8

FINGERBOARD:

Species: *Ebony, East Indian rosewood, Brazilian rosewood

Grain: Quarter sawed, straight grain

Rough Size: 5/16 x 2 1/2 - 3x 19

TOP BRACING:

Species: *Sitka spruce, European white spruce scraps

Grain: Quarter sawed vertical grain

BACK BRACING:

Species: Brazilian or *Honduras mahogany, Sitka spruce

Grain: Quarter sawed vertical grain

TOP LINING BLOCKS:

Species: *Basswood, Brazilian or Honduras mahogany

BACK LINING:

Species: Brazilian or *Honduras mahogany, basswood

BINDING:

Species: Brazilian or *East Indian rosewood

TAIL BLOCK:

Species: Brazilian or *Honduras mahogany

GUITAR MOLD CONSTRUCTION

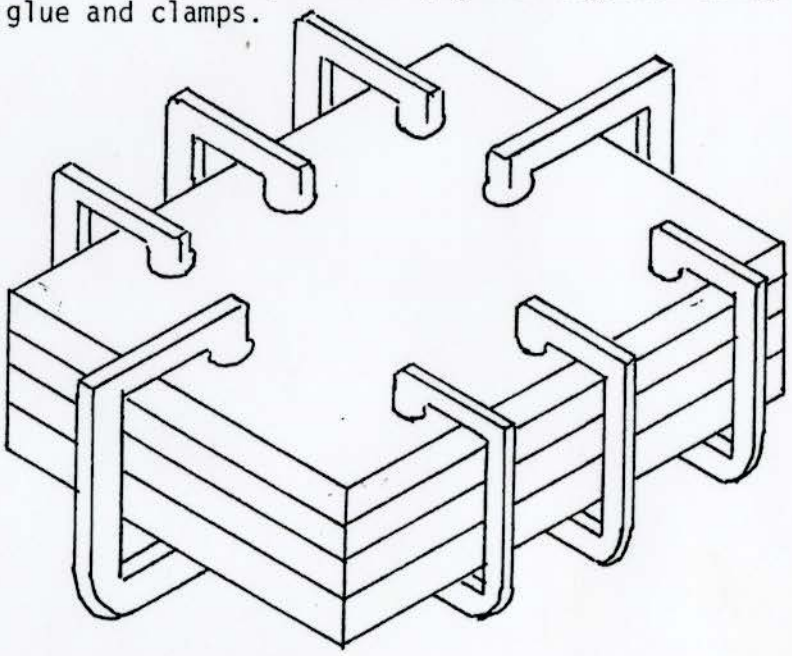
Unlike most Spanish guitar makers Mr. Haile uses a mold during the assembly of a guitar. The use of a mold helps to control the accuracy of the body shape from one guitar to the next. Mr. Haile's guitars have a consistant shape and are symetrical.

A separate mold must be fabricated for each guitar body size. The procedure for making a mold for a classic guitar is outlined below.

1. Prepare a half pattern of the guitar body using 1/8" or 1/4" hardboard. Refer to the master pattern for proper size and shape.

2. Prepare four pieces of 3/4" interior (fir) plywood 18" x 23".

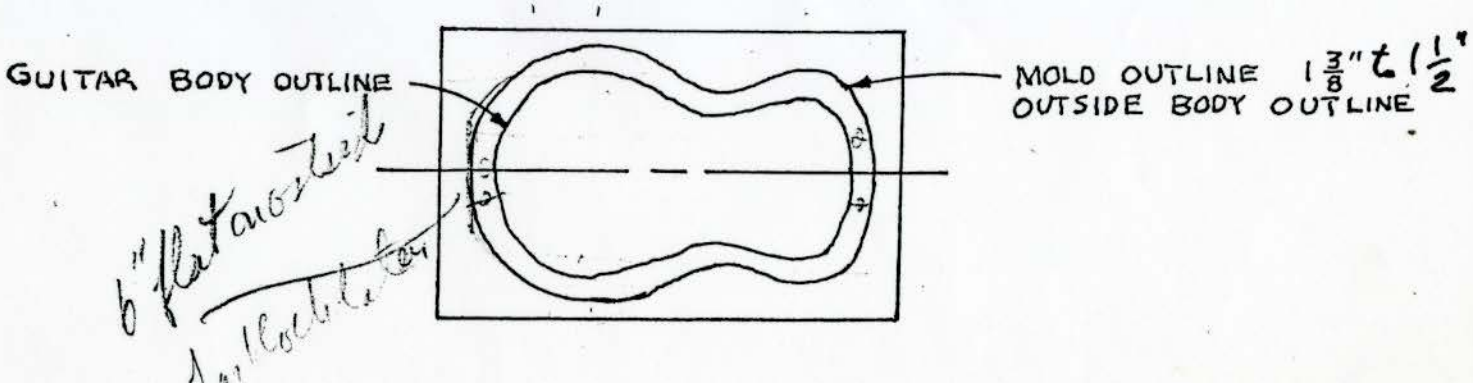
3. Laminate the four 18" x 23" pieces of plywood together using urea resin or liquid hide glue and clamps.



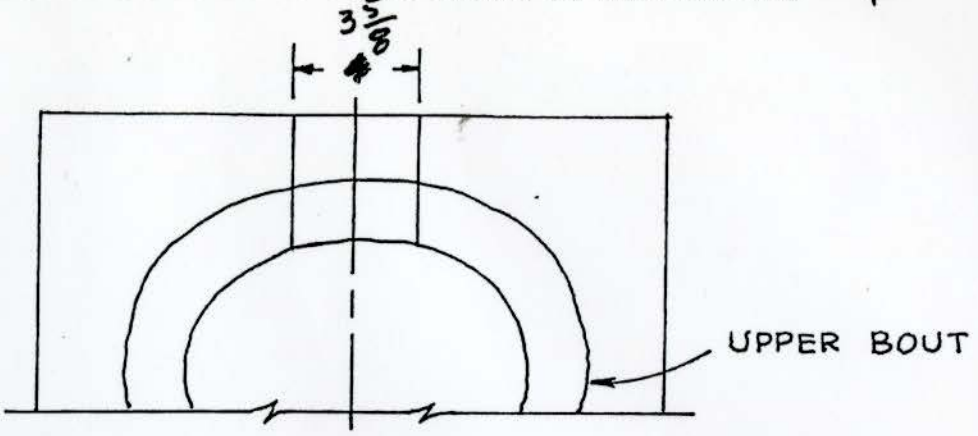
4. Prepare a piece of 3/4" interior (fir) plywood 18" x 30". This piece will be used to make the back or bottom of the mold.

5. Secure a piece of plastic laminate 18" x 30". Glue the laminate to one side of the plywood back using contact cement.

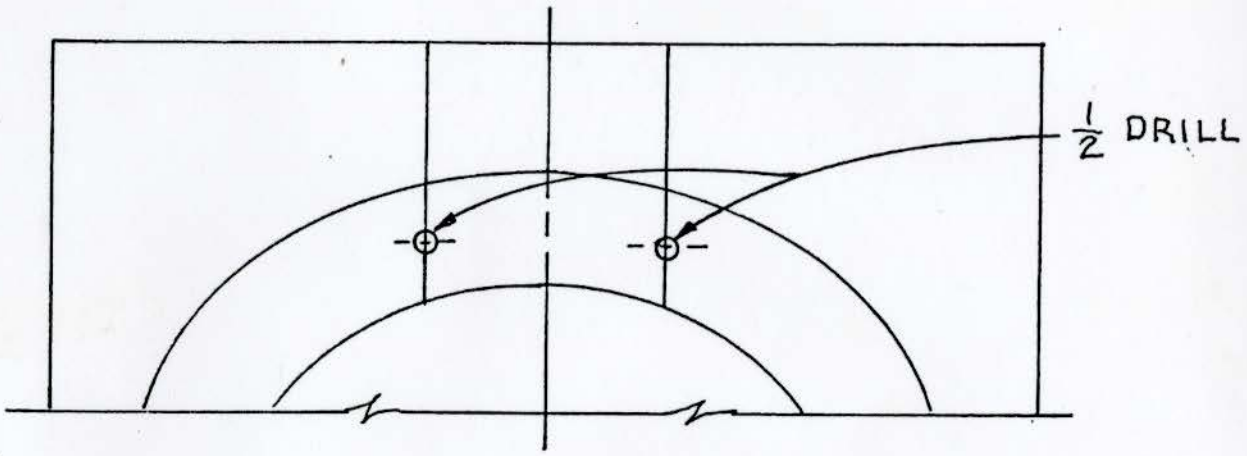
6. Layout a center line and the guitar body outline on the mold.



7. Layout the neck gate on the mold. The gate should be approximately 4" wide. $3\frac{5}{8}$ $3\frac{3}{4}$



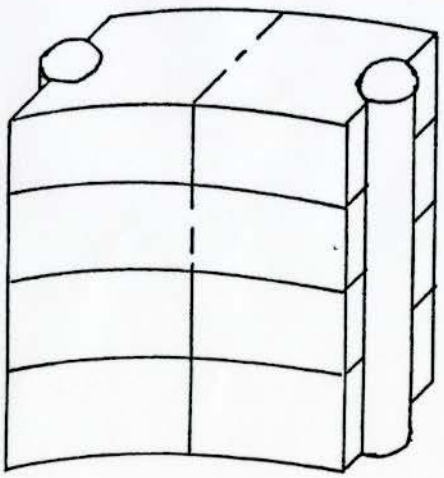
8. Drill two 1/2" diameter holes, centered on gate layout as shown below. These holes should be drilled through the entire laminated assembly.



9. Carefully saw out the inner portion of the mold using a bandsaw. It is very important that the bandsaw is cutting squarely without blade drift.

10. Bandsaw off the waste wood on the outside of the mold blank.

11. Glue 2, 1/2" x 3" dowel rods to the gate block.

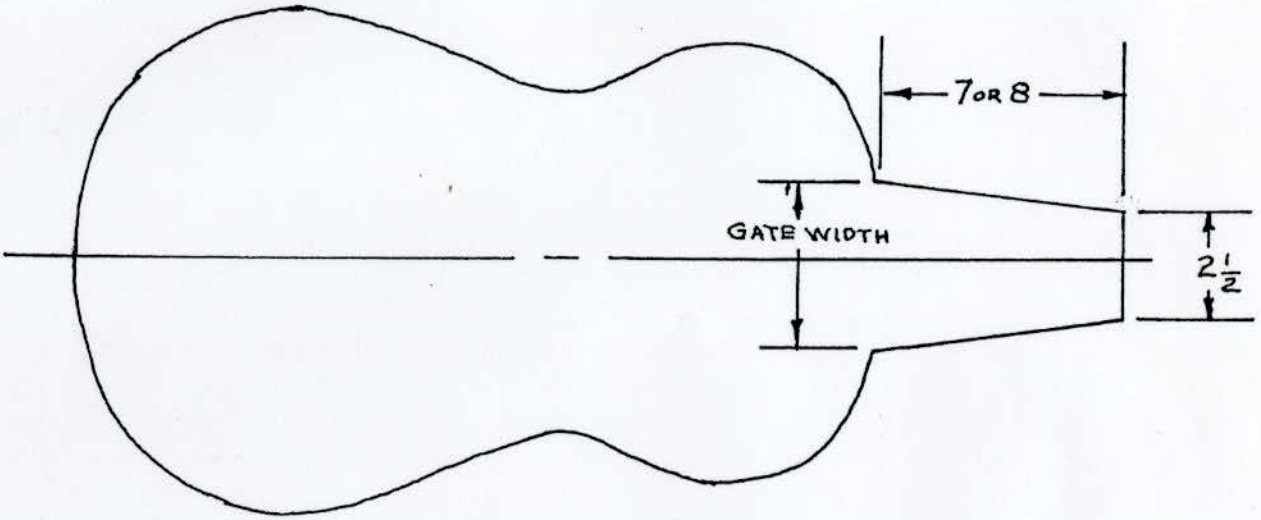


TWO $\frac{1}{2}$ x 3 DOWELS GLUED TO GATE

12. Sand and smooth the interior of the mold. Use a drum sander if one is available, otherwise smooth by hand. The inner walls of the mold should be square and smooth. Serious voids should be filled with some type of wood filler (plastic wood, etc.) and smoothed out square.

13. Secure the mold back or bottom to the upper part of the mold temporarily with about four #10 1 1/ 2" flat head wood screws. Make provisions for approximately 8 equally spaced screws but install only four for temporary assembly. Be sure that these screws will not interfere with the bolt holes to be drilled in step number 16 below.

14. Layout the outside shape of the mold on the mold back leaving an extension for the neck as shown below.



15. Remove the back from the mold and saw the back to shape on a bandsaw.

16. Layout bolt holes on the mold, 1 1/2" OC about 3/8" in from inner edge of the mold. The mold will require approximately 37 holes.

17. Screw the back to the mold with 8, number 10, 1 1/2" screws.

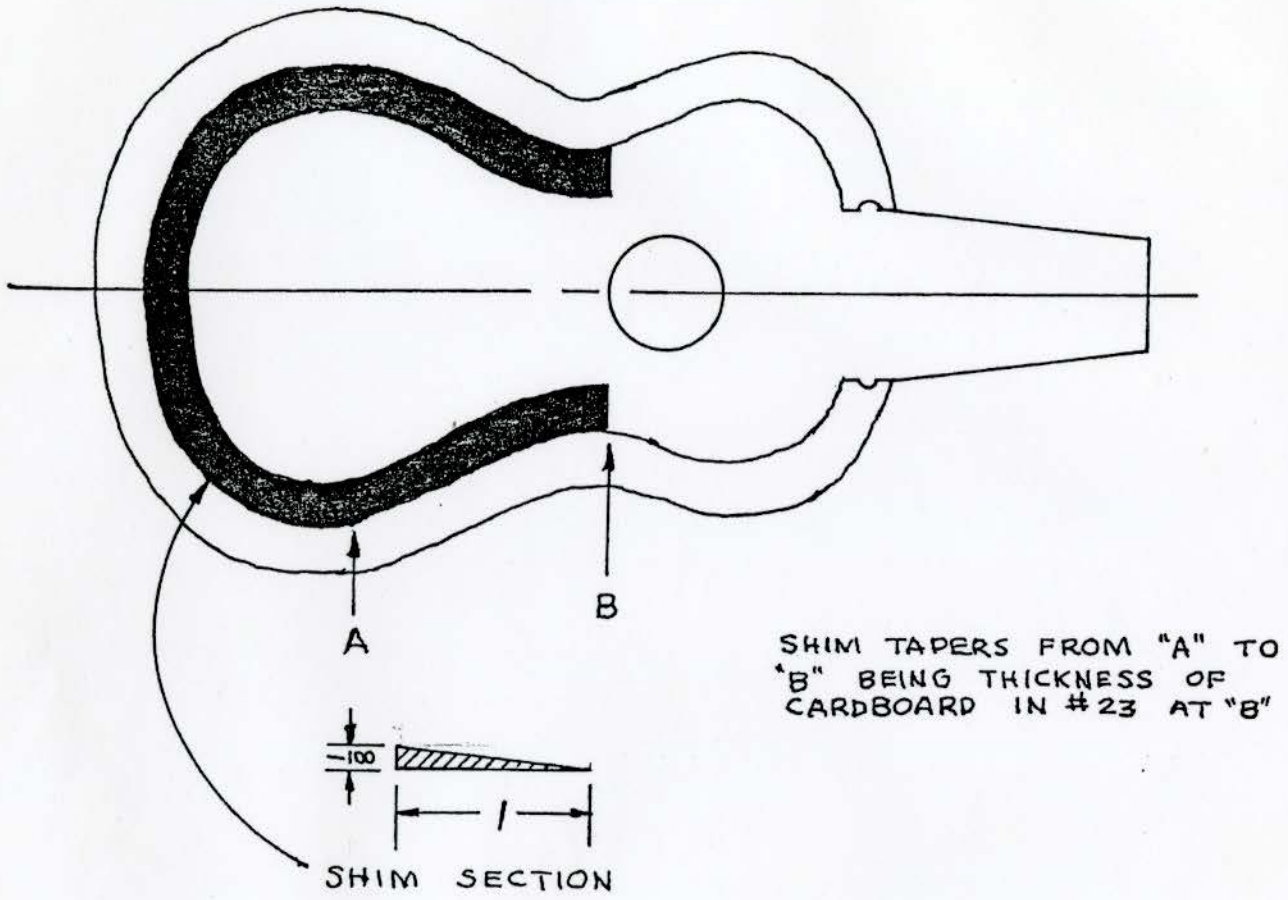
18. Drill the bolt holes (1/4" or 5/16" diameter) using a drill press. These holes must go through the entire assembly, therefore, a long drill bit is required.

19. Carefully locate and scribe a permanent center line on the mold back and at the ends of the upper and lower bout.

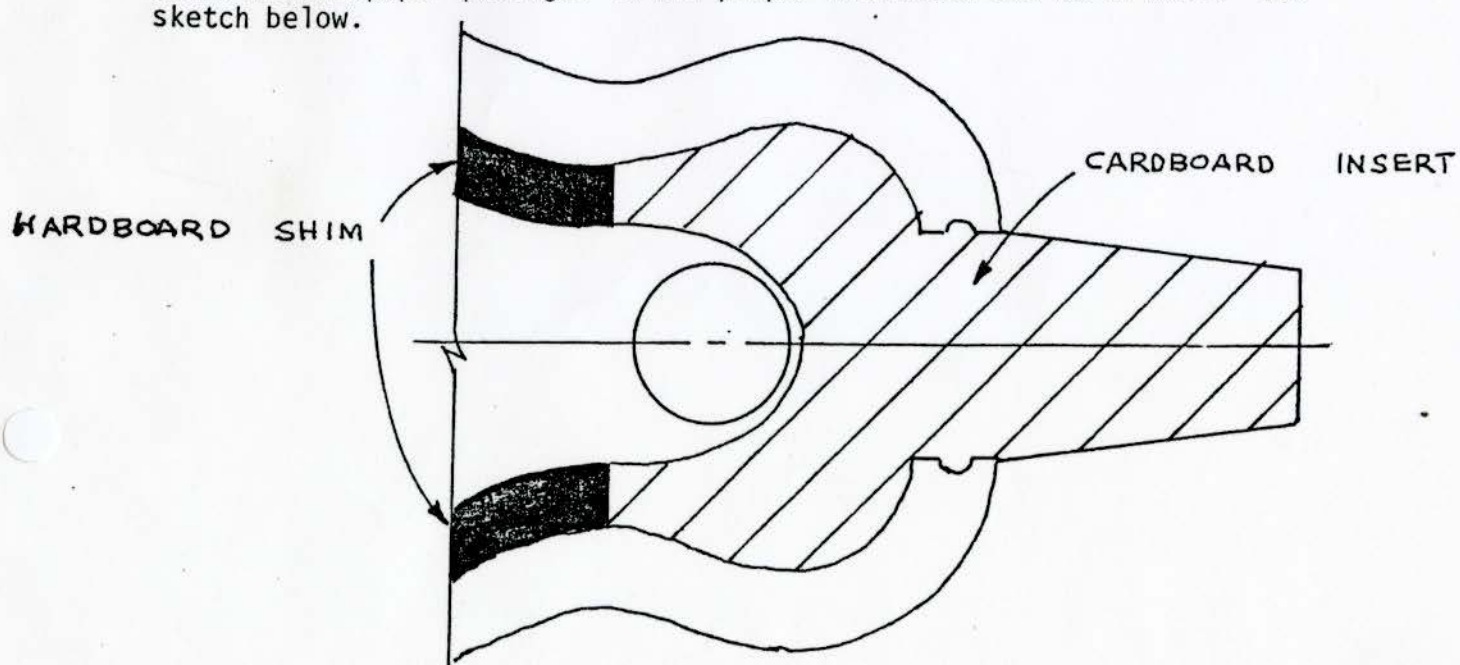
20. Locate a sound hole on the mold back. Center of sound hold is 5 7/8" down from the upper bout end. Sound hole diameter is 3 1/8".

21. Cut out the sound hole in the mold back using a fly cutter in a drill press. This hole will serve as a access and observation hole during assembly.

22. Prepare a mold shim from 1/8" hardboard as shown below.



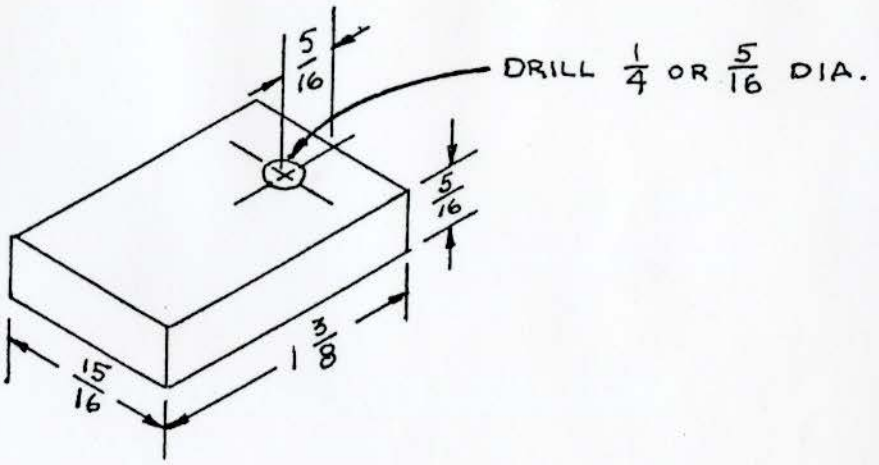
23. Prepare cardboard mold insert for upper part of mold. The cardboard which comes on sandpaper packages is the proper thickness and works well. See sketch below.



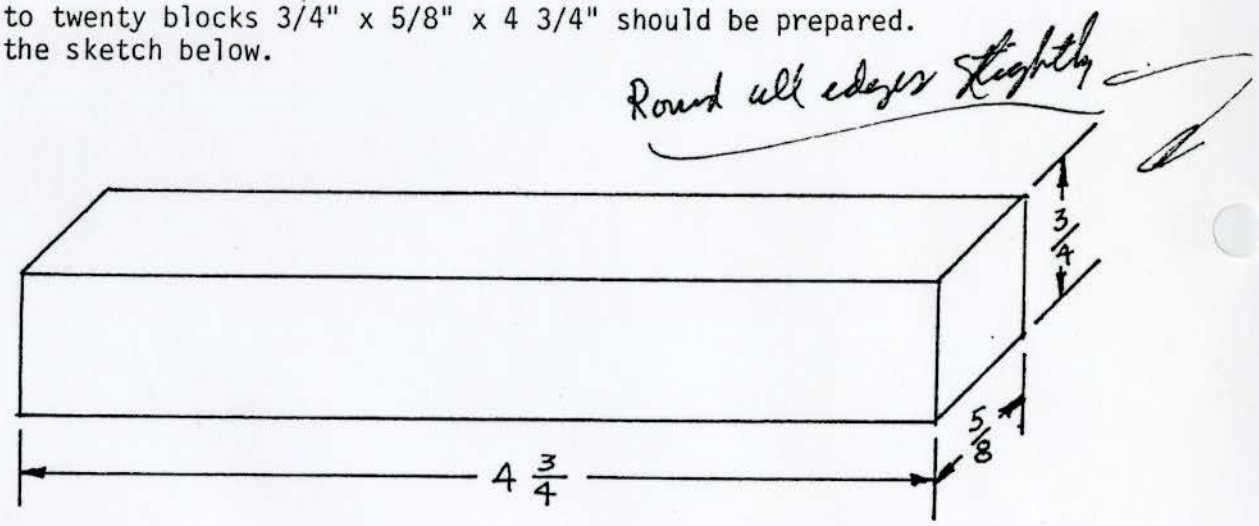
24. Thirty seven 5" carriage bolts, 1/4" or 5/16" diameter, and wing nuts for each should be obtained.

25. Thirty seven or forty bolt blocks 5/16" x 15/16" x 1 3/8" should be prepared. Refer to the sketch below.

NOTE:
SLIGHTLY ROUND
ALL EDGES



26. Eighteen to twenty blocks 3/4" x 5/8" x 4 3/4" should be prepared. Refer to the sketch below.



27. With reasonable care this mold should be useful for many guitars. It may be the only one you will ever need for this particular guitar size.

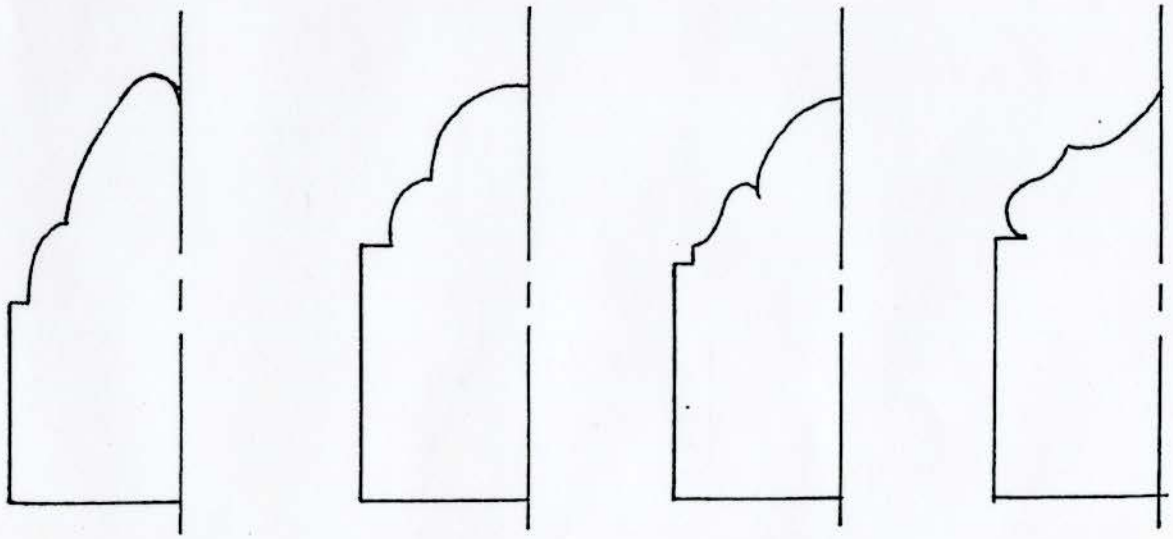
CLASSIC GUITAR NECK CONSTRUCTION

Several decisions must be made before the actual construction of the guitar neck is begun. Scale length, neck width and thickness, and peg head design must be established.

Mr. Haile uses scale lengths of 25 5/8" and 26". He usually uses the short scale for small bodied classic guitars and the longer scale for his large classic guitar. A table of five different scale lengths is provided on page 18.

Classic guitar necks are wider and somewhat thicker than steel string guitar necks. They never have adjustable truss rods as do some steel string guitars. The neck for a classic guitar should be no narrower than 2" at the nut and may be as wide as 2 1/8". A 2" neck is a comfortable width for most players and is the width used most often by Mr. Haile. The fret board for a typical Haile guitar will taper from 2" at the nut to 2 1/2" at the sound hole. The finished thickness of the neck including the fret board thickness will vary from 7/8" to 15/16" with 15/16" being most common.

The design of a classic guitar's peg head should be unique to the guitar maker. Peg heads become somewhat like a trade mark for a guitar maker. (Refer to the peg head examples below)



Guitar makers should carefully design a peg head which is unique and continue to use this head design on each classic guitar they make. An example of a peg head layout is shown on the following page. The area above the slots is the portion of the head to redesign. The slotted portion is fixed and determined by the tuning machines and other jigs and fixtures.

SCALE LENGTHS

USING A RATIO OF: 17.81718

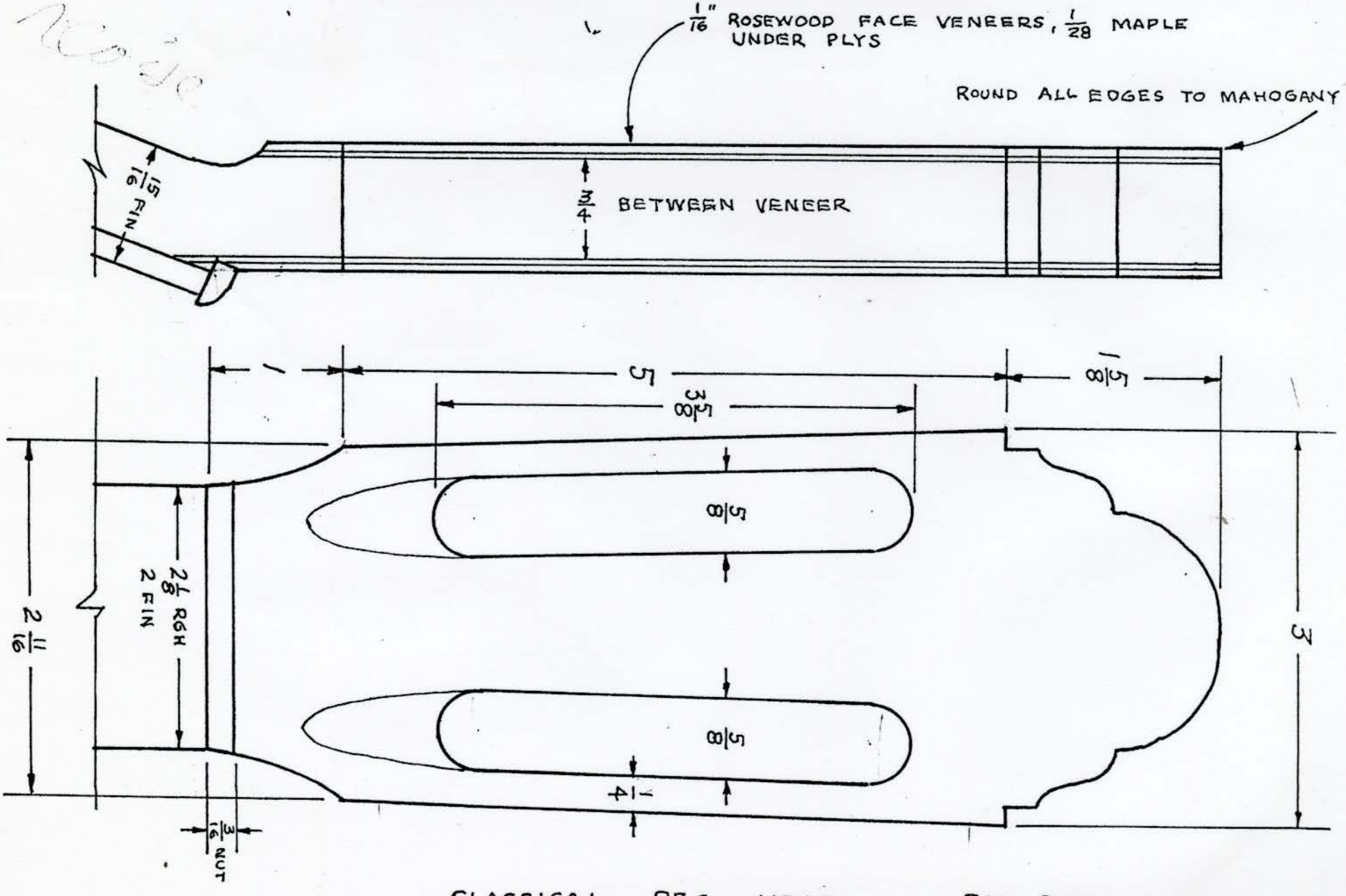
FRET	(26.125)		(26)		(25.875)	(25.75)	(25.625)
0	26 1/8	1.466	26.	1.451	25 7/8	25 3/4	25 5/8
1	24.659	1.383	24.541	1.377	24.423	24.304	24.186
2	23.275	1.306	23.163	1.300	23.052	22.941	22.829
3	21.968	1.232	21.863	1.227	21.758	21.653	21.548
4	20.735	1.163	20.636	1.158	20.538	20.438	20.339
5	19.572	1.093	19.478	1.0932	19.384	19.291	19.197
6	18.473	1.037	18.385	1.032	18.296	18.203	18.120
7	17.436	.979	17.353	.974	17.269	17.186	17.103
8	16.458	.924	16.379	.919	16.300	16.221	16.143
9	15.534	.872	15.460	.868	15.386	15.311	15.237
10	14.662	.823	14.592	.819	14.522	14.452	14.382
11	13.839	.777	13.773	.773	13.707	13.641	13.574
12	13.0625	.733	13.000	.730	12.9375	12.875	12.813
13	12.329	.692	12.270	.689	12.211	12.152	12.093
14	11.637	.653	11.582	.650	11.526	11.470	11.415
15	10.984	.616	11.932	.614	10.879	10.827	10.774
16	10.368	.582	10.318	.579	10.268	10.218	10.169
17	9.786	.549	9.739	.547	9.692	9.65	9.599
18	9.237	.518	9.192	.516	9.148	9.104	9.060
19	8.718		8.676		8.634	8.593	8.551

NOTE:

The 12th fret is always center of scale (nut to saddle).

NOTE:

$\frac{7}{16}$ DRILL IS REQUIRED FOR CLASSIC MACHINE ROLLERS.



CLASSICAL PEG HEAD FULL SIZE

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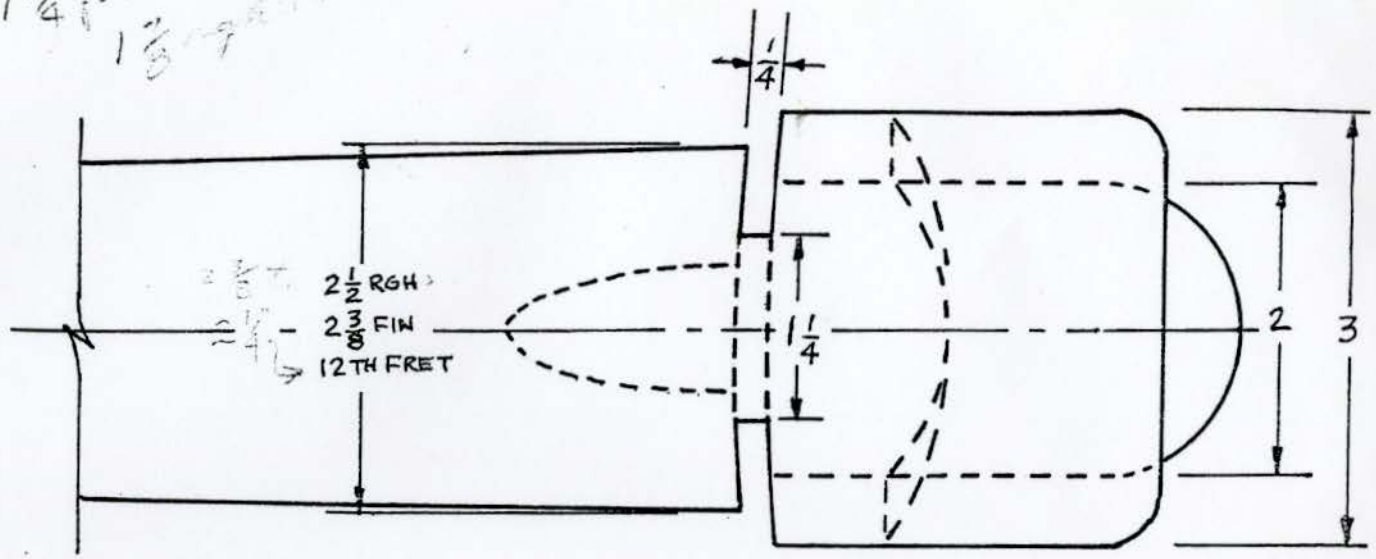
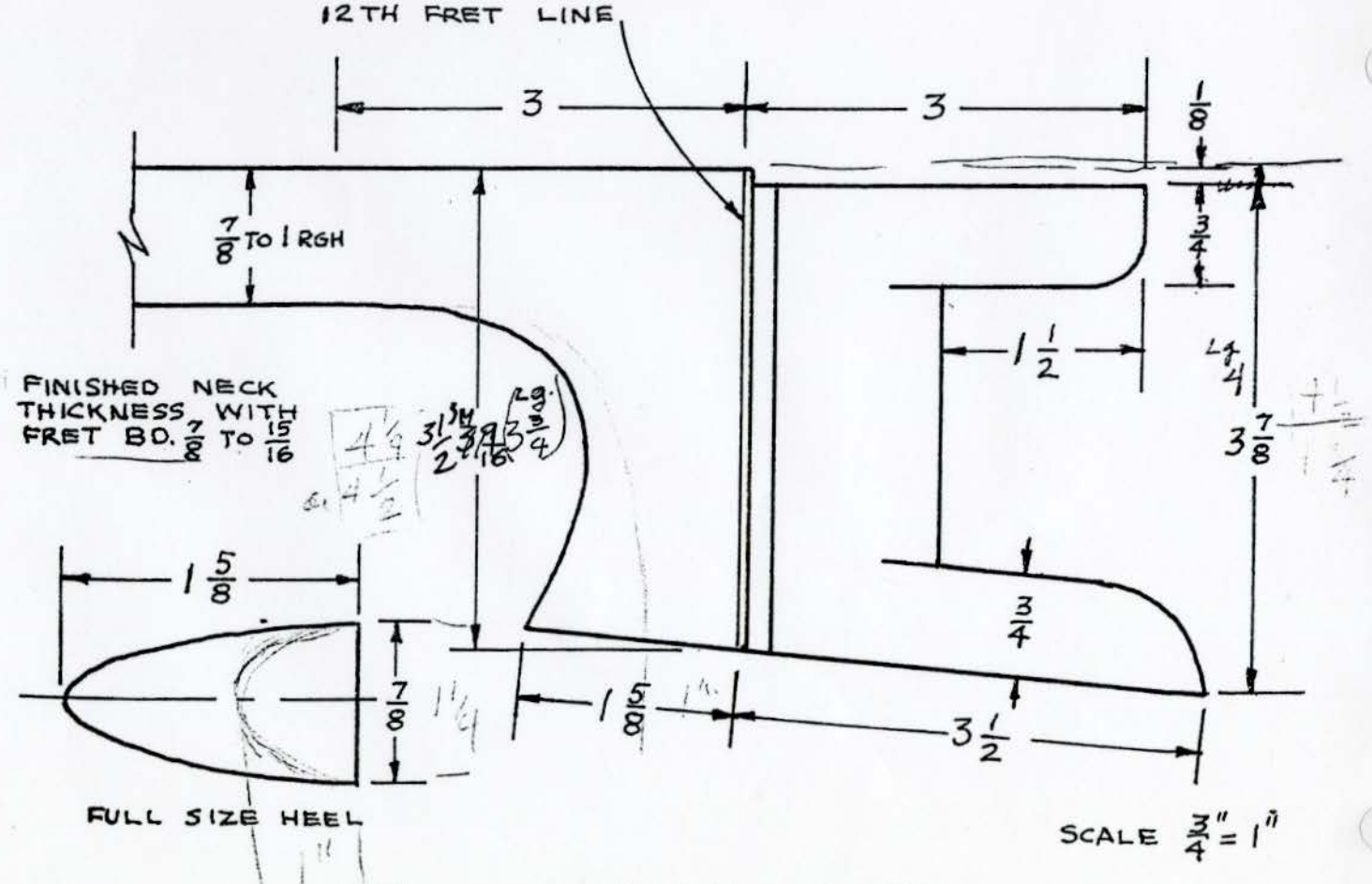
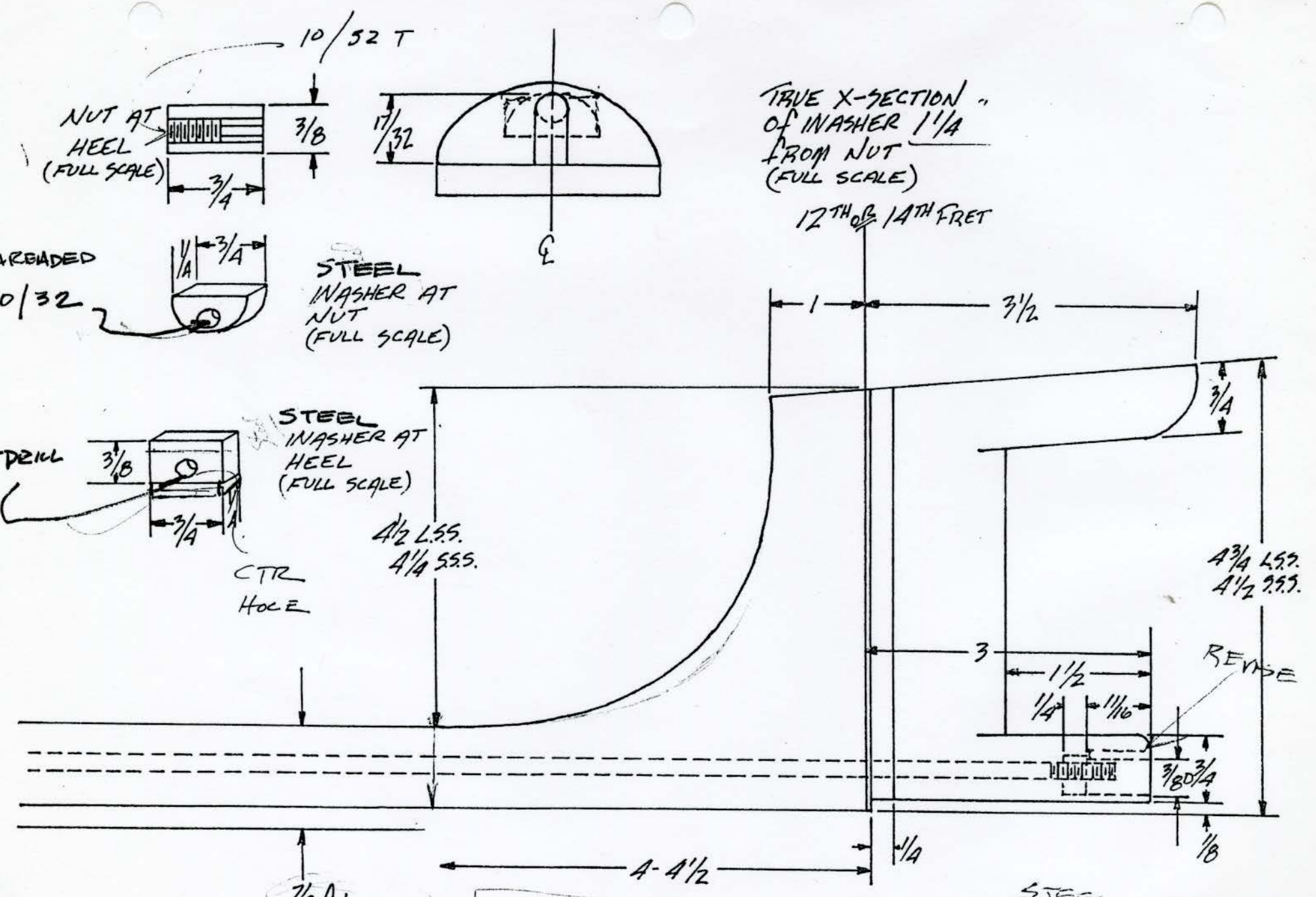
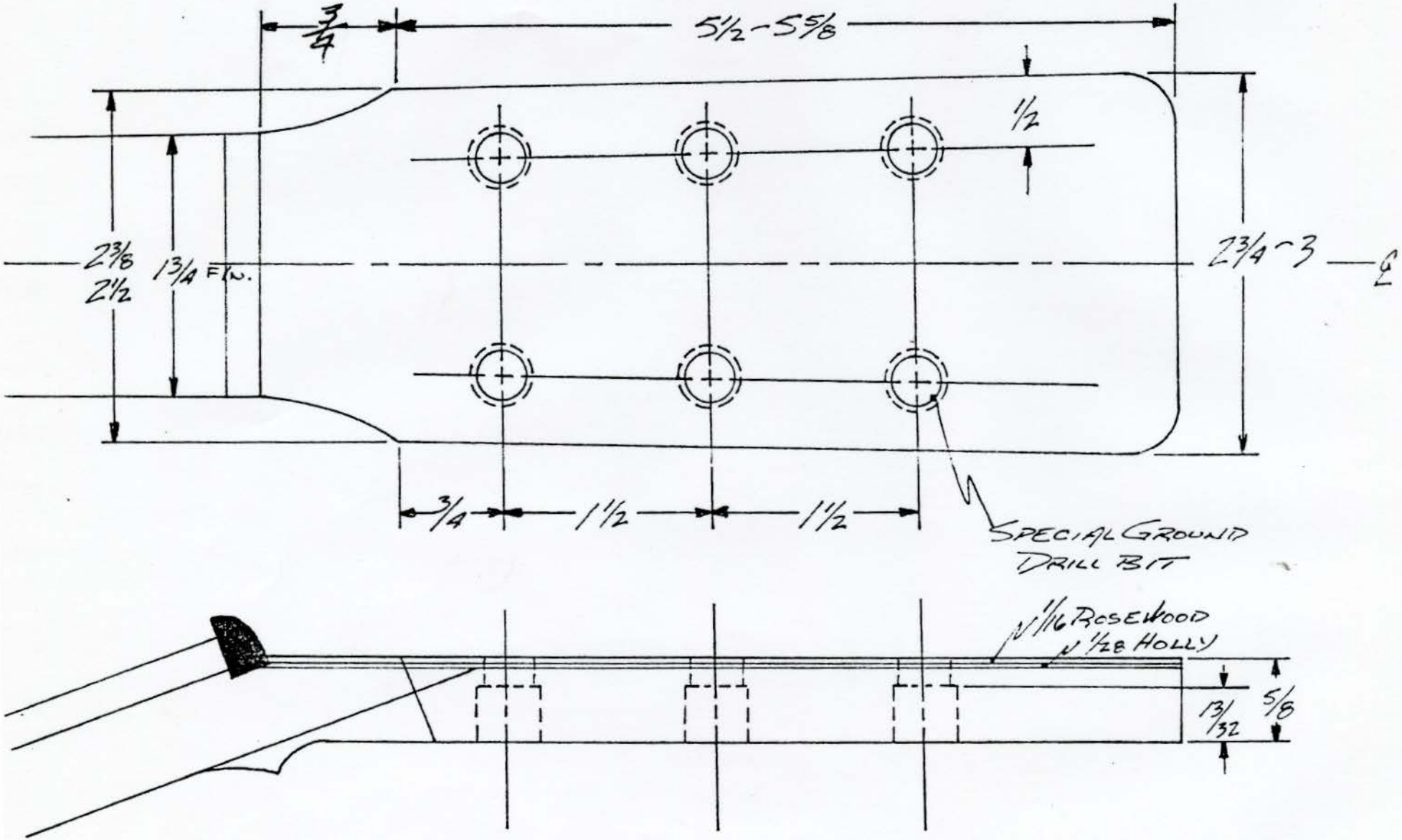


Groove 1/32" deep 1/4" wide from 1/4" end



SMALL CLASSICAL GUITAR
HEEL LAYOUT

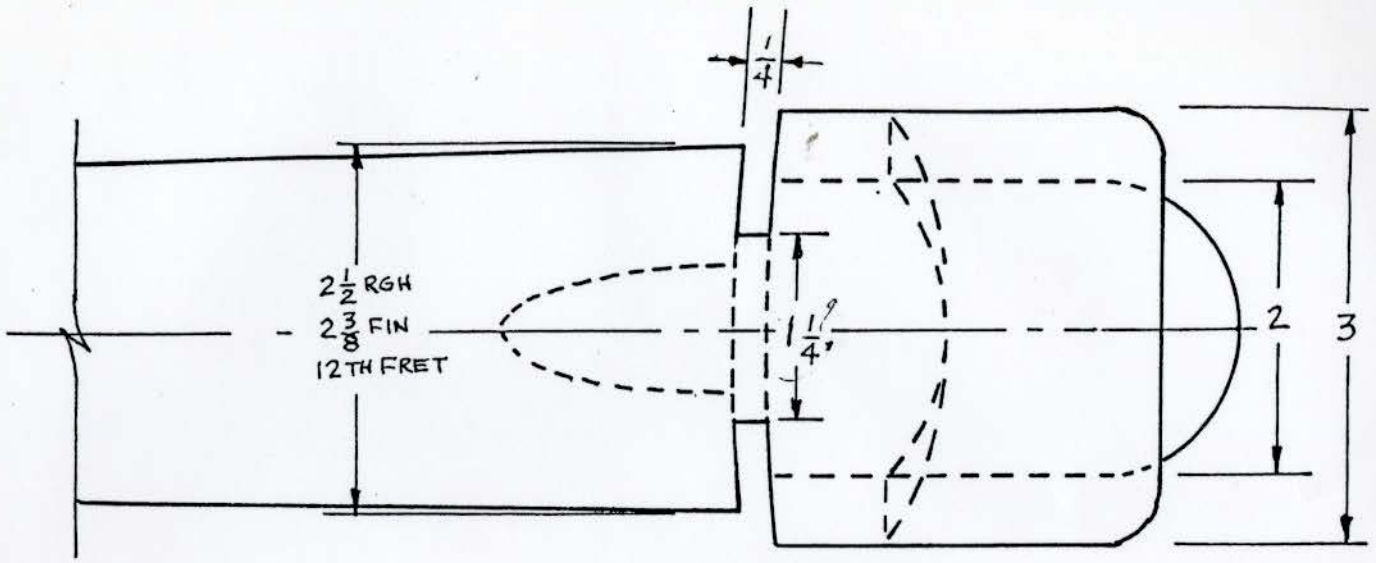

10/32 T
NUT AT HEEL (FULL SCALE)
3/8
3/4
17/32
℄
TRUE X-SECTION OF WASHER 1 1/4 FROM NUT (FULL SCALE)
12TH OR 14TH FRET
1
3 1/2
STEEL WASHER AT NUT (FULL SCALE)
1/4
3/4
STEEL WASHER AT HEEL (FULL SCALE)
3/8
3/4
CTR HOLE
4 1/2 L.S.S.
4 1/4 S.S.S.
4 3/4 L.S.S.
4 1/2 S.S.S.
3
1 1/2
1/4
11/16
REVISE
3/8
3/4
1/8
1/4
4-4 1/2
7/8 FINISHED
55/64" at 1st fret
59/64" Thick at 7th fret
Taper on overarm side
STEEL STRING SCALE 3/4 = 1
1 in = 2.1
17 A

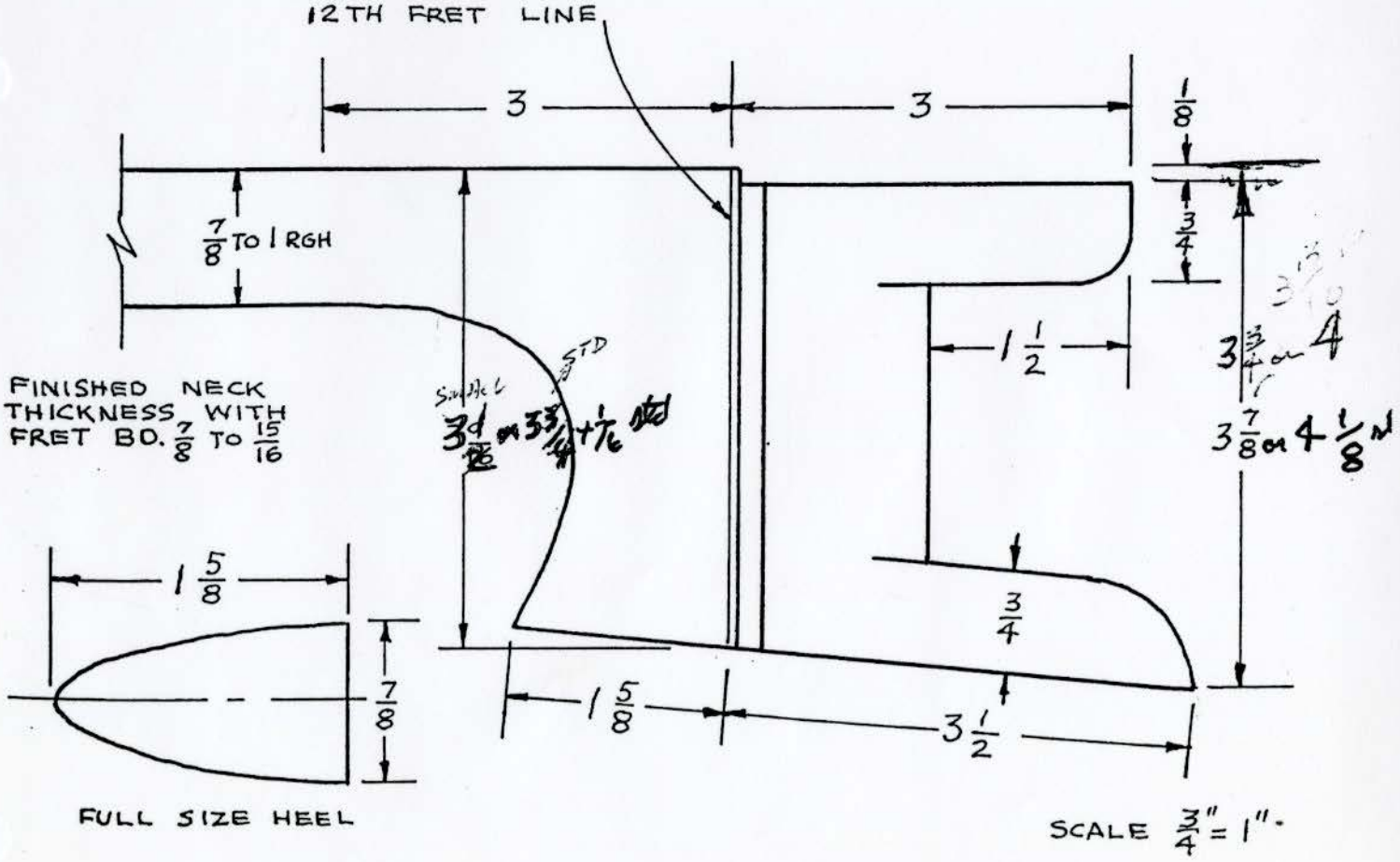


PEGHEAD PLAN, SIX-STRING, STEEL-STRING

—FULL SCALE—

WHF '84





SMALL CLASSICAL GUITAR HEEL LAYOUT

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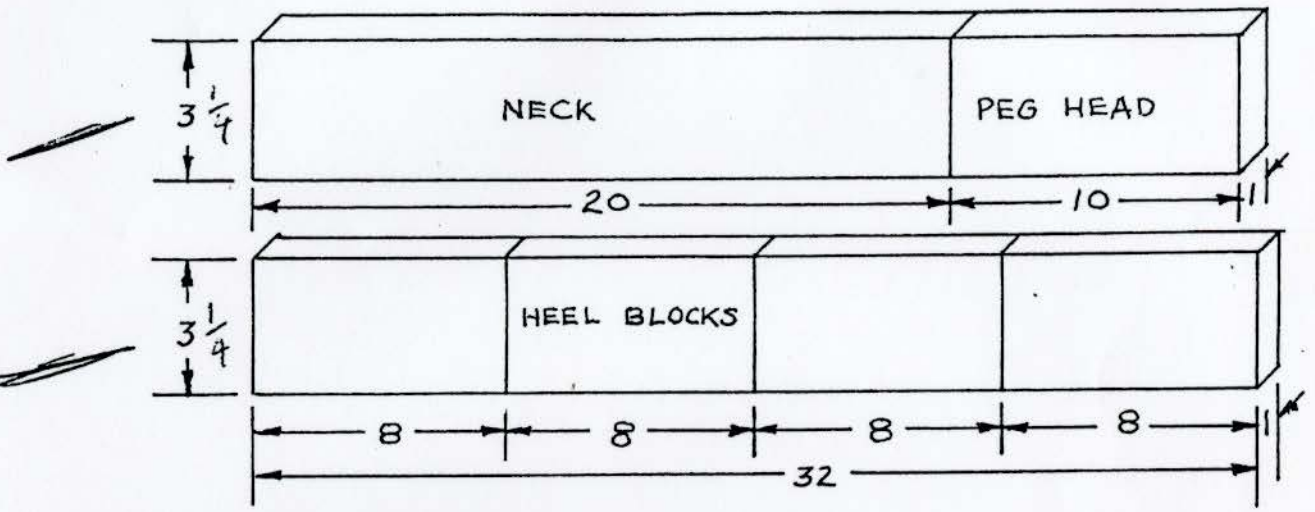
Neck Construction Outline

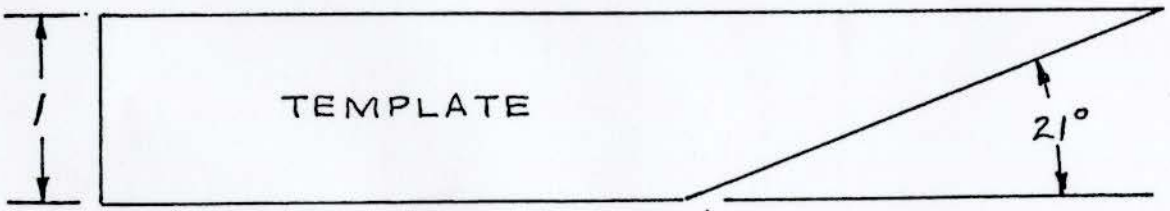
1. Select and prepare quarter sawed mahogany for the neck. The stock should have a rough thickness of 1 1/8" to 1 1/4". Face and surface this material to a thickness of 15/16" or 1". Refer to the sketch below.



2. Cut the 8" blocks to length and carefully hand sand the faces of the blocks to produce perfect joints.

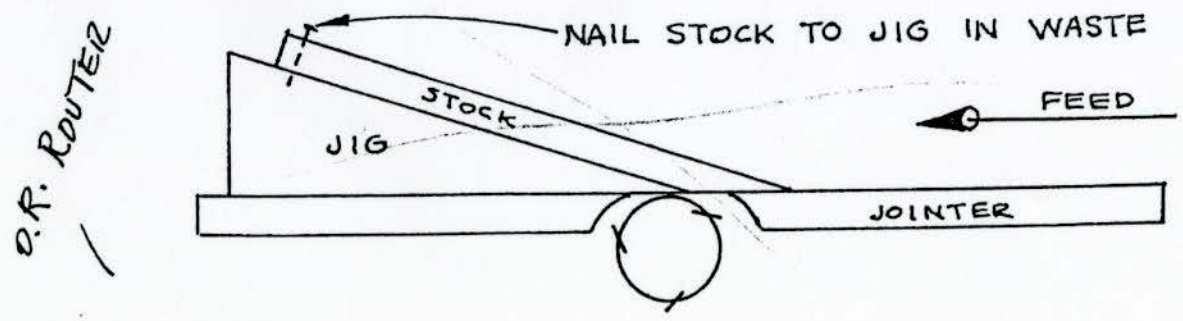
3. Cut a 10" block off of the 30" neck blank. This will be the peg head block.

4. Layout the 21° angle for the peg head on the 10" block. You may want to prepare and use a layout template such as the one shown below.

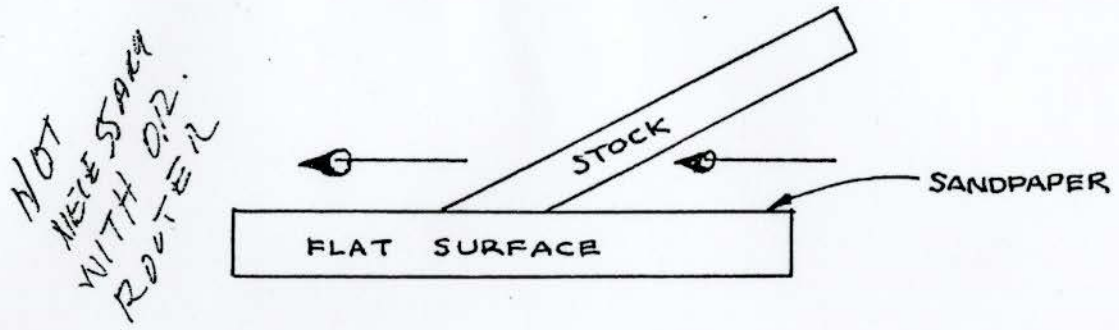


5. Saw the 21° angle on the 10" block using a bandsaw.

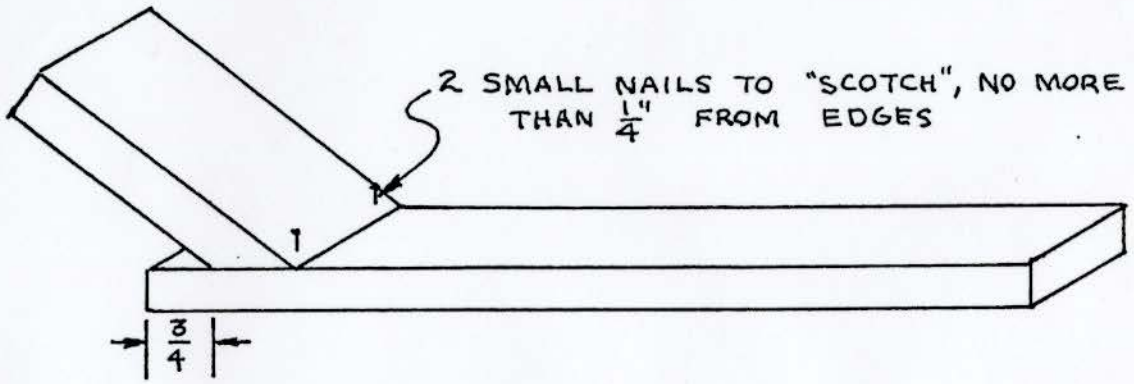
6. Joint the angled surface of the 10" block on a jointer using a jig such as the one shown below.



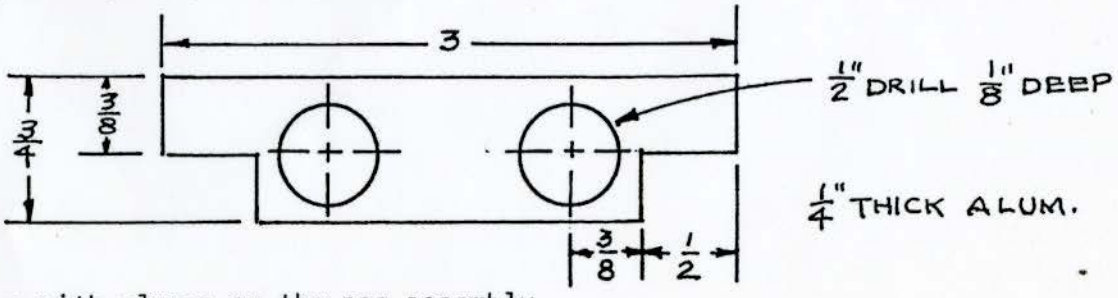
7. Block sand the jointed surface on the 10" block with 100 grit paper by hand to produce a good surface for gluing and a perfect joint. Refer to the illustration below.



8. Locate the peg head block 3/4" to 1" from the end of the neck blank. Use 2 small nails or brads to "scotch" the peg head. These brads should be placed no farther in than 1/4" from the edge of the neck blank so the holes they make can later be cut away.

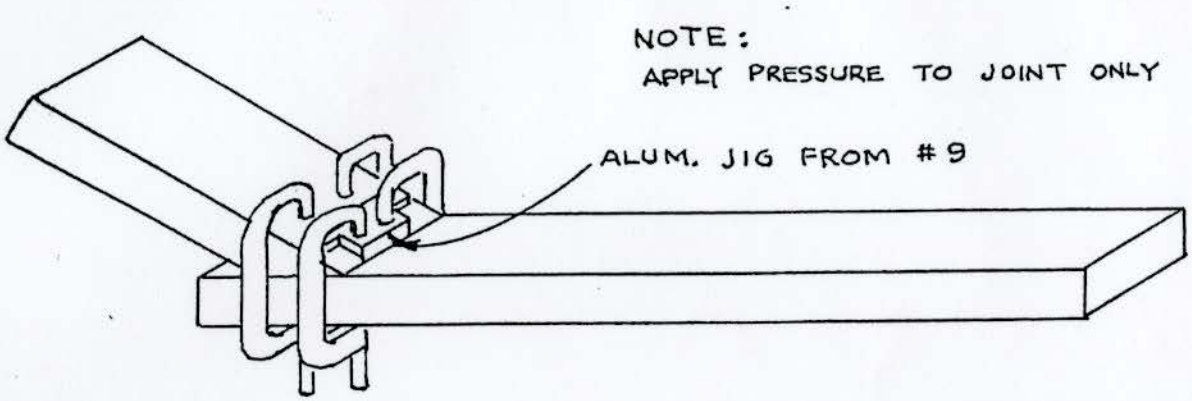


9. Make an aluminum device such as the one shown below to help keep the c-clamps from slipping when gluing the peg head.

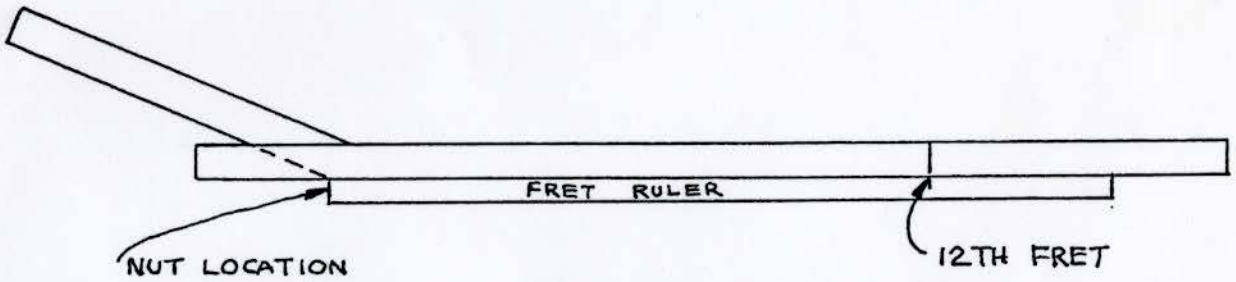


10. Make a dry run with clamps on the peg assembly.

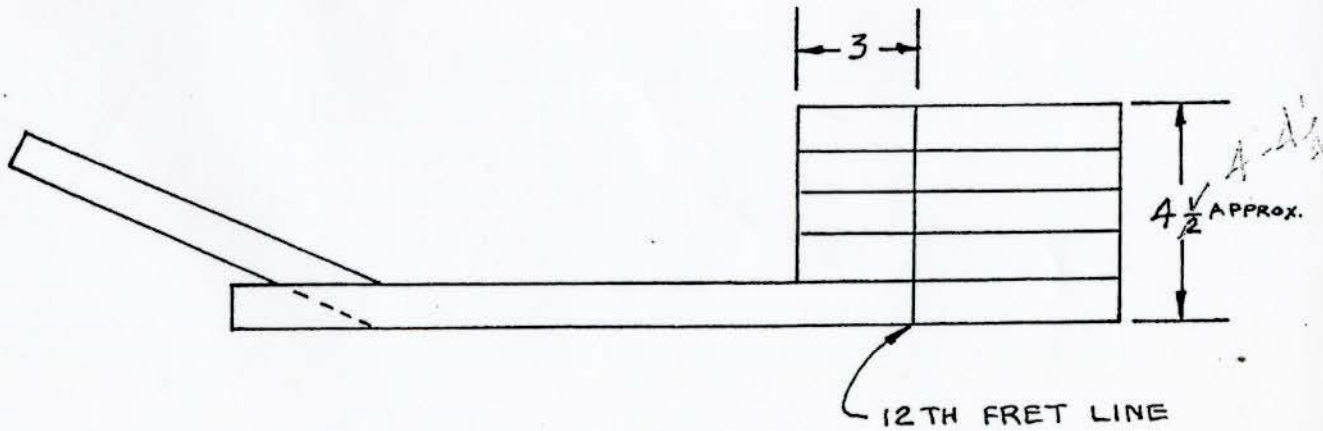
11. When the dry run is satisfactory remove the clamps and apply freshly made, thin hot animal glue to the surfaces to be joined. Tap the brads in place and apply 4 small c-clamps. Allow to dry. Refer to the drawing below.



12. Locate an approximate 12th fret line on the neck using a fret stick or fret ruler as show below.



13. Position the heel blocks using the 12th fret mark as a guide. The end of the blocks should be approximately 3" from the 12th fret mark as shown below.



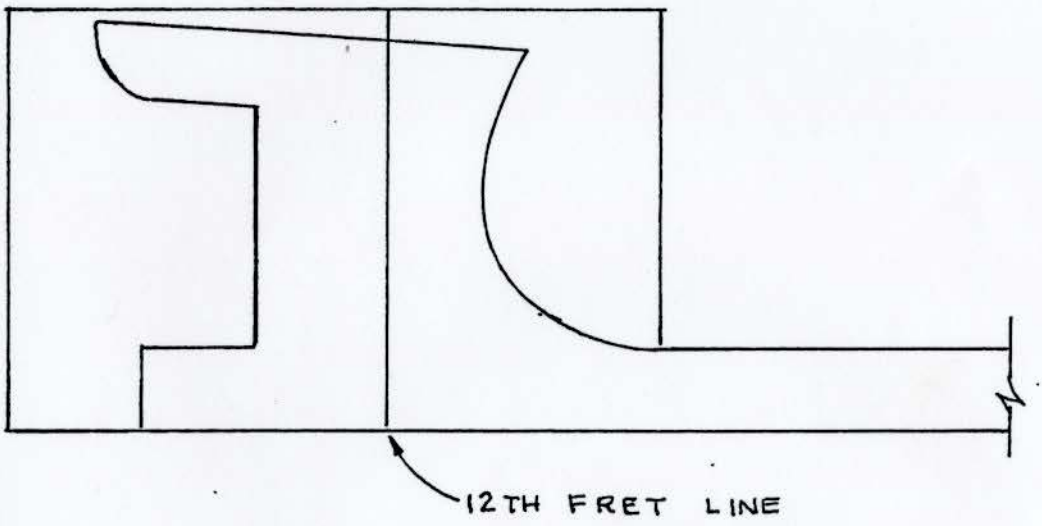
14. Glue the heel blocks in place using fresh, thin, hot animal glue and 4 or more C-clamps. Be careful with the alignment of the blocks. They tend to slide badly after glue is applied.

15. After glue has dried on heel blocks remove the clamps and scrape away excess dried glue.

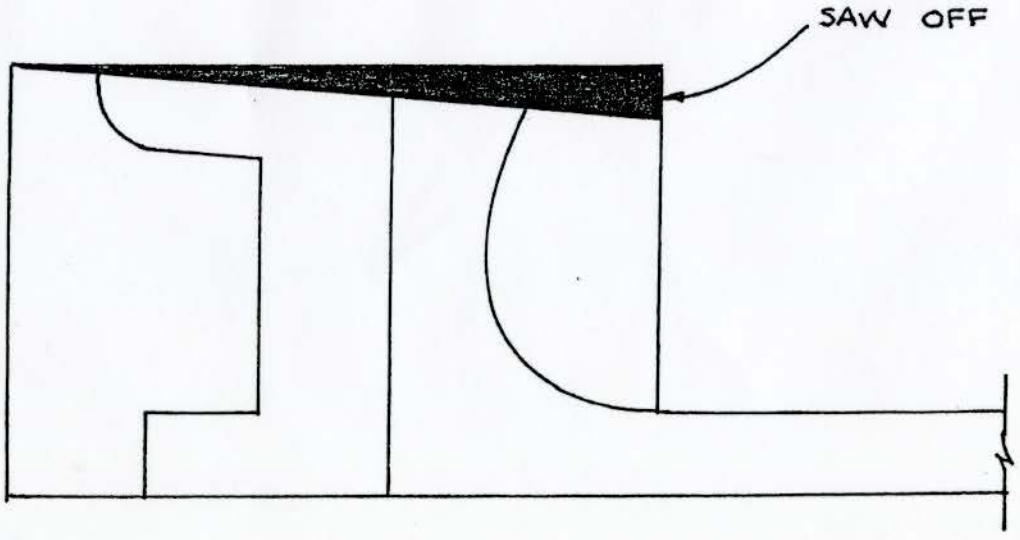
16. Square up the neck blank on a jointer. The face of the neck, which will later receive the fingerboard, should be on the same plane as the face of the peg head and these faces should be square with the edges of the neck.

17. Locate and mark a center line on the neck blank.

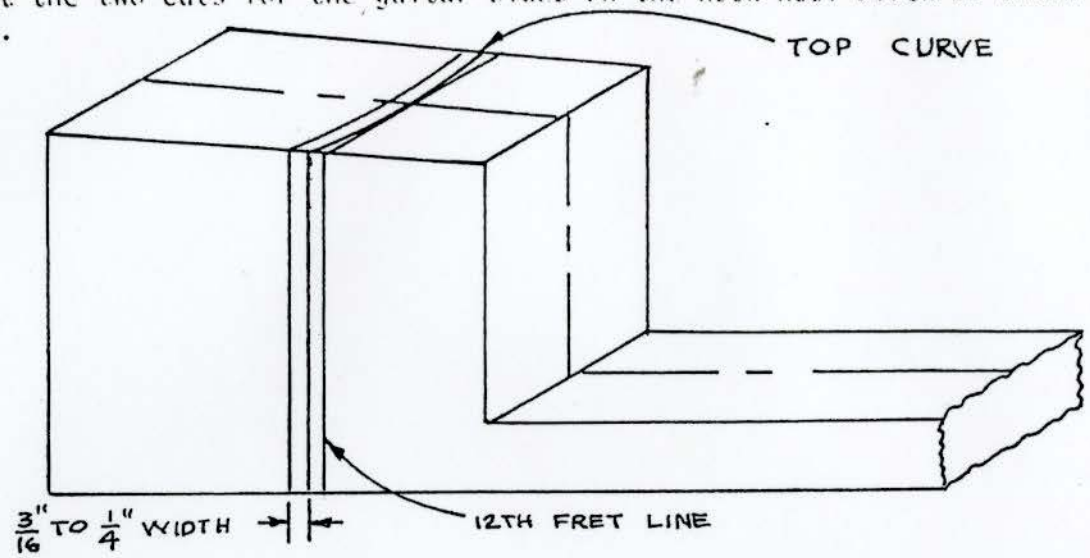
18. Layout the heel shape on the blank as shown below.



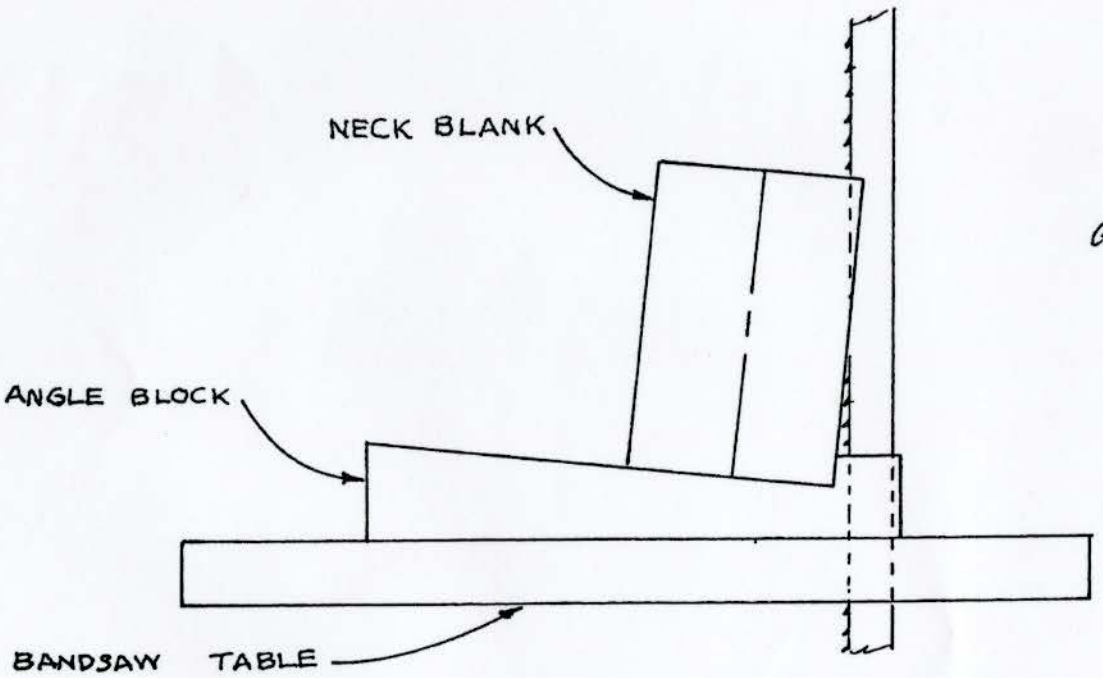
19. Saw off the excess wood from the heel foot as shown.



20. Layout the two cuts for the guitar sides on the neck heel block as shown below.



21. Saw out the two cuts in the heel for the sides using a bandsaw and two special angle holding devices as shown below.



NOTE: These cuts should be from 3/16" to 1/4" wide. They will touch the center line on the bottom of the heel and be approximately 1 1/4" apart on the top of the heel.

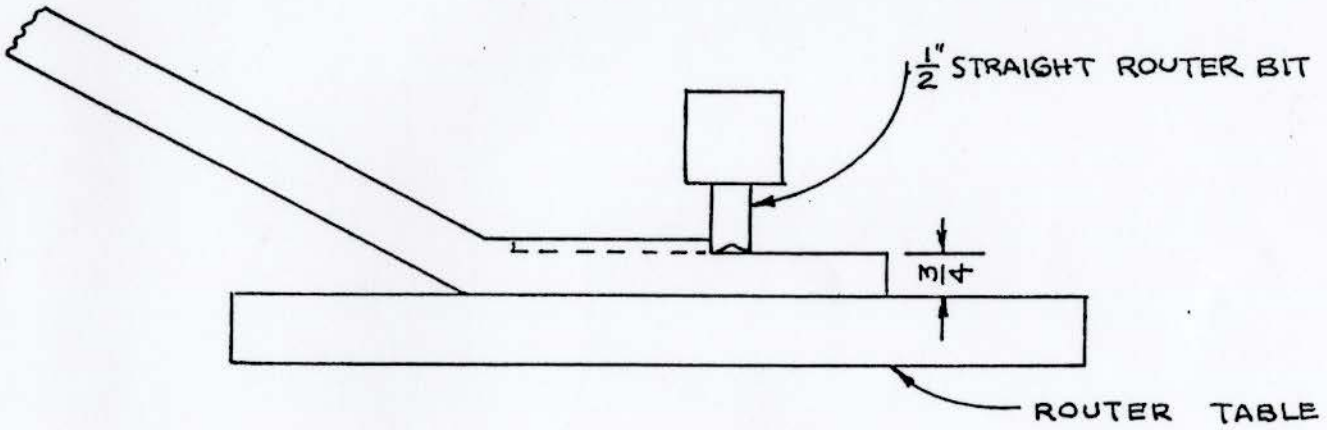
22. Cut away the remaining waste wood on the heel using a small bandsaw.

23. Shape the heel using a hand grinder with a burr, a knife and a file. Sand through 220 grit.

24. Layout the neck and peg head using the center line as reference.

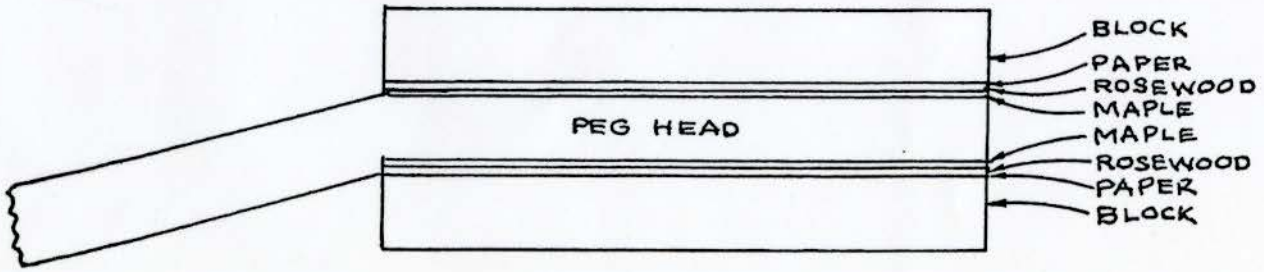
25. Prepare maple and rosewood laminates for the peg head. The rosewood laminates (2 required) should be a little less than 1/16" thick and the maple laminates 1/28" to 1/40" thick.

26. Cut the peg head to final thickness (3/4") using a straight bit in an over-arm pin router or a high speed drill press. Refer to the sketch below.



27. Laminate the veneers to the peg head. You can use small brads in waste wood to prevent slipping. Use special glue blocks which will not stick to the veneers and thin hot animal glue. Approximately six C-clamps are required.

TITEBOND



28. Trim dry laminates to peg head.

29. Layout peg head shape again on the rosewood using the center line as reference. Cut the outside taper on a bandsaw and smooth to finished width.

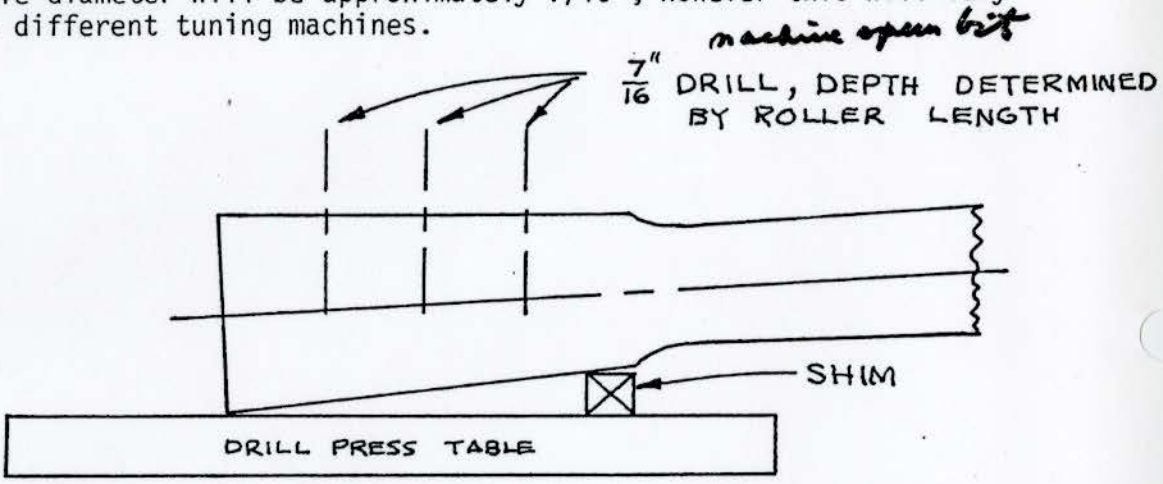
30. Layout the bottom peg head curve.

31. Shape the base of the peg head using a knife and file.

32. Select the tuning machines (machine heads).

33. Layout the holes for the tuning machine rollers. This layout must be carefully done.

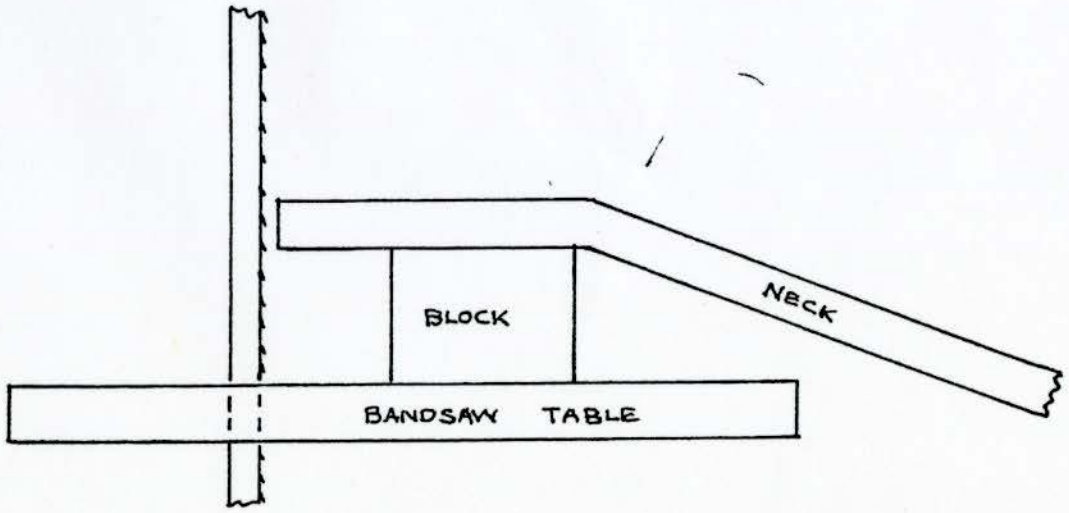
34. Drill holes for machine head rollers in a drill press using a shim as shown below. The hole diameter will be approximately 7/16", however this will vary sometimes with different tuning machines.



35. Fit the tuning machines by tapping them in place and then cutting away rivet areas with a small chisel so heads will seat absolutely flush.

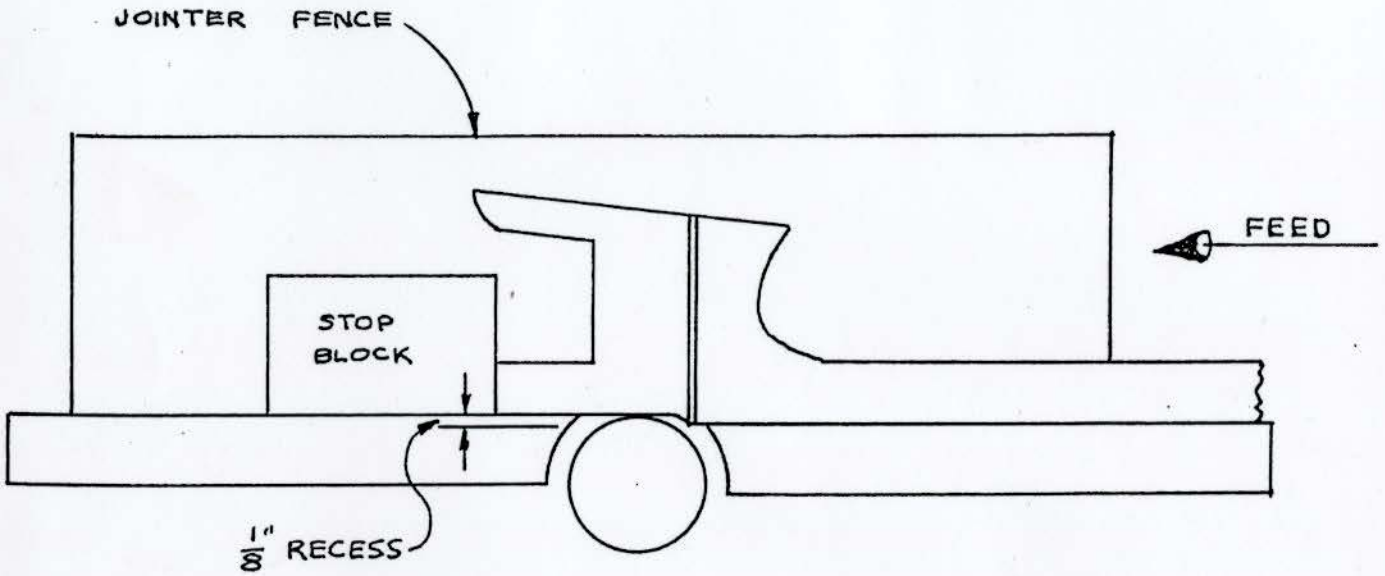
36. Layout and cut slots for tuning machines. Use a portable router and a special router guide to make the cuts.

37. Layout the head design above the slots and saw out using a band saw and the set-up shown below.



38. File and sand the peg head to finished shape.

39. Cut out the 1/8" recess on the top of the heel block. This recess is for the guitar top. The simplest way to make this cut is to set up a jointer for exactly 1/8" depth of cut. Clamp a stop block to the fence to stop the cut. Make the jointer cut and finish out the rounded part of the cut square with a knife and chisel. Refer to the sketch below for jointer set-up.



ROUTER PROCEDURE

40. The neck is now ready to have the sides fitted to it. It will be left in its present condition until after the guitar body is finished. It will be shaped to its final dimensions after the fret board has been installed.

CLASSIC GUITAR SIDES

Fabrication and Bending Procedure:

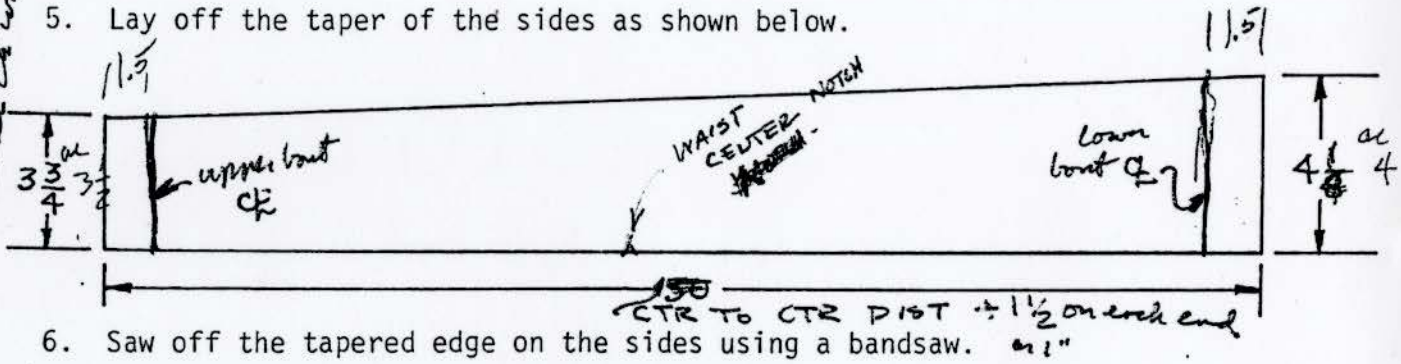
1. Select wood for the sides and the back at the same time. It would be best if the sides and the back were cut from the same piece of wood, however, this is frequently impossible. The grain and color of the sides and back should match reasonably well and the pieces should be book matched.

2. Plane or sand the sides to final thickness. (.090" ± .002")

3. Cut the sides to rough length, 30" to 32". - max to fit in mold is 35"

4. Edge one edge of each side straight on the jointer. This straight edge will be the part of the sides which is glued to the guitar top. Be sure to remember that the sides should be book matched when they are installed on the guitar.

5. Lay off the taper of the sides as shown below.



6. Saw off the tapered edge on the sides using a bandsaw.

7. Edge the bandsawed edges with one light cut on a jointer.

8. Cut a small notch on each side on the straight edge. This notch will serve as a identifying mark for the straight edge when bending.

9. Place one side in the ~~boiling~~ steaming tank and ~~boil~~ steam approximately ~~two~~ hours. ~~Be sure that the side is always covered by water during boiling~~. At the same time you start a side in the ~~steaming~~ tank you should turn on the heat on the bending mold so it will be sufficiently hot when boiling is complete.

10. Remove the side from the boiling tank and turn off the hot plates.

11. Quickly place the boiled side in the hot bending mold.

12. Cook the side in the bending mold approximately ~~five~~ 2 1/2 hours then turn off the mold heat. Leave the side in the mold until the mold has reached room temperature. (5 to 6 hours)

13. Remove the side from the cool mold and immediately clamp it to one side of your assembly mold. Use the 3/4" x 5/8" x 4 3/4" blocks and C-clamps

to clamp the side to the mold. Place the blocks about every three inches, or at least be sure that the side is firmly fitted against the mold. Caution: The portion of the side which projects above the mold is very vulnerable, it is easy to split (scissor). Be Careful.

14. Repeat the above procedure with the second side being sure to carry out the book matching idea.

CLASSICAL GUITAR TOP FABRICATION

Fabrication Procedure:

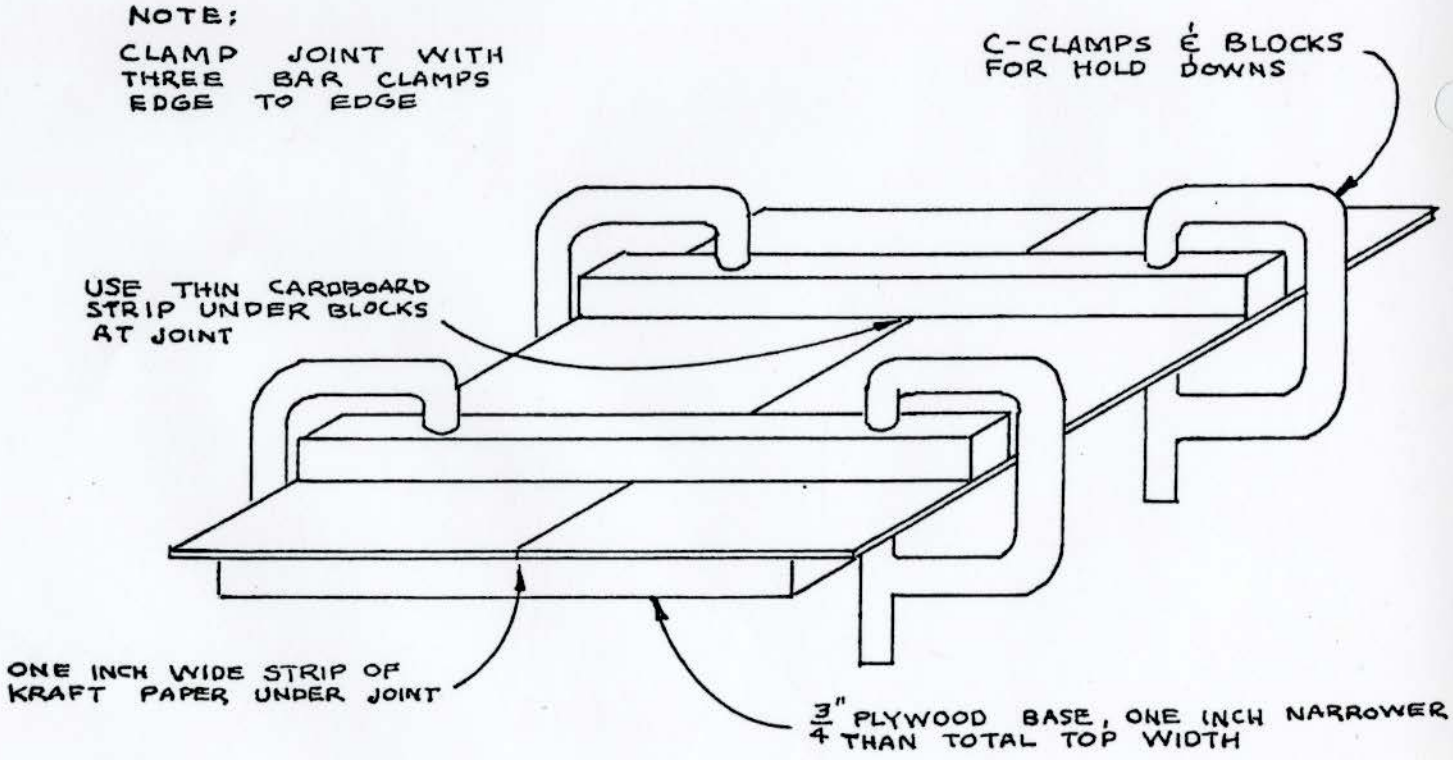
1. Select book matched, quarter sawed, European or Sitka spruce for the top. Machine sand the faces of the top boards lightly so you can see the grain pattern.

2. Locate the edges which should be joined together to produce the best top appearance.

3. Prepare the joint using light cuts on a sharp jointer. Strive for a perfect joint -- not a spring joint.

4. Make a dry run on the joint assembly with clamps.

5. When the dry run is satisfactory apply thin hot glue to both halves of the joint, "saw" the edges together to remove excess glue, and clamp as shown below. You must work fast during this assembly and probably need a helper.



6. Allow the top to dry.

7. Remove clamps and machine sand or plane the top on both sides. The objective here is to simply get the faces of the top flat. You should leave the top over thickness now (.100 to .110).

8. Lay out a center line on both sides of the top. Try to make the center joint the center line.

9. Select a face side.

10. Layout the outline of the outside edges of the top using a template.

11. Saw out the outline of the top using a bandsaw. Sand the edges of the top until it fits into the assembly mold.

12. Locate the center of the sound hole 5 7/8" from the end of the upper bout.

13. Select a sound hole rosette (inlay).

14. Tack the top to a 3/4" plywood back board for support. Use four small brads or tacks in the waste wood in the center of the sound hole. Be sure that the backing board is flat and uniform in thickness.

15. Set up a fly cutter in the drill press. — Dremel procedure

16. Clamp the top and its backing board firmly to the drill press table.

17. Cut the groove for the sound hole rosette starting with the outside first. The cut depth should allow the inlay to be perfectly flush with the top or just slightly below flush.

18. Cut until inlay fits exactly. — Dremel procedure

19. Reset the fly cutter and cut out the sound hole. The sound hole opening should be 3 1/8".

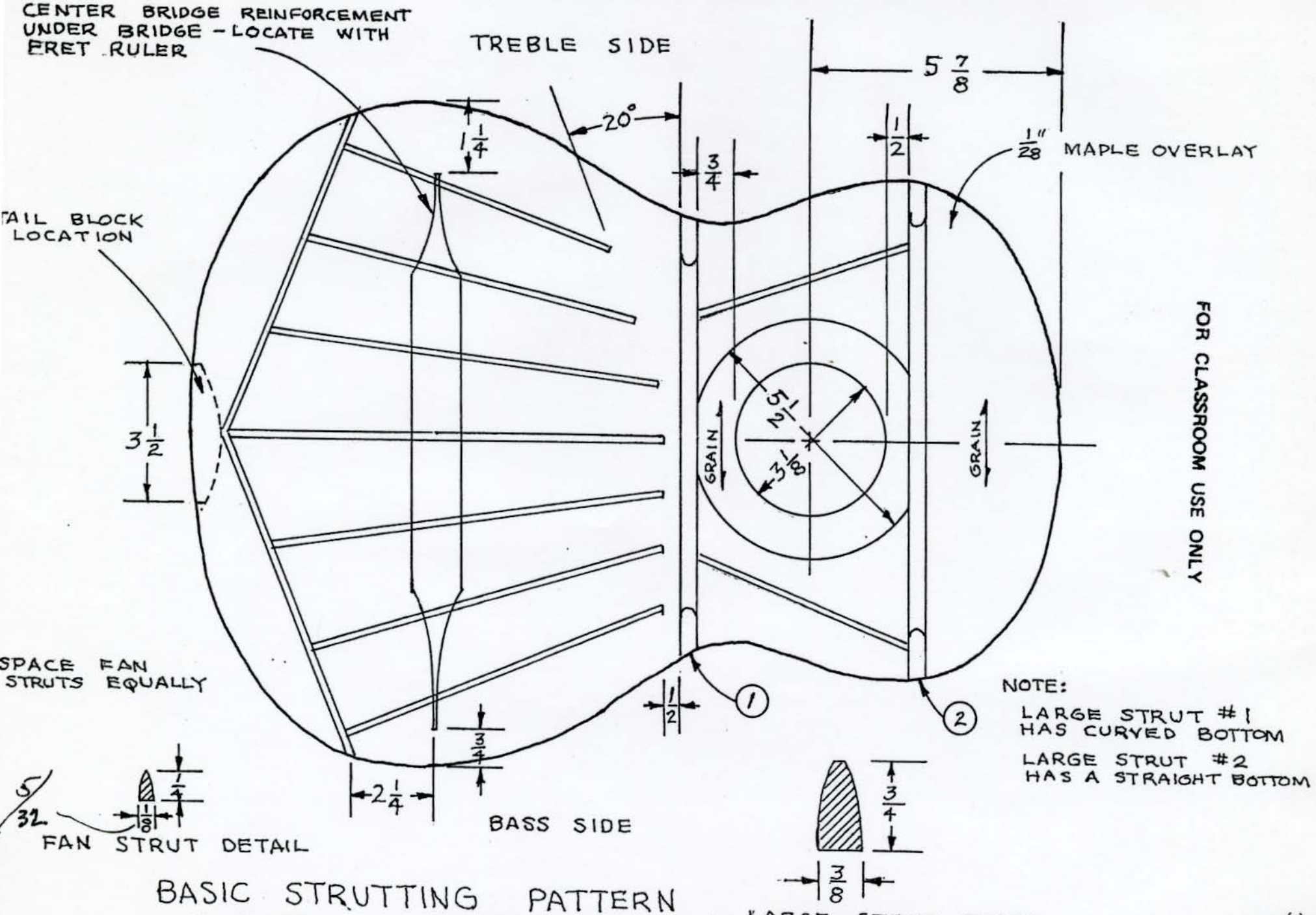
20. Glue in the sound hole rosette using circular clamping blocks above the inlay and as a back up under the top. Clamp through the sound hole using about seven small C-clamps. Be sure to put wax paper between the clamping blocks and the inlay.

21. Allow the glue to dry at least over night.

22. Carefully sand the top surface of the top flat, remove as little wood as possible. Turn the top over and sand it to final thickness from the back side. The final thickness should be .090" plus or minus.002".

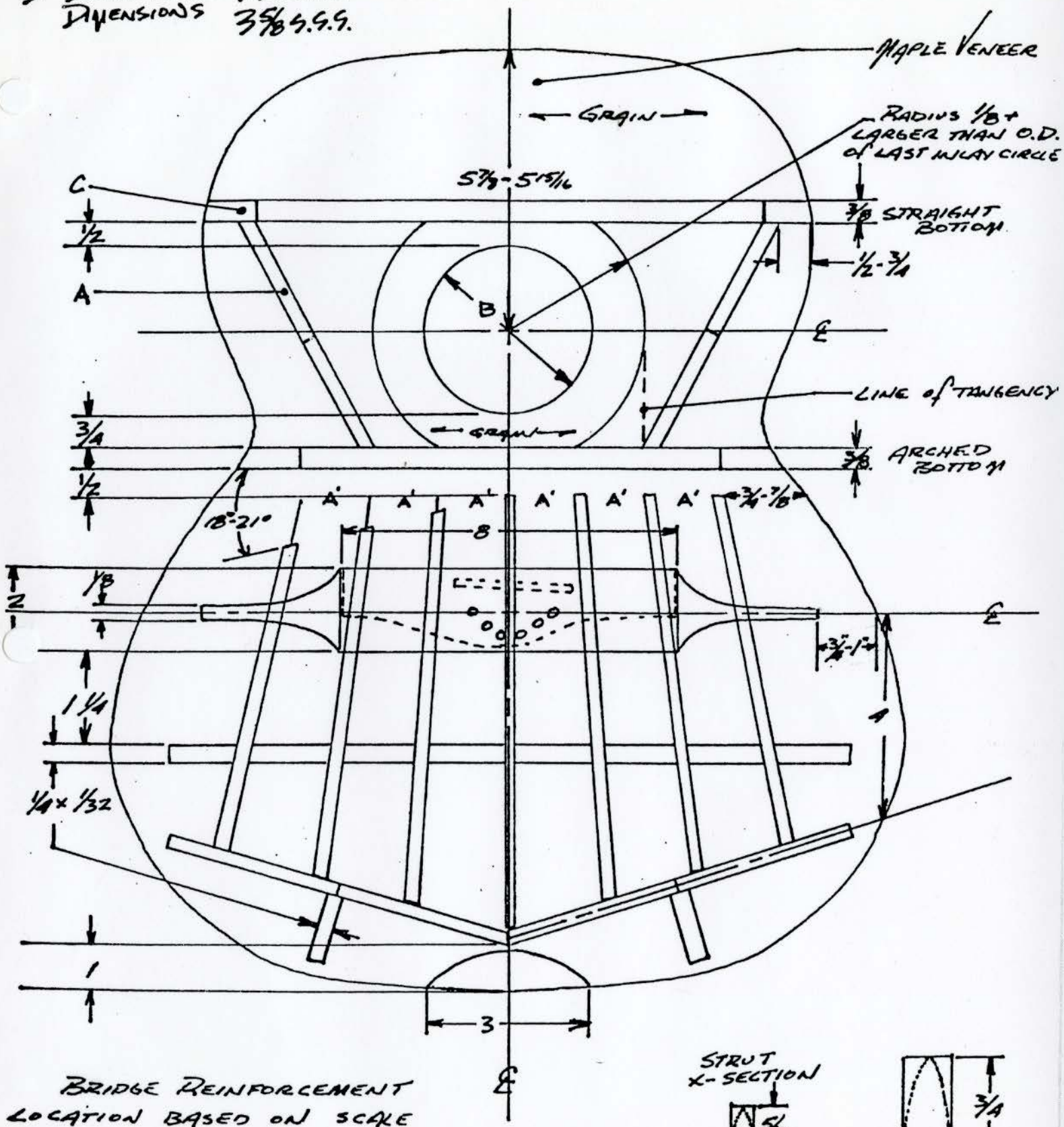
23. After the top is sanded it is easily damaged. Protect it when storing and handling.

24. Layout the top struts as shown in the drawing on the following page.



BASIC STRUTTING PATTERN
CLASSICAL GUITAR

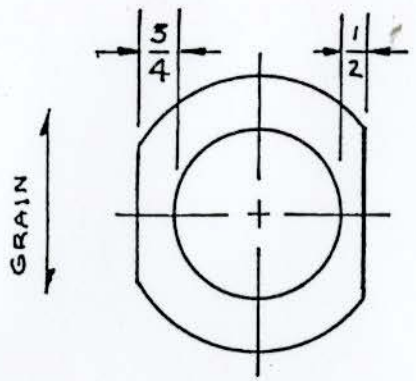
B-SOUND HOLE 3 3/4 L.S.S.
DIMENSIONS 3 5/8 S.S.S.



BRIDGE REINFORCEMENT LOCATION BASED ON SCALE LENGTH. LOCATE USING A BRIDGE BLANK & FRET RULER.

"STEEL STRING-
FAN STRUTS"

25. Cut out a circular piece of Sitka spruce for a sound hole reinforcement as shown below.



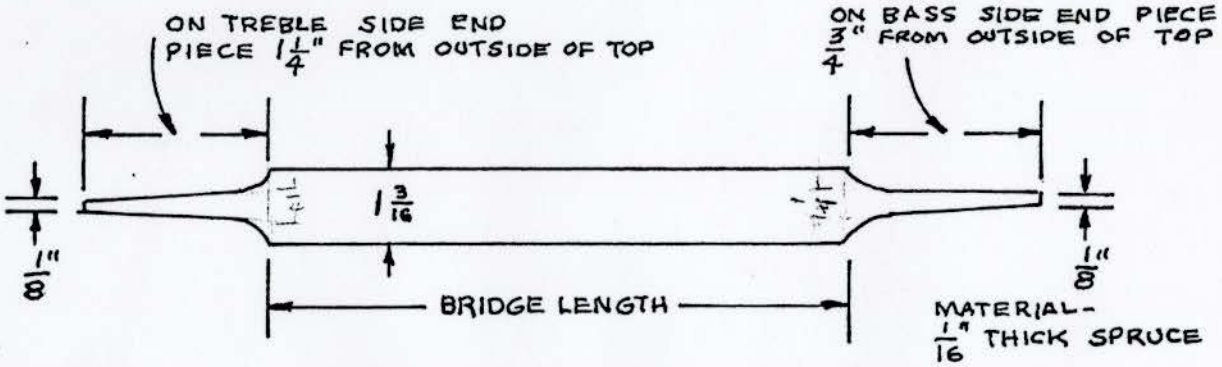
$5\frac{1}{2}$" OD
$3\frac{1}{8}$" ID

$\frac{1}{8}$" THICK SPRUCE

FULL SIZE SECTION OF REINFORCEMENT AFTER TRIMMING

26. Glue in the sound hole reinforcement through the sound hole on a strutting table using about seven small C-clamps and hot glue. After drying trim the reinforcement to finished shape.

27. Fabricate a bridge reinforcement piece from 1/16" thick spruce as shown below.



BRIDGE REINFORCEMENT PIECE

28. Fabricate the two large struts for the top. One of these struts is straight on the bottom and the other one has a curved bottom. Prepare the curved bottom strut using a special jig and the over-arm pin router. The parabolic shape of the top of these struts can be formed by sanding on a belt sander.

29. Cut the two large struts to rough length. They should overhang the top about 1/8" on each side.

30. Prepare the wood for the fan struts. Use quarter sawed Sitka spruce. These pieces should be 5/32" x 1/4" in cross section.

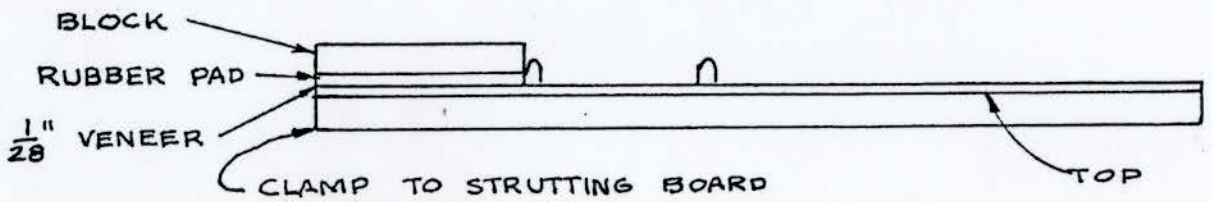
31. Cut the parabolic shape on the top of the fan struts using a special portable router set-up.

32. Locate and glue in the two large struts above and below the sound hole.

33. Locate and glue in the bridge reinforcement piece. Trim the ends of the reinforcement piece after the glue dries.

34. Prepare a 1/28" maple laminate to be glued in the upper part of the upper bout.

35. Glue in the upper bout maple reinforcement as shown below.



36. Cut the fan struts to finished lengths.

37. Cut notches in the bottom edge of the fan struts to fit over the bridge reinforcement. A small table saw is useful for cutting these notches.

38. Glue the fan struts to the top with hot animal glue.

39. Trim the top fan struts. The more trimming you do the louder the guitar will be and the "boomier" the bass. Excessive trimming should be avoided since it seriously weakens the top plate. It is better to leave the struts heavier than you think necessary at first. You can always trim them through the sound hole after the guitar is assembled.

40. Sand the fan struts after trimming with 220 paper.

41. Finish shaping the large struts around the sound hole, and sand.

42. Install the two small struts beside the sound hole, glue trim and sand.

43. The top is not ready for installation. Keep it wrapped in a plastic bag until you are ready to install. Check the top occasionally to be sure it still has its arch. Occasionally tops will loose their arch and actually become concave. If this happens to you, you can simply go over the concave surface with a damp cloth and return the top to its plastic bag. It should reverse itself.

BACK FABRICATION

Procedure:

1. Select wood for the back that matches the grain and color of the sides as closely as possible. The back material should be quarter sawed and bookmatched.

2. Sand or plane the faces of the back pieces lightly until the grain pattern is clearly visible.

3. Locate the edges to be joined.

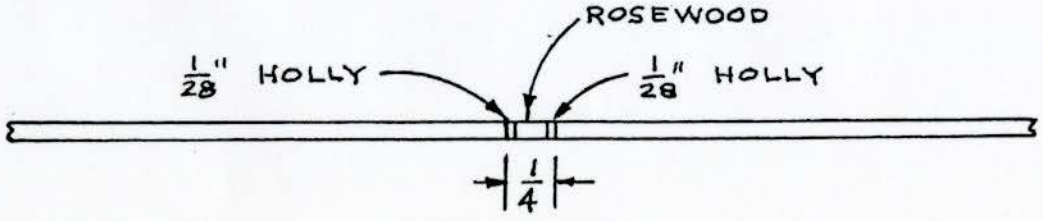
4. Make a butt joint on the back pieces using a jointer. Strive for a perfect joint.

5. Some luthiers recommend that rosewood backs be "depitched" before they are assembled. The natural oil in rosewood does present special problems in gluing and finishing on occasions. Builders will sometimes attempt to remove some of the oil from rosewood by soaking it in acetone. Others simply wipe acetone over the surfaces to be glued just prior to gluing to remove surface oil and hopefully produce a better joint. Mr. Haile has used both of the above techniques but most of the time he will simply be sure that the rosewood surfaces to be joined have just been freshly cut and glues with hot animal glue without special treatment. He seldom has a joint failure.

6. Prepare the inlay strip for the back. Make sure that the strip you prepare is long enough to make the inlay for the end of the lower bout. The back will require about 20" and the end of the lower bout about 5", a total length of 25" to 26". The inlay strip should be made so that it is the same thickness as the back and no wider than 1/4". It is usually made by ripping a piece of rosewood on a small table saw to 1/8" x 3/16" x26", then rip two strips of 1/28" maple or holly veneer 1/8" x 26". These three pieces of wood are then glued together with hot animal glue. The easiest way to clamp this assembly while the glue dries is to simply wrap the pieces with rubber bands from end to end. After wrapping the strip be sure it is reasonably straight before setting it aside to dry. It can easily become twisted with rubber band pressure.

7. After the glue has dried on the back inlay strip it must be carefully trimmed square in cross section on a small table saw.

8. Make a dry run assembly of the back joint with the inlay installed. Refer to the sketch below.



BACK JOINT

9. If the dry run checks out proceed to glue the back pieces together using the same clamping procedure that was used to glue the top together. (page 29)

10. Plane or sand the back to final thickness (.090") -100- Be sure that both faces are flat and smooth.

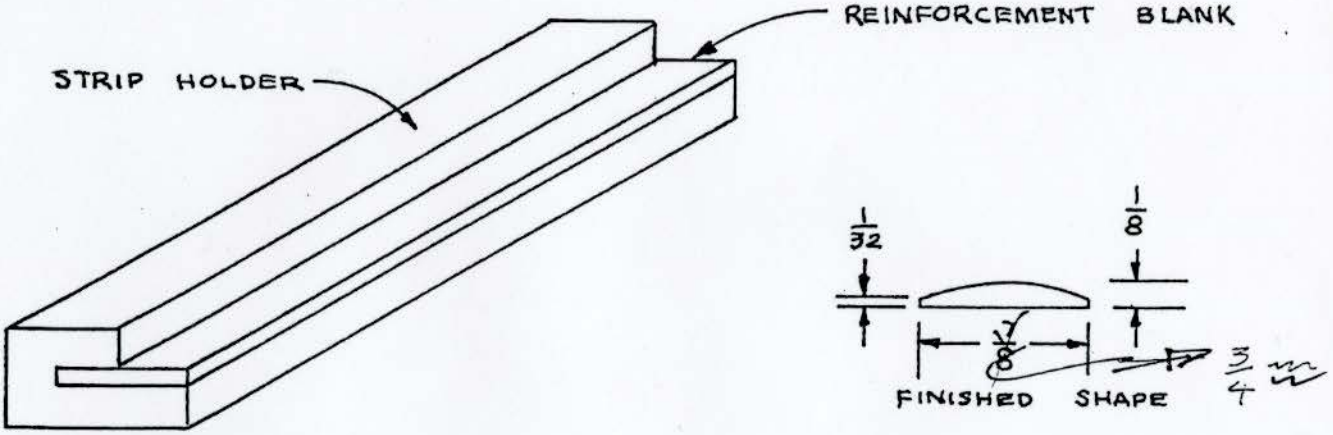
11. Layout a center line on the back assembly.

12. Using the center line as a guide layout the outside shape of the back using your pattern.

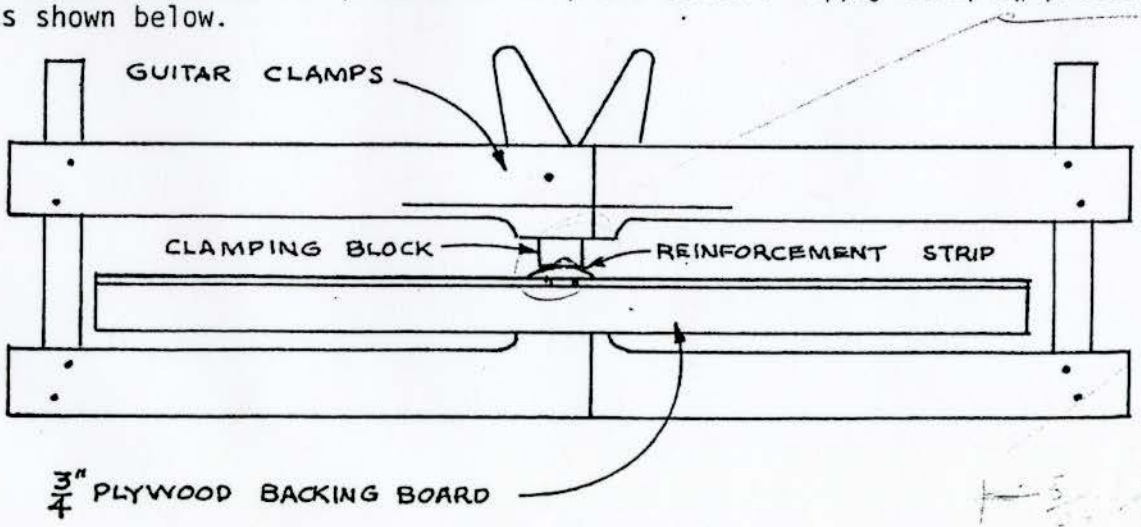
13. Cut the back to shape on a small bandsaw.

14. Prepare the material for a back reinforcement strip 1/8" x 18"x ~~7/8~~ 3/4". The grain on this piece must run across the ~~7/8~~ 3/4" dimension.

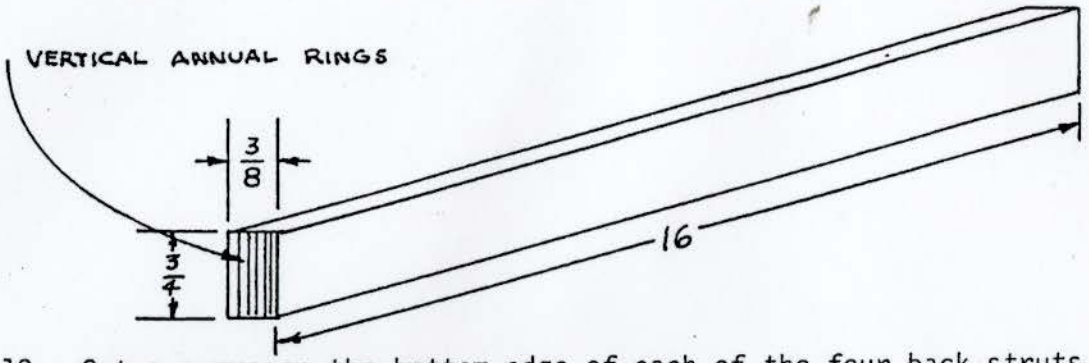
15. Round over the top surface of the back reinforcement strip. Hold the strip in a device such as the one shown below and sand the top surface to rough shape with a portable disc sander. After disc sanding smooth with hand sanding to the shape shown below.



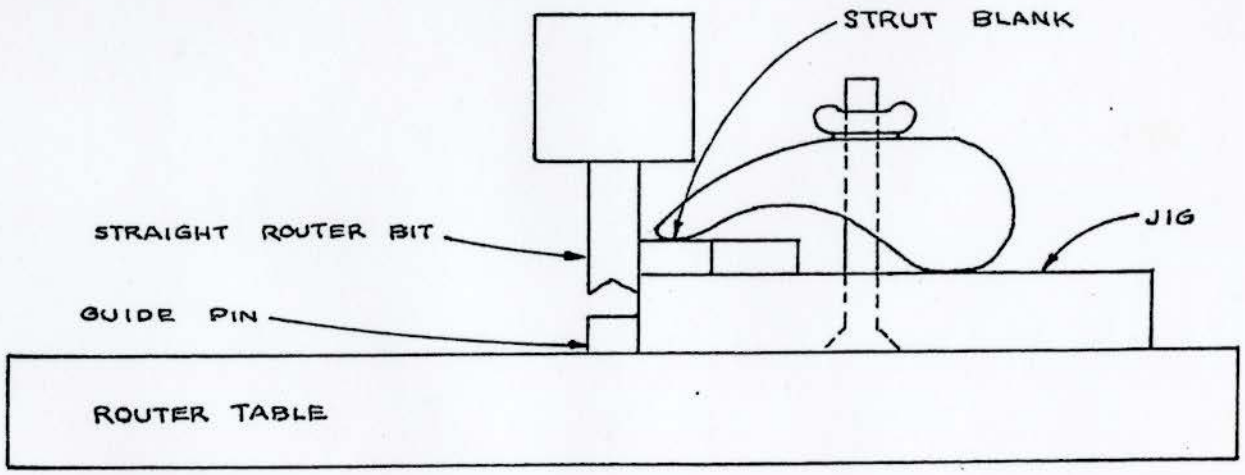
16. Locate and glue in the back reinforcement strip. Be careful during this process since the strip tends to slip off center. Apply clamping pressure as shown below.



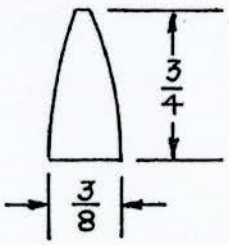
17. Prepare the wood for the four back struts 3/8" x 3/4" x 16". Use quartered spruce and mahogany. The annual rings on these pieces should be vertical on the 3/4" dimension as shown below.



18. Cut a curve on the bottom edge of each of the four back struts. This curve will form the arch of the back. It is actually an arc segment of a circle with a radius of 25 feet. This curve will cause the back to be about 1/8" higher in the center than it is at the edges. The simplest way to cut this curve is to made a shaper or over-arm pin router jig to hold the strut blanks and cut the shape against a shaper collar or pin using a straight cutter. Refer to the drawing below.



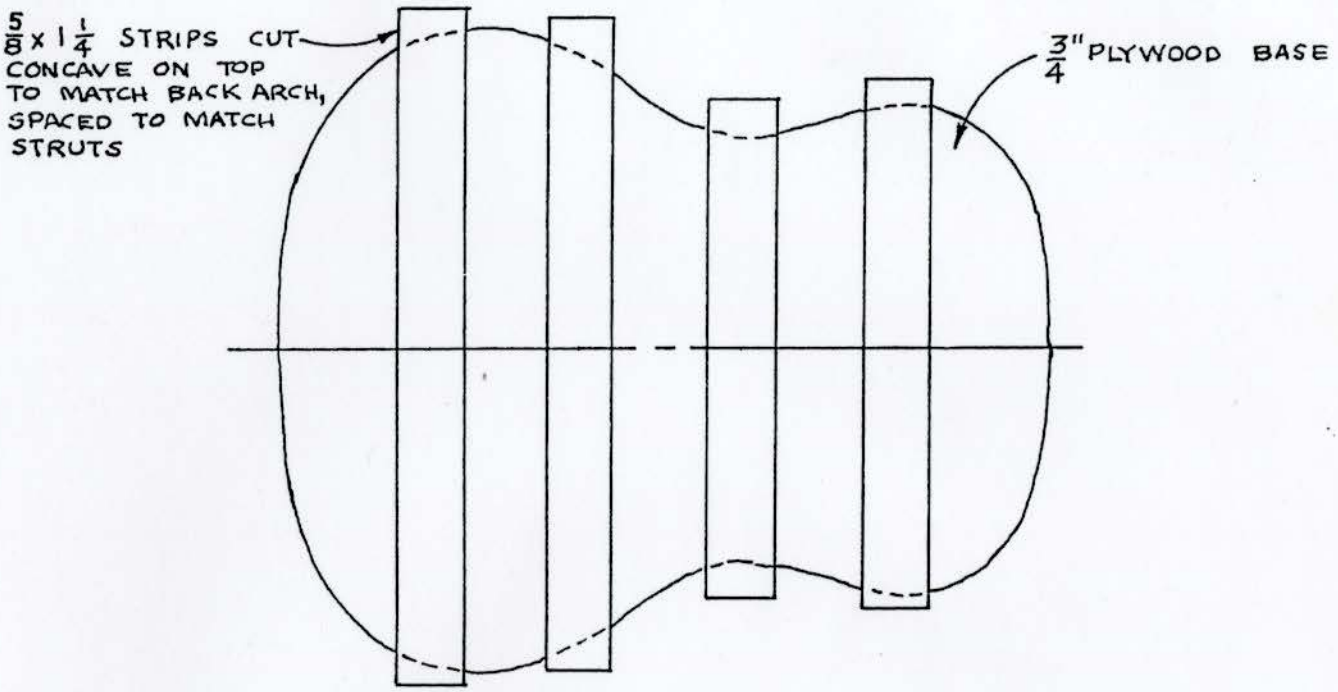
19. Shape the top edge of the back struts on a belt sander to the parabolic shape shown below.



20. Locate the back struts as shown in the drawing on the following page.

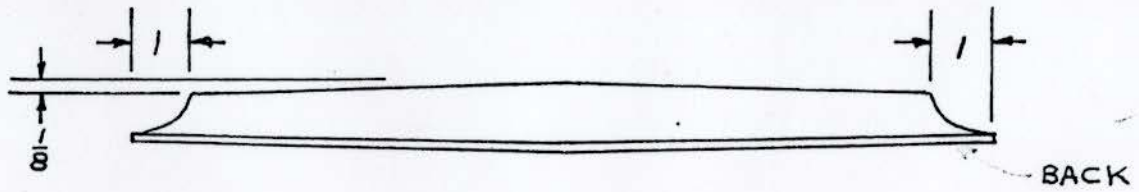
21. Carefully saw and chisel away the back reinforcement strip under each strut so the strut will contact the back all the way across.

22. A back strutting board such as the one shown in the drawing below should be prepared so it can be used to glue in the back struts.



23. Glue in the back struts using the strutting board.

24. Trim the back struts to length and shape the top of each as shown below.



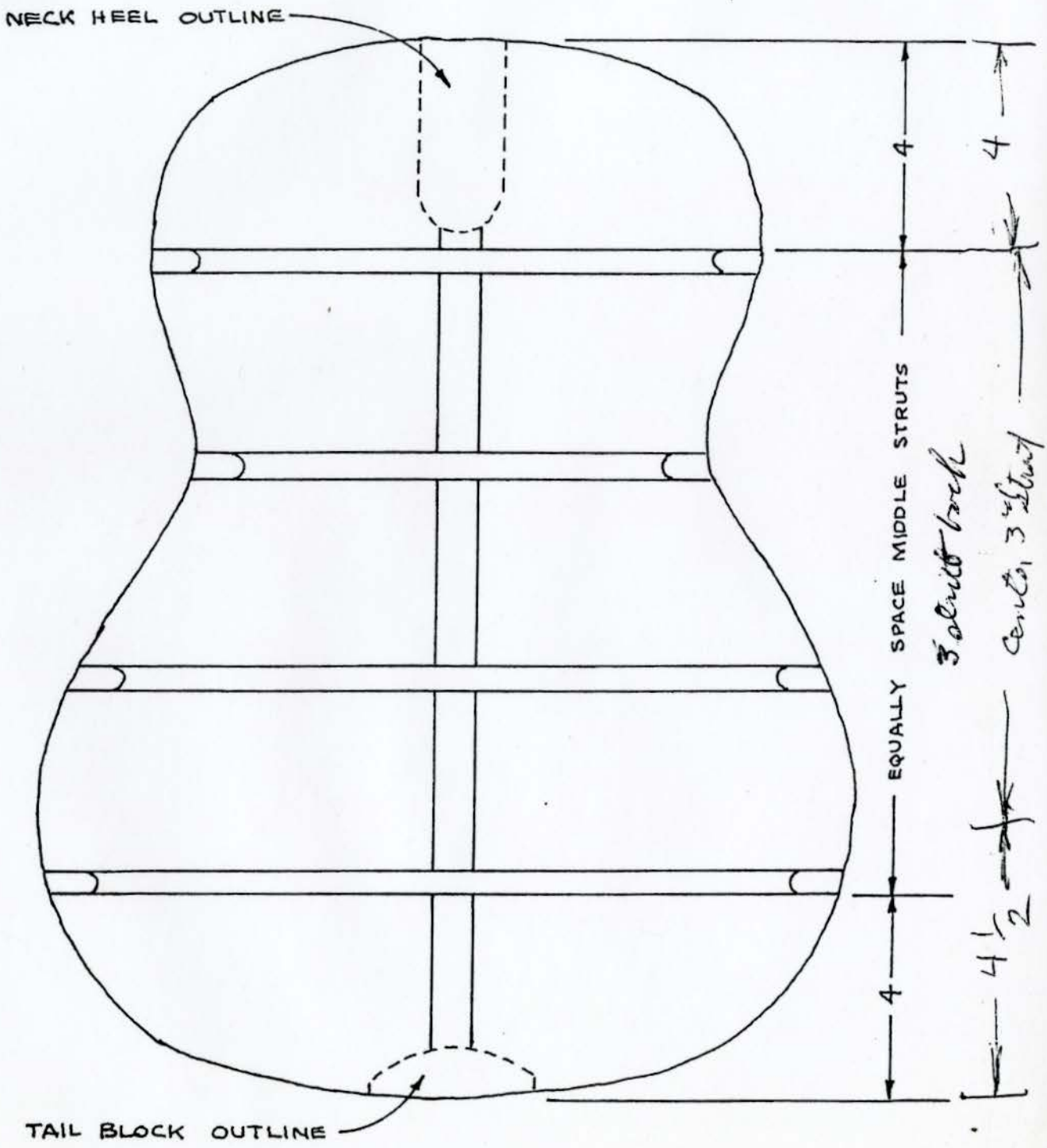
25. Trim away excess back reinforcement strip to make room for the tail block and the neck heel.

26. Sand the back and struts through 220 grit.

27. Engrave your name and date on the reinforcement strip.

28. Brush on two coats of 50/50 lacquer sealer to the inside of the back, leaving the areas to be later glued uncoated.

CLASSICAL GUITAR BACK



GUITAR ASSEMBLY

The assembly of the guitar begins as soon as the ~~assembly~~ neck and sides are complete. The guitar body is assembled in the mold.

Procedure:

1. Put one of the guitar sides in the mold with the mold gate in place. Clamp it to the side of the mold so it fits snugly.

2. Mark this side to its finished length using the center line of the mold as a guide.

3. Repeat steps one and two above for the second side.

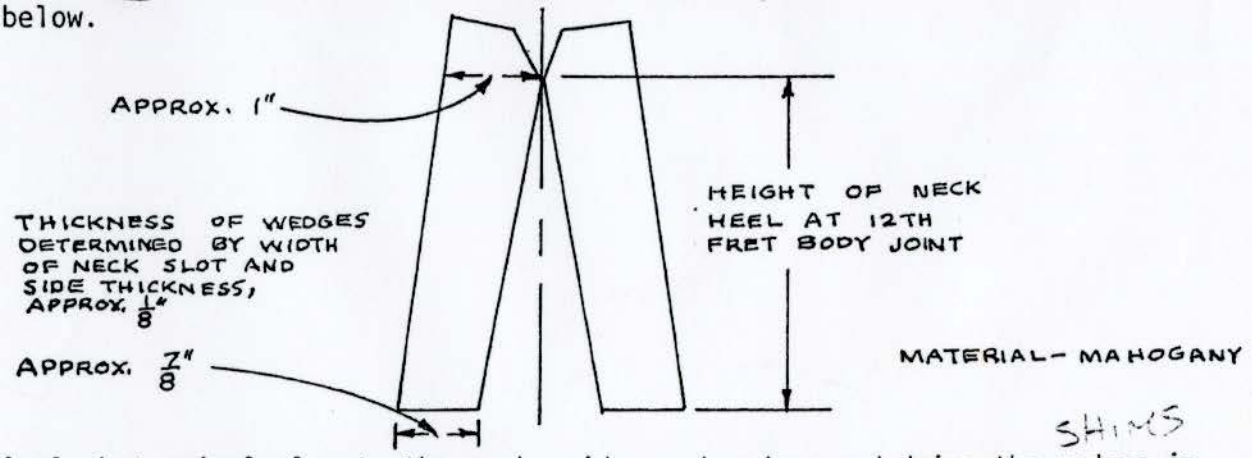
4. Cut the sides to finished length on a bandsaw. Be sure to make the correct angle layout and cut the end of the sides that will fit into the slot in the neck.

5. Remove the mold gate and clamp the neck in place on the mold using the center line as a guide.

6. Prepare ten 1/8" thick shims to be placed between the mold and the top of the sides when they are in the mold. These shims are used during the assembly of the sides to the neck and tail block. They create space which will later be filled by the top.

7. Place the sides in the mold and in the slot in the neck. Clamp the sides to the mold and check for fit. Be sure that the sides are in contact with the 1/8" shims.
SHIMS

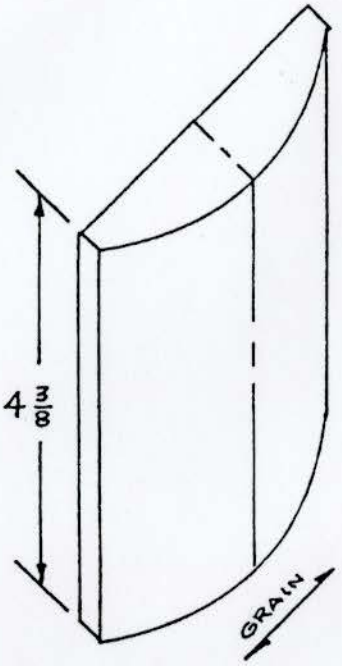
8. Make ~~wedges~~ to be used in the neck/side assembly similar to the ones shown below.

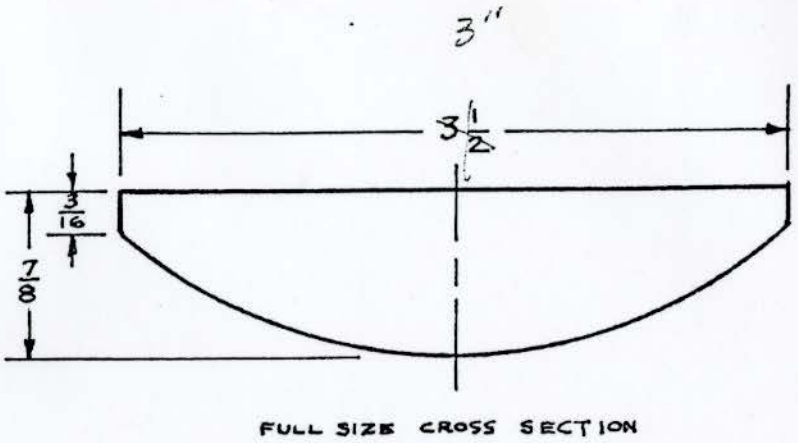


9. Apply hot animal glue to the neck, sides and wedges and drive the ~~wedges~~ in place securing the sides to the neck. Be sure that the ~~wedges~~ fit to the bottom of the slot. As soon as both ~~wedges~~ have been driven in place the neck/side assembly can be removed from the mold and the excess glue removed.

10. Prepare the wood for a tail block 7/8" x 4 3/8" x 3 1/2". Mahogany is usually used.

11. Shape the tail block to a cross section similar to the one shown below. It can be shaped by machine and hand sanding.





FULL SIZE CROSS SECTION

12. The part of the tail block which is glued to the sides must be sanded until it fits the assembly mold perfectly. You can rub blue chalk on the end of the mold where the tail block fits and rub the block up and down in this area. The blue chalk will locate high spots. Continue fitting until the entire surface of the block is blue from the chalk.

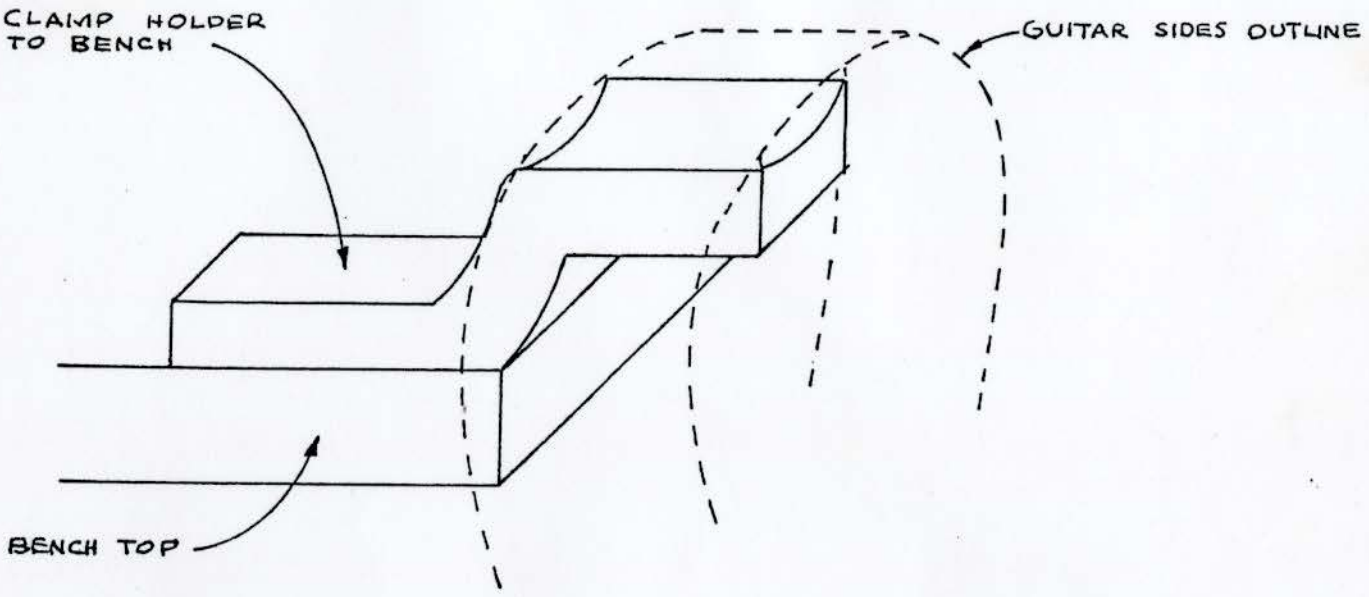
13. Clamp the neck/side assembly back the mold, being careful to line up on the center line.

14. Put some wax paper between the mold and the sides in the area of the tail block joint. This will prevent the sides from being glued to the mold.

15. Apply hot glue to the sides and the tailblock and clamp the block in place. The end of the block should be touching the bottom of the mold and the sides should be resting on the 1/8" shims. Allow this assembly to dry in the mold.

16. Remove the neck/side assembly from the mold and prepare to cut the slot for the tail block inlay.

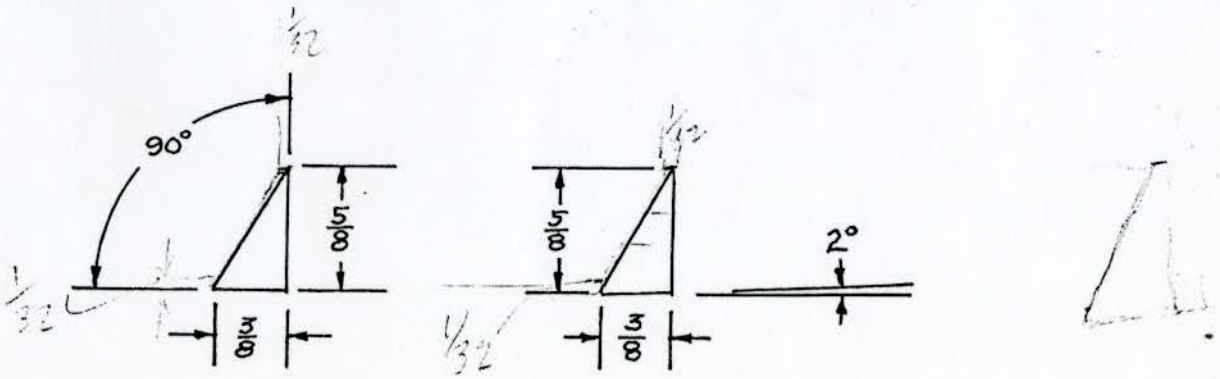
17. Clamp the tailblock in a holding device like the one shown below.



18. Carefully layout and cut the slot for the tail block inlay using the center line as a reference. Use a razor saw and a sharp chisel to make this slot. The slot should be cut so that the inlay will be flush with the surface or slightly above flush.

19. Glue in the inlay and clamp.

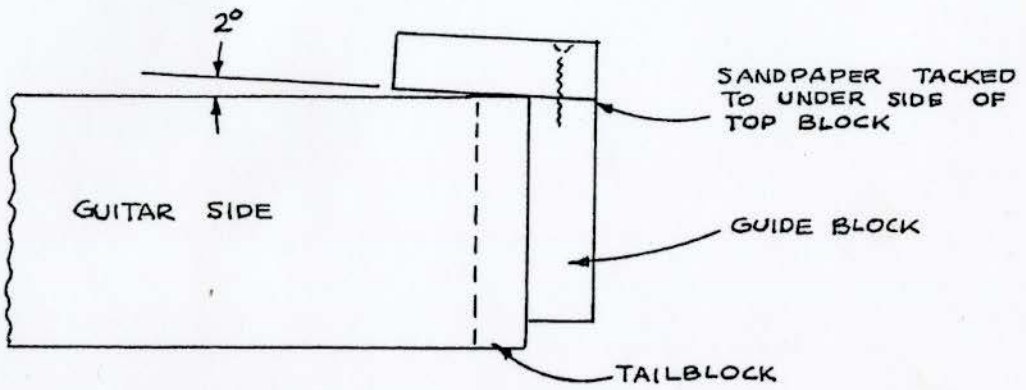
20. Prepare the wood for the top lining blocks. These blocks can be made from basswood or mahogany. You should cut out several strips with cross sections like the ones shown below. You will need more two degree blocks than square ones, 48" of 2 degree material and 28" of 90 degree material.



21. Cut the liner strips into short blocks about 3/8" long. Leave a short section of strip uncut so you can custom cut some pieces to fit into specific areas. Keep the two degree and 90 degree blocks separated, it is easy to get them mixed up.

22. Install the tapered mold shim in the lower bout area and tape it in place. Install the cardboard shims in the upper bout and neck area with tape.

23. Sand a 2 degree angle on the top end of the tailblock. A special sanding block like the one shown below can be useful for this purpose.



24. Check the fit of the top to the neck recess. Correct the fit if necessary. The top should be flush with the top of the neck.

25. Place the top in the mold being careful to center it on the molds center line.

26. Place the neck/side assembly in the mold over the top, center and clamp. Check to be sure that the sides are resting against the top and that the top is resting against the mold shims around the edges.

27. Glue in the small liner blocks around the entire top with hot glue. It is easier to handle these blocks if you first place a block on the end of a sharp knife, then apply glue to the block. The knife is then used to push the block in place. This is a single spread gluing operation with glue on the blocks only. No clamps are applied, simply push them in place and leave them to dry. This is a fairly slow operation and will usually take at least an hour. Remember to use two degree blocks from the sound hole around the lower bout and 90 degree blocks from the sound hole around the upper bout.

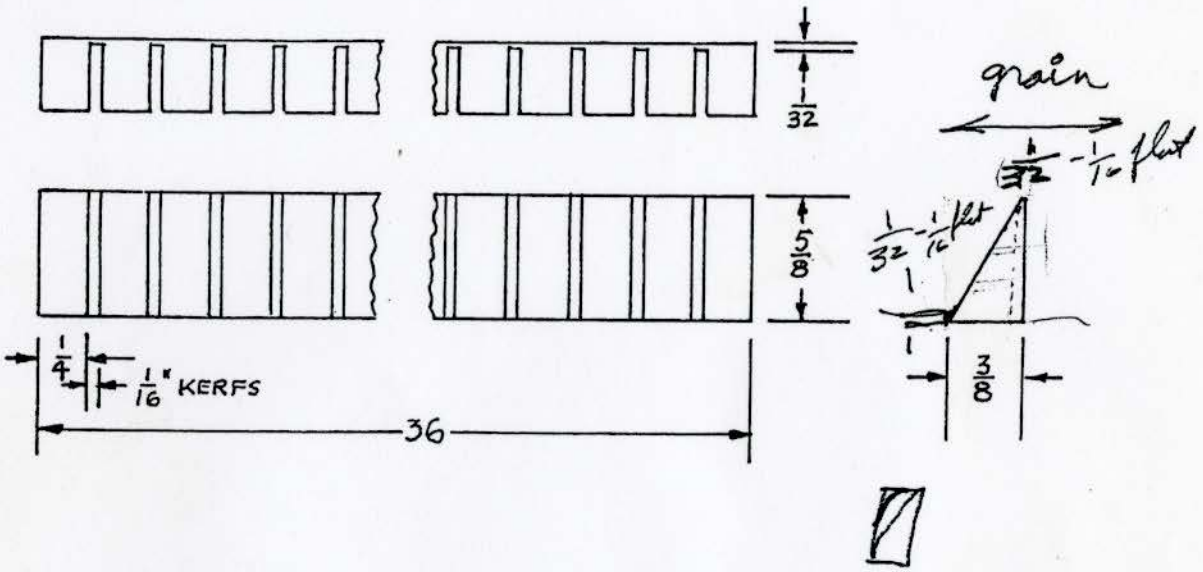
28. Sand and clean up the top/side assembly in the mold. Sand with 220 or finer paper.

29. Blow out the dust from the interior of the assembly.

30. Brush on two coats of 50/50 lacquer sealer or 50/50 Deft to the interior of the assembly, sanding lightly between coats. When the last coat is dry, polish it with 4/0 steel wool. Leave the area for the back liner uncoated.

31. Sand the sides, tail block and neck heel block to fit the back. Use a portable disc sander and a hand sanding block for this purpose. Check the accuracy of the sides frequently with a flat chalk board and blue chalk. Take your time with this operation and fit the back carefully.

32. Prepare two strips of back liner from either mahogany or basswood. The strips should be approximately 36" long and match the cross section and details shown below.



33. Glue in the back liner using hot glue and spring clamps.

34. Sand the liner to a two degree angle to fit the back using a portable disc sander and block sanding.

35. Locate and cut away areas in the liner for the back struts so the back fit against the liner perfectly.

36. Make a dry run back assembly using mold bolts and blocks. Be sure that the back fits without sags or dips.

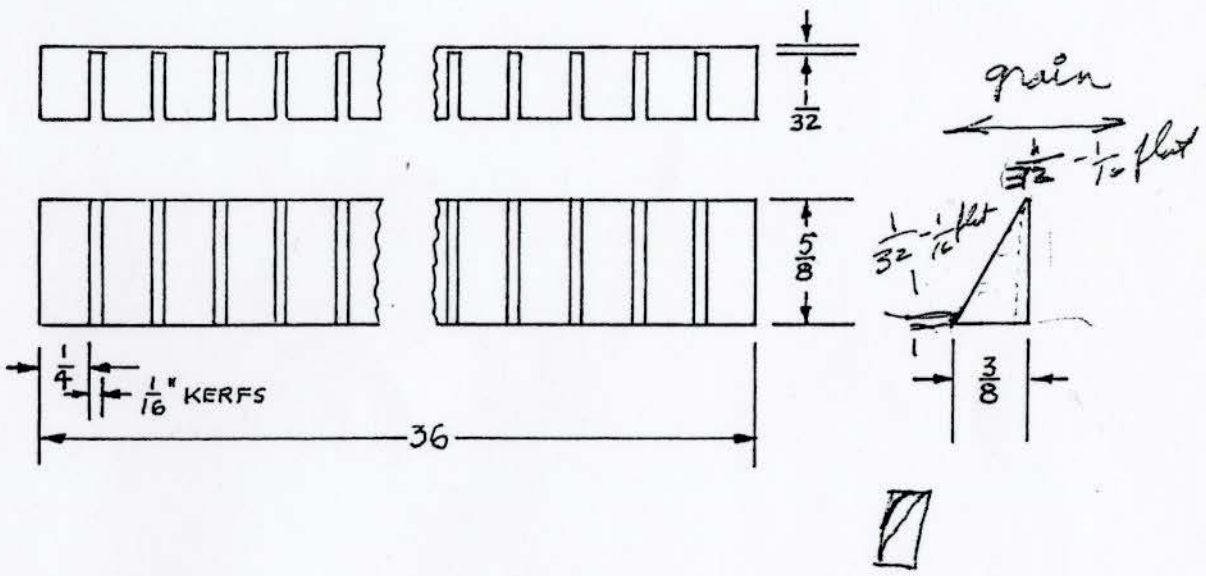
37. Apply hot glue to the liner and the back and glue it in place. Be sure to center it carefully with the center line. This is another operation which requires speed because of the fast setting glue. Get someone to help you.

38. After the glue has dried remove the bolts from the mold and unscrew half of the wood screws in the base of the mold so the mold side can be sprung open slightly. Remove the guitar from the mold.

30. Brush on two coats of 50/50 lacquer sealer or 50/50 Deft to the interior of the assembly, sanding lightly between coats. When the last coat is dry, polish it with 4/0 steel wool. Leave the area for the back liner uncoated.

31. Sand the sides, tail block and neck heel block to fit the back. Use a portable disc sander and a hand sanding block for this purpose. Check the accuracy of the sides frequently with a flat chalk board and blue chalk. Take your time with this operation and fit the back carefully.

32. Prepare two strips of back liner from either mahogany or basswood. The strips should be approximately 36" long and match the cross section and details shown below.



33. Glue in the b :lamps.

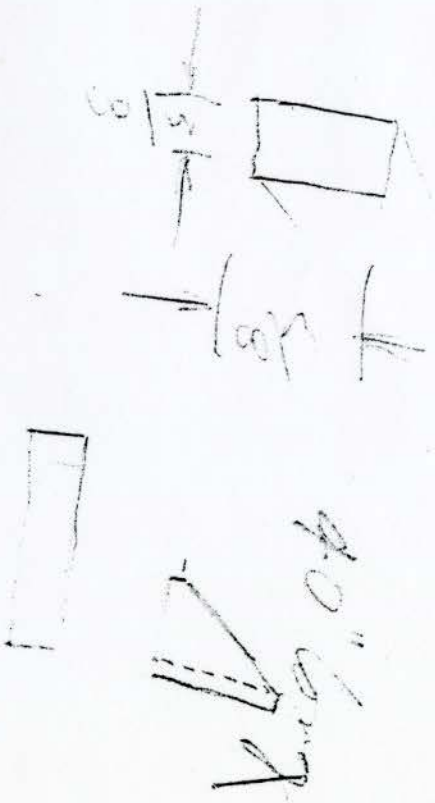
34. Sand the lin)ack using a portable disc sander and t

35. Locate and)ack struts so the back fit against th

36. Make a dr and blocks. Be sure that the back fits

37. Apply ho glue it in place. Be sure to center i lis is another operation which require lue. Get someone to help you.

38. After t rom the mold and unscrew half of the wood s mold side can be sprung open slight



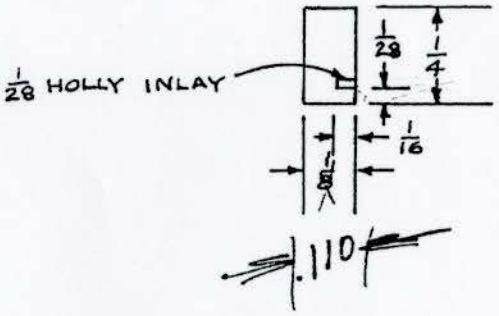
39. You are finished with the mold now and it can be stored away until the next guitar.

40. Sand and true up the guitar sides.

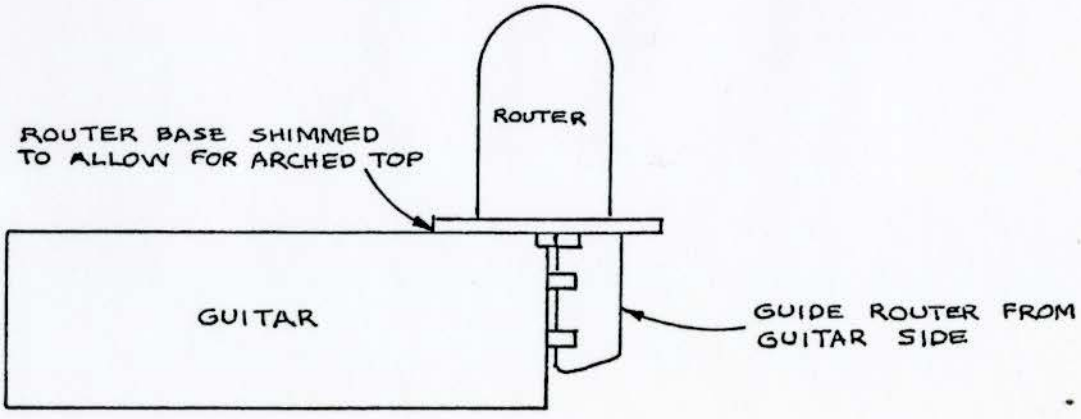
41. Sand and true up the top. Sand across grain with 180 & 280 grit paper to true up and then sand with the grain to smooth out the cross grain scratches. Coat the top with one coat of 50/50 lacquer sealer. Brush it on.

42. Sand and true up the back using the same procedure as with the top, except the sealer coat is not necessary on the back.

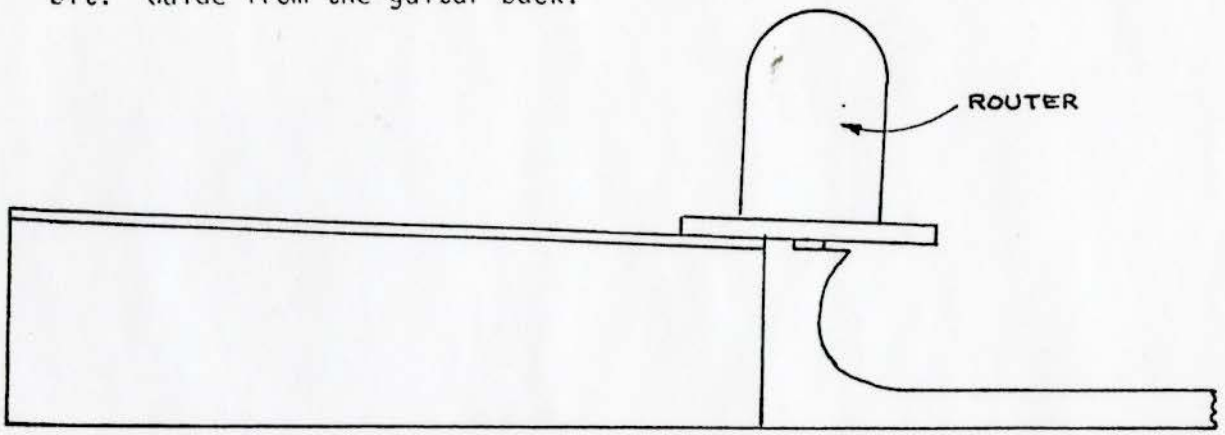
43. Prepare the binding strips and inlays. The bindings can be prepared by bending a blank of 1/8" rosewood just like a guitar side. Set up a special router operation and saw off four 1/4" wide binding strips from the blank. Cut an inlay slot in each binding strip using another special router set-up. Prepare maple or holly veneers for binding. The finished binding should look like the one shown below. <u>Be sure to remember to make left and right binding strips</u>.



44. Set up a special portable router attachment and cut the rabbet for the binding. It is best to first make a light cut, climb cutting, and then finish the cut to full depth. The climb cut will help eliminate outside chip out. Cut the rabbet so that the binding just barely comes above the top surfaces.



45. Cut away the end of the neck heel using a portable router and a straight bit. Guide from the guitar back.



46. Finish cutting the binding rabbets by hand in the neck area on both the top and the back.

47. Fit one piece of binding to the rabbet and cut to length. Apply glue to the binding and veneers and to the rabbet itself, use ~~liquid~~-hide glue ~~to allow for more assembly time~~. Tape the binding and veneer in place using nylon reinforced tape. Always fit the binding to the waist or the smallest bend first and locate the joints on the center line. Be sure during this process that the binding is fitting firmly against the sides of the rabbet. Use a push stick to push it in place while applying tape. This operation requires two people.

48. Apply all four binding strips following the procedure suggested above.

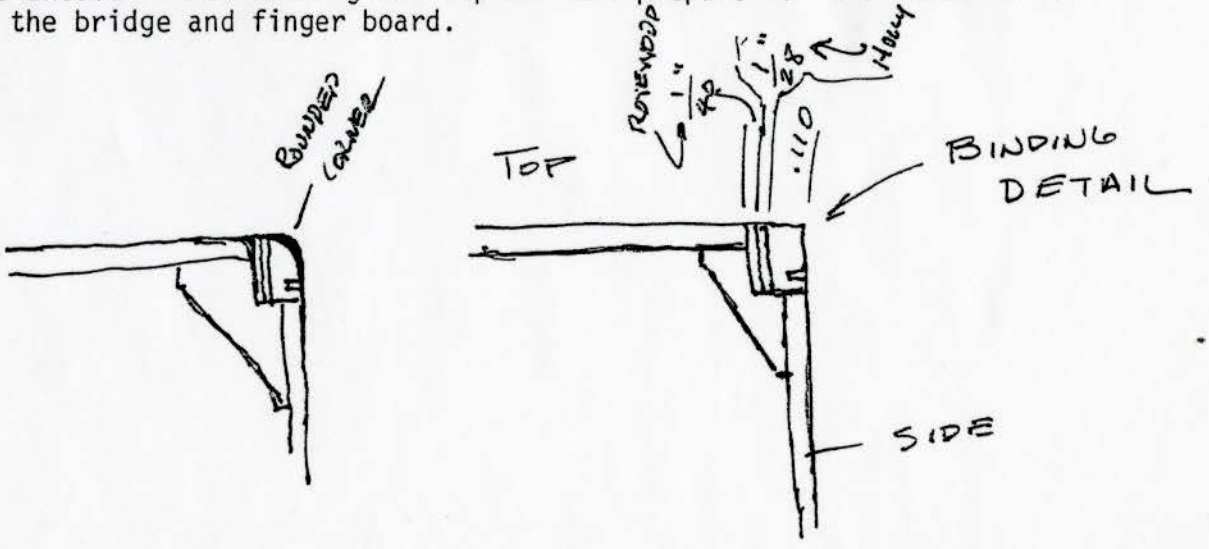
49. Remove the tape after an over night drying period.

50. Prepare and install the heel cap.

NEEDS DETAIL DRAWING

51. True up and sand the binding. File and sand over the edges to form a comfortable radius around the guitar body.

52. The guitar body is now essentially finished except for final sanding. You should finish sanding the top now and prepare for the installation of the bridge and finger board.



2 3/8 at 12th fret

FINGER BOARD FABRICATION

1. Prepare a finger board blank 1/4" x 2 1/2" x 18". Be sure that the blank is square.

2. Place the finger board on the neck and place the bridge on the top in its approximate final location. Lay a long straight edge across the finger board and bridge. Check the distance between the bottom of the straight edge and the top of the guitar just below the sound hole when the straight edge is held 1/8" above the 12th fret and 1/16" above the end at the nut location. The distance from the bottom of the edge to the top should be approximately 7/16" and you should also have about 1/8" reserve at the saddle location. If the space under the straight edge is more than 7/16" thin or taper the fret board blank until the space is correct.

3. Carefully locate and mark the fret slots using a fret ruler. Mark the fret slots so their location can be seen from the edge of the board.

4. Set up the small table saw with a blade that will make a kerf to fit the tang of the fret wire. The kerf width will vary with different kinds of fret wire. .023 or .025 kerfs seem to fit most medium gauge wire, however, you should make several practice kerfs and test the fit of the wire to be sure. Another way to determine the kerf width is to carefully file away the small spurs on the tang of the fret wire until only the tang remains and then measure the tang thickness with a micrometer. The kerf width should equal the tang width.

5. Set the depth of cut on the saw so it will cut a slot about 1/32" deeper than the tang is long.

6. Cut the fret slots on the small table saw.

7. Layout the finished width of the finger board using the center line of the board as a guide. The finger board should be 2" wide at the nut and ~~2 1/2~~ 2 3/8 at 12th fret wide at the sound hole.

8. Saw off the excess finger board width using a band saw. Joint the outside edges smooth with light cuts on a jointer.

9. Layout the sound hole curve on the lower end of the fret board.

10. Saw out the sound hole curve on a bandsaw and file and sand smooth.

11. The finger board is now ready for installation. Classical guitar finger boards are usually not inlayed with any sort of markings.

secure fret bd blank to a carrier block as shown in drawing & saw tapers off each side using a table saw.

Need drawing

CLASSICAL BRIDGE FABRICATION

1. Prepare a bridge blank from quarter sawed rosewood or ebony 3/8" x 1 3/16" x 7 1/2". You will find it easier to prepare two or three blanks at once leaving them 16" or 24" in length for some of the machining operations.

2. Locate and saw or rout an 1/8" wide slot for the saddle. Refer to the bridge details on the following page.

3. Saw ~~of~~ or rout away rabbet for the tie-block inlay.

4. Shape the part of the bridge around the saddle slot on a over arm router or shaper.

5. Bandsaw off the excess thickness on wings of the bridge.

6. Sand the bottom of the bridge to fit the top of the guitar. Use a special curved sanding block for this purpose. The bridge should fit the top perfectly.

7. Round over the top surface of the wings with a file and sanding.

8. Hand cut the remaining portion of the tie-block rabbet.

9. Carefully layout the string holes in the tie-block. The outside holes should be 2 3/8" OC and all others equally spaced.

10. Drill ~~the~~ 1/4" DIA. holes ~~being sure to drill the two holes for the large bass strings larger than the other four~~. It is important that the holes be below the tie-block rabbet. You must also be sure that they will not be too close to the top.

11. Prepare the inlay for the tie-block. Bone and wood veneers are usually used for this purpose.

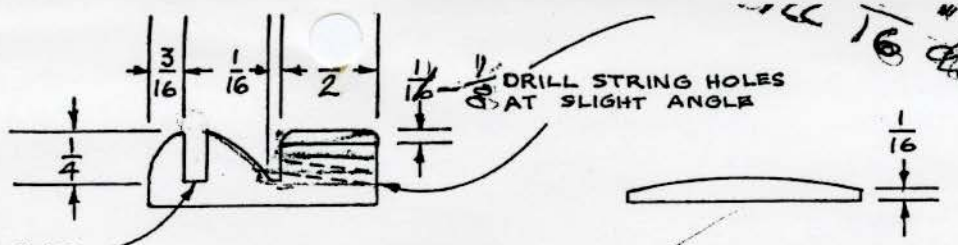
12. Miter the inlay to fit the tie-block and glue in place. You can use rubber bands through the string holes to hold the inlay strips in place while the glue is drying.

12a. — File & sand tops on the top of the tieblock

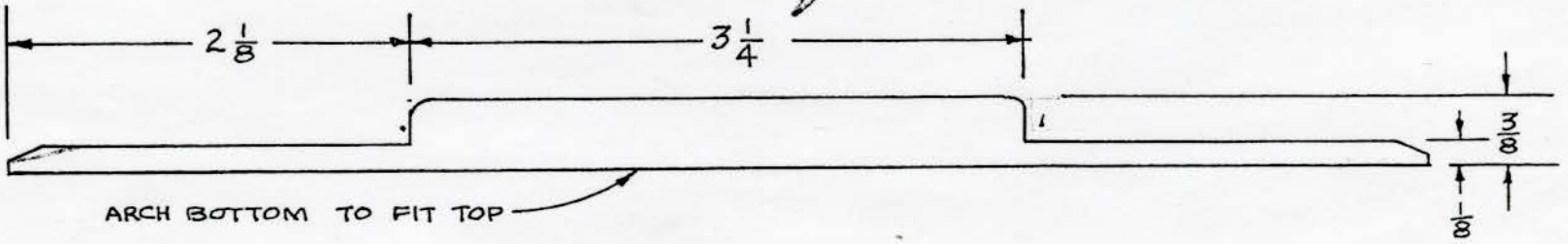
13. ~~File and sand the tie-block inlays and~~ Finish shaping and sanding the entire bridge.

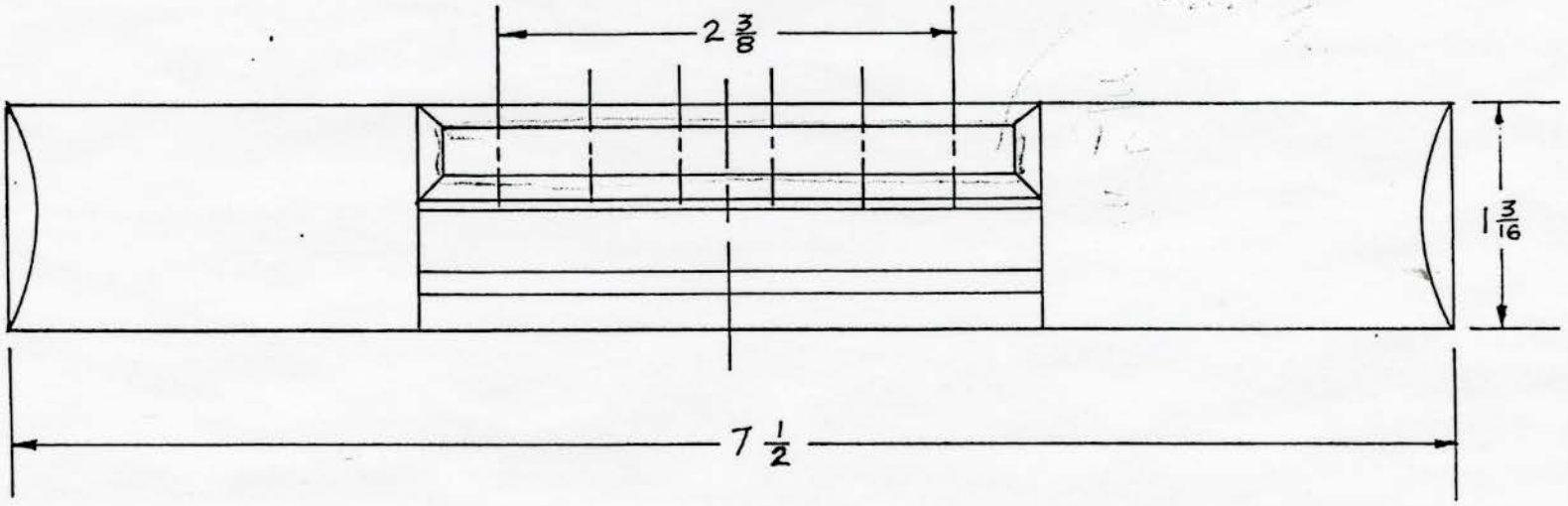
14. Apply a coat of brown paste filler to the top surface of the bridge and allow to dry. It is easier to fill the bridge before it is glued to the guitar top. Be sure not to fill the bottom surface which will later be glued to the top.

15. The bridge is now ready for installation.



Redraw





SCALE ~ FULL SIZE

CLASSICAL GUITAR BRIDGE

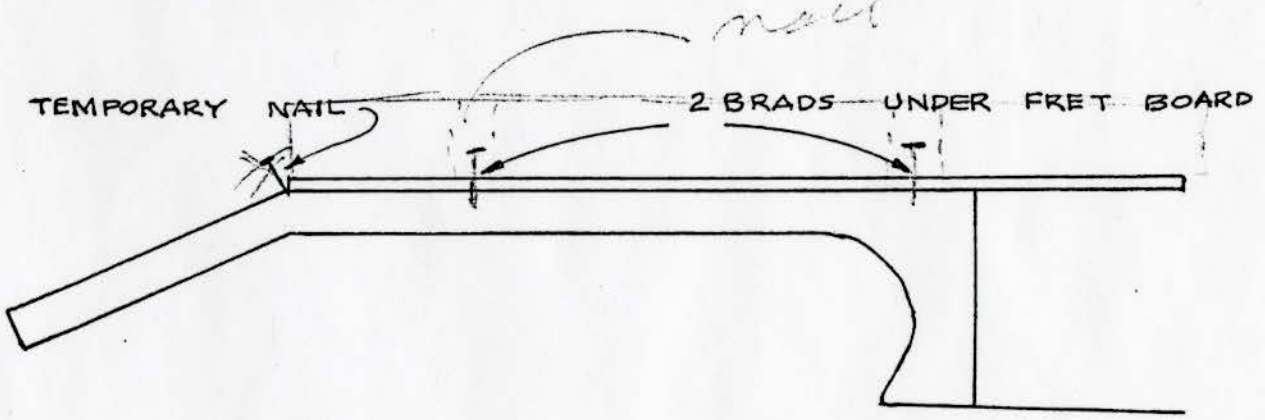
INSTALLING THE FINGER BOARD AND BRIDGE

1. Carefully locate the finger board on the neck being sure to leave enough space for the nut and also locate the 12th fret over the neck body joint. Place two long straight edges along each side of the finger board and carefully center the finger board over the sound hole. It is important that the guitar strings are centered over the sound hole.

2. With the finger board dry clamped in position locate the bridge. The bridge must be centered on the finger board. Locate the bridge by measuring 12 frets plus the appropriate compensation from the 12th fret to just inside the front edge of the saddle slot. Once you have determined the position of the bridge, mark its location lightly with a pencil on the guitar top.

3. Locate and install two small brads in the under side of the finger board. Cut off the heads of the brads and file the ends to a point. These brads will help prevent the finger board from sliding when gluing.

4. Install a heavy temporary nail in the neck at the nut location. This nail will also prevent sliding. Refer to the sketch below.



5. Prepare a heavy glue block to cover fret board.

6. Dry clamp the fingerboard assemlby.

7. Glue on the finger board using hot glue, double spread. Work quickly and accurately.

8. After the finger board assembly is dry you should prepare to glue on the bridge.

9. Prepare a strip of 1/4" plywood 1 1/4" wide and 7 1/2" long with slots cut in it to bridge over the struts under the top. This block will serve as a clamping surface for the bridge clamps.

10. Tape the bridge clamping block under the top on the bridge reinforcement piece with masking tape.

11. Install two small brads in the under side of the bridge. Cut off the heads of the brads and file the ends to a point. These brads will help prevent the bridge from sliding when gluing.

12. Dry clamp the bridge in place using three or four deep throated guitar clamps through the sound hole. Be careful to protect the guitar top during this operation.

13. Glue the bridge in place. Apply glue to the bridge only and clamp.

14. After the bridge assembly is dry the back of neck can be shaped.

15. Shape the back of the neck using a portable disc sander, knife and file. The neck should be shaped to fit a template. It should be uniform and smooth from end to end. A neck template is drawn full size below.

16. Cut fret wire strips to rough length. They should be about 1/4" longer than the width of the fret board.

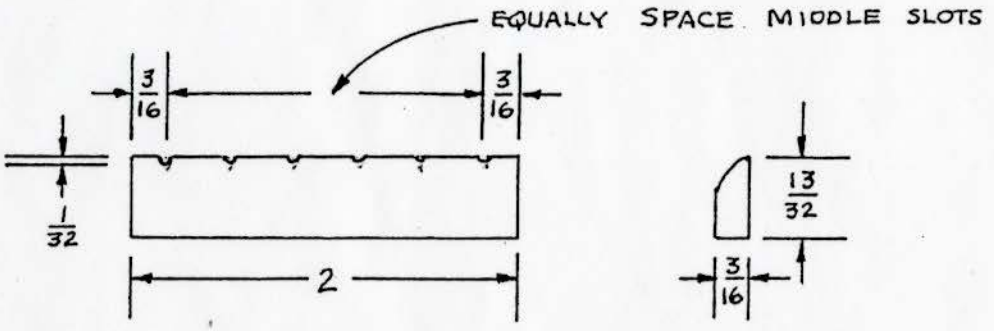
17. Drive the frets in place using a plastic face hammer. Begin at the nut end and work toward the sound hole. You may find it necessary to glue in the last fret above the sound hole especially if it is a split fret. A small amount of polyvinyl glue across each fret slot will make fret driving a bit easier. It will serve as a lubricant.

18. Cut the frets flush with the finger board and file smooth.

19. Check the accuracy of the frets using a very accurate straight edge. Locate and file down all high frets with a mill file.

20. Round over all flattened frets using a fret file. It is best to mask off the finger board when filing frets to prevent marring the surface.

21. Prepare bone for the nut as shown below.



22. Cut the recess in the neck for the nut. Carefully fit the nut in this recess. The recess should be no deeper than 1/16".

23. Carefully locate the string slots on the nut blank as shown above. File the slots to proper depth using needle files.

24. Prepare the bone for the bridge saddle. Cut the bone so it fits the saddle slot and projects above the bridge enough to allow for a proper playing action. The strings should be above the 12th fret about 1/8" as a starting place for the action.

25. Install the tuning machines and string up the guitar.

26. Adjust the action to fit your playing style.

27. Final sand the entire guitar and apply a finish after the action has been refined.

28. Before finishing the guitar you should mask off the finger board with tape and fill the body cavity with paper.

Guitar Construction and Repair

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