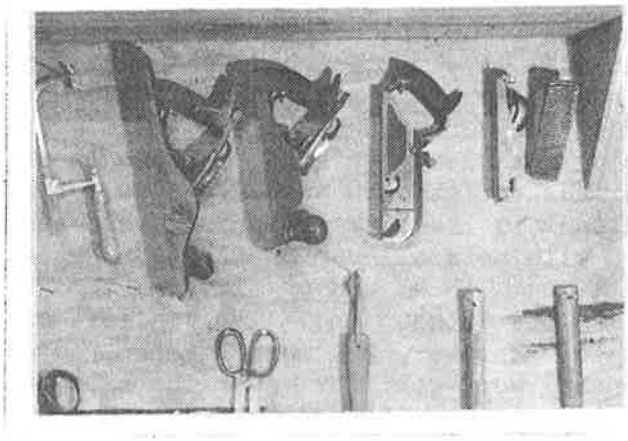
CHAMBER HARPSICHORD

Instruction Manual K52W49

Hughes Company
Denver, Colorado

You are about to start building a harpsichord. This is a project that is challenging, fulfilling, rewarding—and to be honest, sometimes a bit tedious, irritating, and a little frustrating. Although this is a long project with many small pieces and detail work, everyone who has built a harpsichord not only feels that is was worth all the effort, but is even somewhat hooked on the idea of instrument making.

I know that you are anxious to begin, but it is worth planning a few things before you begin.



TOOLS Some people will attack any project with a bent screwdriver and a rusty nail. The amazing part is that they sometimes succeed! Even these people, though, won't say that decent tools will hinder you, so do try to have the right tool for each operation. This is not to say that every item on the following list is absolutely essential or that there is only one tool or method for accomplishing a given step. Every operation on the entire harpsichord is not only possible, but practical with home workshop tools. In most cases, we take this to mean hand-powered tools. An exception is the electric drill. Those fancy power tools that tempt us all do increase efficiency—you can make your mistakes in a fraction of the time required by hand tools. In general, stay away from any power tool that you don't have extensive experience with.

Glue. This is easily the most important tool. We usually use the aliphatic resin type (cream colored), although white glue will work quite well too. Some familiar brands are Titebond glue by Franklin, and Elmer's Professional Carpenter's Wood Glue. Epoxy glues and "super glues" are messy, and not appropriate.

Just as important as the type of glue, though, is understanding just how glue works. Glue joints can be incredibly strong. "Stronger than the wood itself" is not just advertising. Glue works so well because its bond to wood is so strong. However, those big globs of dried glue are by themselves rather weak. So, the goal of woodworking joinery is to have the wood fit together with the smallest possible space for glue. If care is taken with this fitting, it is quite possible to make a virtually invisible glue joint. Once this fitting is completed, you simply spread the glue and squeeze the parts tightly together overnight. Last, always make a dry run of every glue joint so that you can assemble it quickly and accurately when the glue is on. And this brings us to the next tool.

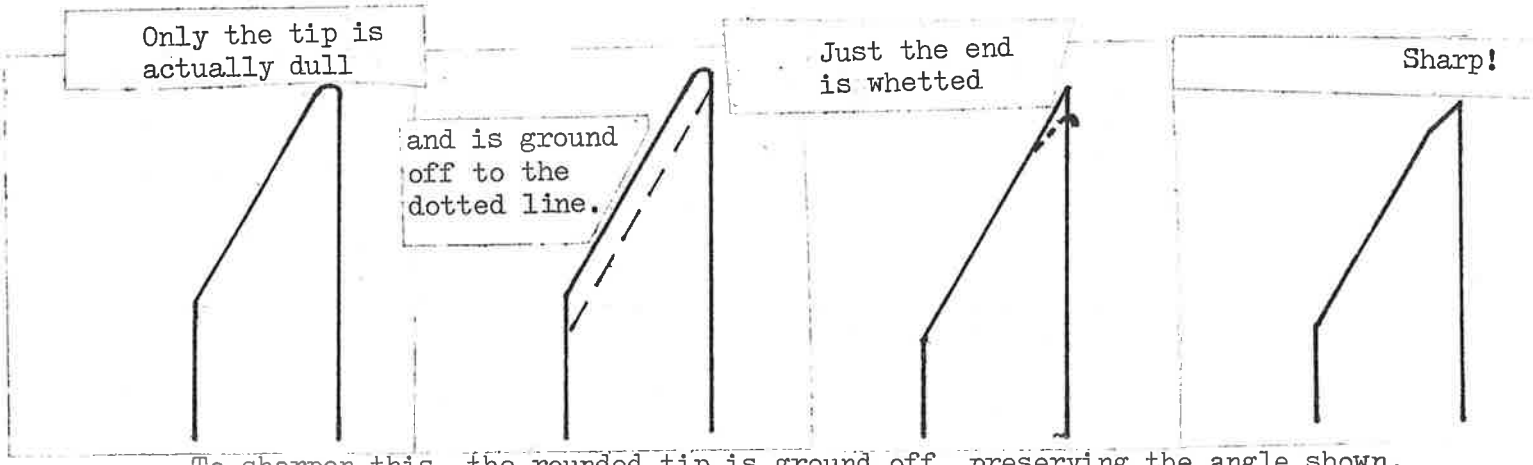
Clamps.The popular image of instrument building is a bench with about a hundred clamps. Quite aside from the expense, it seems that for every time a clamp works well, there are two occasions when it simply won't work because the material is too thin, the joint is angular, or there is not enough room. So, you will have to be more inventive. Keep in mind that clamping only serves to

keep the pieces in close contact. If they fit correctly, extreme pressure is not necessary. Masking tape is quite a useful clamp for small pieces. Another useful technique, especially for larger areas, is to use weights, such as bricks, to "clamp" pieces together.

Screws and Nails. Almost all of these in the entire kit are used only as clamps! I cannot stress this enough-most of the screws and nails serve only to clamp the glue. Although we will leave them in place (no use wasting the additional solidity) they could safely be removed after the glue is dry. You cannot use the screws alone without glue. Screws used as gluing clamps are installed somewhat differently than usual. The piece against which the screw head bears must have a loose fit hole for the screw shank to slip through, and the opposite piece must have a pilot hole which is large enough to permit full tightening. The most common error is making these holes too small, and then being unable to pull the screw down fully. There are special pilot drill bits (such as the Stanley Screwmate) which do a nice job of screw hole drilling and sizing. They are made to fit each specific size screw. In all cases, flat head screws are countersunk to leave their heads level with the surface.

So, you could eliminate all use of clamps. But a few will be comforting, so you might get a pair each in 4" and 6" sizes.

Plane. I can't work without one. The smallest size (called a block plane) is entirely adequate. However, you must sharpen, adjust, and use a plane properly or it will never work well for you. The main secret is sharpening. Even a brand-new plane is not sharp-it has been ground and is ready to sharpen. An old dull blade is even worse, and might look like the first diagram.



To sharpen this, the rounded tip is ground off, preserving the angle shown. When you have ground that surface nicely flat, and removed all the roundness at the tip, the old blade will match a brand-new one, and is sharpened in the same way. The very tip is sharpened still more by whetting this area under very solid pressure on an Arkansas-type whetstone. Most carborundum stones aren't fine enough to work well. Notice that the diagram shows that this whetting is done at an angle very slightly greater than that generated during grinding. The cutting action of a whetstone is slow, and whetting the entire beveled surface would take an inordinate amount of time. When a slight "wire edge" forms on the backside of the blade, this can be "stropped" off on an old pants leg. When you reassemble the plane, notice the adjustments for blade depth and angle. Because the plane is hand-powered, it must be adjusted to make a very small cut that is even in depth across the blade. Try it thoroughly on a long piece of scrap until it works smoothly and produces the characteristic long curls. The major advantage of the plane is that it tends to remove only high places in the work, which will help straighten it, and that it will make a flat surface that will make a good glue joint. When sharpened properly, it can also leave a surface smoother than sanding. It is possible to use other tools, such as the Stanley Surform, or even a large sandpaper block. However, I think the plane is superior.

Sandpaper. Although everybody is familiar with it, there are some points worth covering. Its major disadvantage is that it tends to round off edges and corners. This is acceptable on many outside and decorative edges, but causes trouble if you try to sand a glue joint area. For this reason, you will usually sand only non-joining areas. In general, all of these non-joining areas are sanded before assembly.

Sanding is ordinarily used to remove roughness or visible marks from visible or mechanical surfaces. Usually you should start with coarse (60-80 grit), and progress to finer (100-180 grit). In some areas you will want an even slicker finish, which can use up to 400 grit sandpaper. This black,"wet-or-dry" type sandpaper can be used damp to avoid clogging when sanding finishes. Always use your sandpaper attached to a block to minimize rounding.

Drill. Small electric drills are so universally available that almost everyone seems to have on available. With several hundred holes to drill, they are better than a hand-crank type.

Drill Press. Since almost all holes are supposed to be perpendicular, a drill press is quite useful. If a standard model is not available, the drill press stand which clamps your hand drill is a good substitute. This is much better than trying to eyeball 300 holes at right angles in two dimensions. Always use an awl to tap a definite dimple at the starting point of the hole to be drilled. This will eliminate the tendency of the drill to start wandering around. Good, sharp drill bits do drill better holes.

Screwdrivers. The main points here are sharp, square tips, and sizes to fit (almost fill) the screw slots. Too small a tip will chew up the slots, and prevent proper tightening.

Files and Rasps. Files are for metal and rasps are for wood. Both have directional teeth, and should be lifted on the return stroke to avoid clogging. An 8-inch mill bastard (yes, that's really its name) is a useful size metal file, and the handiest rasp is a "4-in-hand", which is actually four rasps in one.

Pliers. The work with music wire demands good, accurate needle-nose pliers, preferably with built-in cutters. Don't let anyone else use these, and they will always work well.

Tri-square. This combination square is useful for scribing lines and measuring, in addition to checking for squareness.

Voicing knife. This is available in most hobby and hardware stores as a hobby knife, such as the X-acto brand. You will use it a lot for voicing the plectra, but also for trimming felts, and even for very accurate marking.

Work space. Although you might not think of it as a tool, your "shop" is pretty important. Don't misunderstand-harpsichords can (and have been) be built on the living room rug. But, because of the more extended nature of the project, you will find it much nicer if you can have some area where you can work and leave things out to dry, and so forth. Very few people will have the time (or desire) to work straight through from start to finish. Let's keep in mind that this is intended to be enjoyable.

Last, the most important part of the kit is you. Most people feel a bit apprehensive at the start, and are tempted to take the kit to "someone with experience". We don't advise this. It's fine to collect ideas on woodworking, but even extensize woodworking experience is not quite the same as harpsichord building experience. So, it's usually best for you to figure out your own best way of accomplishig things. Also, the project is long enough to really test the devotion of any help who doesn't own the instrument.

It is worthwhile to read through all the instructions before starting construction. It isn't necessary (or practical) to absorb every detail, but a working knowledge of the overall construction will assist you greatly at all stages.

Everyone worries about making mistakes-and everyone makes them. No matter how talented or careful you are, you will just plain "goof" occasionally. There is no such thing as a mistake with no remedy, so just figure the one you can, and continue. Put your fears aside and proceed-you will be the most knowledgeable person in the world about your harpsichord!

PARTS LIST

The purpose of all dimensions in this list is only to help you to identify the parts. Some parts, especially those noted as "stock" are cut only approximately to their final dimensions. This is done because many pieces need to be trimmed to fit other pieces only. Their actual dimensions are unimportant.

By contrast, many other parts are toleranced much more closely than the nominal dimensions in this table seem to indicate.

INNER CASE PIECES:		
Spine	45½ x 5½ x ½ fir plywood	2 dadoes
Tail	7 3/4 x 5½ x ½ fir plywood	Angle on one end
Slantside	40 3/8 x 5½ x ½ fir plywood	Angles on both ends
Cheek	12¼ x 5½ x ½ fir plywood	angled end, 2 dadoes
Upper bellyrail	28¼ x 2¼ x ½ fir plywood	
Lower bellyrail	28½ x 4 x ½ fir plywood	
Cheek cleat	1 3/8 x 5 x ½ fir plywood	angled edge
Tail cleat	7 x 5 x ½ fir plywood	angled end
Spine to back strip	48 x 3/4 x 3/4 mahogany	stock
Slantside to back strip	" " "	"
Back	48 x 28 x ½ fir plywood	pre-cut shape
Pin block	28 x 5 3/4 x 1 7/16 Birch plywood	
Long case brace	24 1/16 x 4 x 3/4 fir plywood	angled end
Short case brace	13½ x 4 x 3/4 fir plywood	angled end
Spine to top strip	41 x 1 x ½ mahogany	stock
Slantside to top strip	" "	"
2 spine/cheek end supports	15 3/4 x 11/16 x 3/4 birch plywood	
2 Pin block supports	10 1/8 x 3 1/16 x 3/4 birch plywood	
2 Cheek/spine extensions	1½ x 5 5/8 x ½ fir plywood	
KEYBOARD PIECES:		
Keyboard base	26½ x 15½ x ½ fir plywood	1 dado
Balance rail	26½ x 5/8 x 3/4 fir plywood	lengthwise notch
Overrail top	26½ x 1⅛ x ¼ fir plywood	
Overrail support	26½ x 1 7/8 x ½ mahogany	
Balance rail dowel	26½ x ¼ birch dowel	¼" diameter dowel
Keyfall spacer	26½ x 2 x ¼ fir plywood	
32 Natural key blanks	14½ x 3/4 x ½ walnut	vee notch
20 Sharp key blanks	12 7/8 x 3/4 x ½ walnut	"
20 Sharp key tops	3 x ½ x ½ maple	angle on one end
20 #1 key end blocks	3/8 x 1 5/8 x 3/4 walnut	
12 #2 key end blocks	1/4 x 1 5/8 x 3/4 walnut	
20 #3 key end blocks	3/16 x 1 5/8 x 3/4 walnut	
Brass pin material	1/16" diameter brass rod	
FELTS		
Key rest felt (under keys)	½ x 27 x ¼ thick felt	Key rest and key dip
Key dip felt (on overrail)	" " "	felt cut from wide pc
Jack pad felt	1" x 27 x 1/16 thin felt	
JACK PARTS:		
55 Jack bodies	3/16 x 4½ x 3/4 walnut	long slot
60 Jack tongues	3/16 x 7/32 x 1¼ walnut	
60 Jack tongue stops	3/16 x ¼ x 3/8 walnut	

Jack axle material	1/16" diameter brass rod	stock to cut
Jack spring material	Small steel wire	stock to cut
Jack damper felt		

SOUNDBOARD PARTS:

Soundboard	29 x 38 5/16 x 1/8 mahogany ply	pre-cut shape
2 pc. bracing	28 x ½ x 3/4 pine	triangular
Rosette	Brass/gold to fit 2 5/8 dia hole	
Hitchpin rail stock	4 pc, 42,39,8,4 x 3/8 x ½ walnut	stock to cut
Bridge stock	3 pc. 32, 9, 7, x 3/8 x ½ walnut	bevel on top edge
Nut stock	29 x 3/8 x ½ walnut	" " " "
Buff stop rail	3/8 x 3/8 x 28 walnut	
Hitchpins	1 1/8" blued nails	
Buff stop knob	3/4 x 1 x 3/4 walnut	
Buff stop knob shaft	1" long ¼" dowel	
Buff felts	¼" square, cut from jack rail felt	
Buff stop nails	5 decorative head nails	
Pin block screw hole filler	4 x 3/8 diameter dowel	stock to cut

OUTER CASE PIECES:

Outside spine	52½ x 8 x 1/8 walnut plywood	trim to fit
Inside spine	46 x 2 3/8 x 1/8 walnut plywood	"
Outside tail	8 x 8 x 1/8 walnut plywood	"
Inside tail	8 x 2 3/8 x 1/8 walnut plywood	"
Outside slantside	41½ x 8 x 1/8 walnut plywood	"
Inside slantside	41½ x 2 3/8 x 1/8 walnut plywood	"
Outside cheek	18 x 8 x 1/8 walnut plywood	"
Inside cheek	12 x 2 3/8 x 1/8 walnut plywood	"
Spine filler	46 x 2 3/8 x ¼ fir plywood	"
Tail filler	8 x 2 3/8 x ¼ fir plywood	"
Slantside filler	41¼ x 2 3/8 x ¼ fir plywood	"
Cheek filler	12 x 2 3/8 x ¼ fir plywood	"
Keywell ends (2)	6½ x 6½ x 1/8 walnut plywood	"
Keywell end fillers (2)	6½ x 6½ x 1/4 fir plywood	"
Nameboard	28¼ x 4½ x 1/2 walnut plywood	
Music desk base	" " " " "	
Music desk bottom	14 x 1 x 3/4 walnut	bevel on bottom edge
Music desk top	14 x 2 3/4 x 3/4 walnut	
3 music desk dowels	3" x 3/8 birch dowels	
Music desk lip	14 x 3/8 x 3/8 walnut	bevel on edge
2 Music desk supports	4 x 1 3/8 x ½ walnut	
Lockstrip	29 1/8 x 1 7/8 x ½ walnut	
Lockstrip stiffener	27 3/4 x 1 ½ x ½ mahogany	
Outer case edge tape(11 pc.)	48,42,3-29,13,3-8,2-3 x 3/32 x ½ walnut tape	
2 key end blocks	5½ x 1 x ½ walnut	
2 key end block supports	3¼ x 3/8 x ½" mahogany	
Jack rail top	1¼ x 28 1/8 x ½ walnut	
2 Jack rail sides	1 x 28 1/8 x ½ walnut	
Music desk felt	½" red felt	22" of red felt,
Jack rail support block felt	½" red felt	for all 3 pc.
Jack rail felt	1 x 27 x 3/16 felt	extra wide-buff felts
Jack rail support blocks	1 3/16 x 1 x ½ walnut	
Lid stick	23 x 3/4 x ½ walnut	
3 legs	w/ hardare-plates and screws	
8 pc Back band material	8¼ x 5/16 x ½ walnut	trim to fit

LID PIECES

2 Lid panels (inner & outer)	39 x 27 1/8 x 1/8 walnut plywood	pre-cut shape
Spine molding	42 x 1 3/4 x 3/4 walnut	Dado & 2 miters
Tail molding	8½ x 1 3/4 x 3/4 walnut	" "
Slantside molding	41 x 1 3/4 x 3/4 walnut	" "
Front molding	30 x 1 3/4 x 3/4 walnut	" "
Cheek molding	7¼ x 1 3/4 x 3/4 walnut	" "
1 set Hinges, w/ screws		

Hardware & Misc.

Pin setting tool	6 x ¼" diameter brass rod
Pin tool handle	1¼ x 2 x 1¼ mahogany
Nail pads	½" square, 1/8 mahogany
Small nails	3d, 1½" long Used in: spine/cheek to back area, keyfall spacer, and lockstrip
Large nails	6d, 2" long Used in inner case slantside
Sample jack	
Sample string loop	
1 set tuning pins	
1 tuning wrench	
1 set stringing wire	bulk material
Small(est) nails	Used in nail pads, when nailing through 1/16" bridge pin holes

Screws

20	1¼ x #8 FHWS
30	1 x #8 FHWS
50	7/8 x #8 FHWS
4	2½ x #10
2	3 x #12
2	1 x #8 Brass RHWS

Drill bits

1 3/16" dia.	Tuning pin holes
1 1/16" dia.	Keyboard pins, bridge pins, nut pins, jack tongues
1 #51 drill	Jack body holes
1 #67 drill	Plectra holes in jack tongues

It is worthwhile before starting, to lay out all the parts, and try to identify each as you read through the instructions. It is best to leave the plastic bags sealed until you need those particular parts. However, the location of absolutely every little part probably won't be entirely clear until you start assembly.

THE INNER CASE

1. At last we're ready to begin. We will start by building the inner case of entire instrument. The we'll add all the action parts to the inside, and then build the outer case work on the outside of the inner case, and finally do the stringing and adjusting.

The inner case pieces are all standard fir plywood. Here we need structure, not beauty, so this material works quite well. You might be shocked to see the ugly materials built inside some lovely old harpsichords.

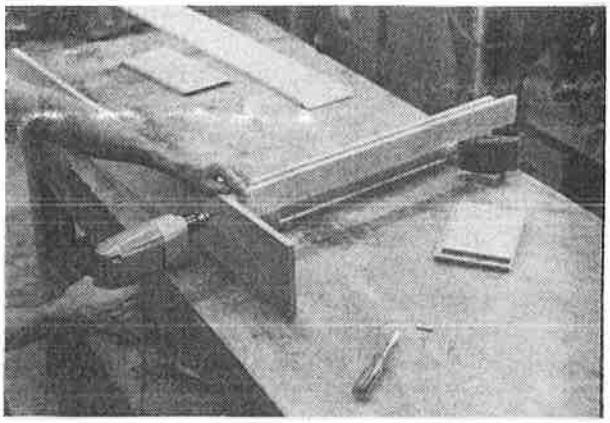
You will need:

- 1 inner case spine
- 1 inner case tail
- 1 inner case slantside
- 1 inner case cheek
- 1 upper belly rail
- 1 lower belly rail
- 1 cheek cleat
- 1 tail cleat
- 6 1-¼" x #8 Flat head wood screws
- 6 7/8" x #8 flat head wood screws
- 4 small nails
- and necessary tools

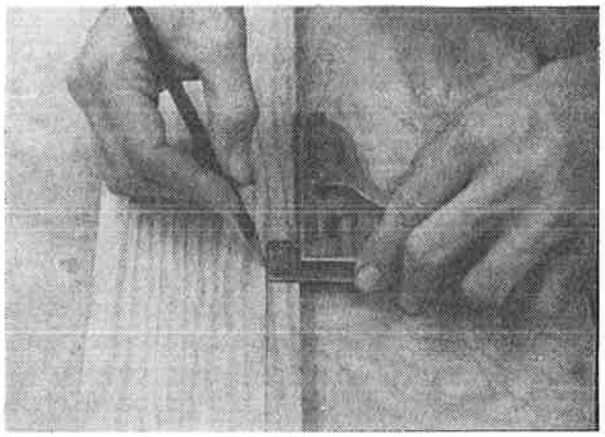
2. Remember about dry runs? Put your glue bottle aside, and see how all these parts fit together. The spine is the longest piece, and forms the long, left hand (bass) edge of the instrument. It has two slots to receive the upper and lower belly rails, which reach across to fit into two similar slots (carpenter's term: dado) in the cheek, which is the short, right-hand (treble) edge. The short tail piece is placed at right angles to the spine (parallel to the belly rails), and finally the slantside reaches from the sharp point of the cheek piece across to the blunter point of the tail. Notice the belly rails. The upper belly rail (the narrow one) goes flush (flat) with the top edge and must be in the slot that is closer to the keyboard area. The photos show these joints more clearly. The lower belly rail goes in the slots closer to the tail, but not flush with the bottom edge. This is because the back (or bottom) fits up inside the inner case. So, the lower belly rail is located exactly ½" (13mm) up from the bottom edge of the case pieces to form a support ledge for the back. When you fit in the tail cleat and cheek cleat, you will notice that they are not as tall as the pieces they join. This is because they fit flush at the top, which leaves the bottom edges ½" short to form more fo the ledge to support the back. The photos show the way the joints in these areas fit together. Now make a line ½" (13mm) up from the bottom edge on the inside of the spine, slantside, and cheek. This will be used to locate the strips used to support the other edges of the back. Now we're ready to start assembly.

3. We want you to now assemble the case first using just the screws (no glue yet). You can't install the slantside now because it is clamped using nails, which should only be used once. You may find it handy to work with the case upside down, as most pieces are flat (flush) with the top. A helper is quite useful.

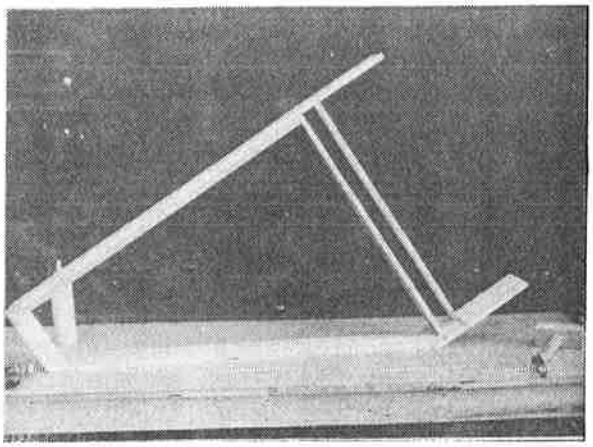
First, screw the tail cleat to the inner case tail, using four 7/8" x #8 FH wood screws, through from the inside. Notice that the square ends should be offset by ½" to form the joint for the spine. Now, attach the tail to the spine, using two 1-¼" x #8 FH wood screws through the tail and into the end of the spine. Remember that the holes for the screw shank (in this case those in the inner case tail) must be almost loose. The areas around the screw heads should be countersunk so that the heads are at least level, and preferably slightly below the surface. These screws that go into the edge of plywood are never rock solid, but should be tightened enough to pull the joint snugly together. Now, attach the belly rails in their proper order and location in the spine dadoes. The upper belly rail uses one 1-¼" x#8 FHWS, and the lower uses two.Your helper will be most useful when drilling holes. The cheek is then



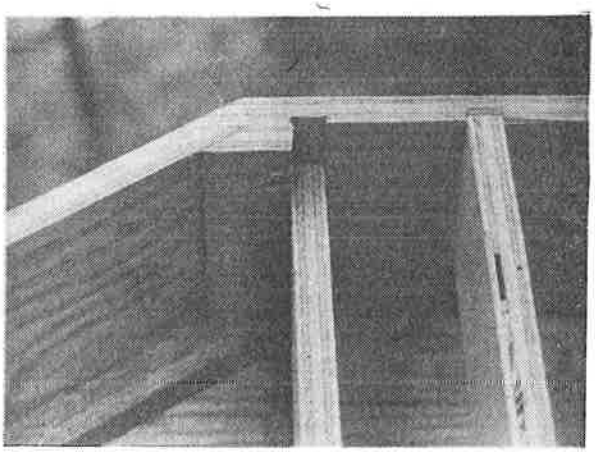
1. Drilling spine & upper bellyrail



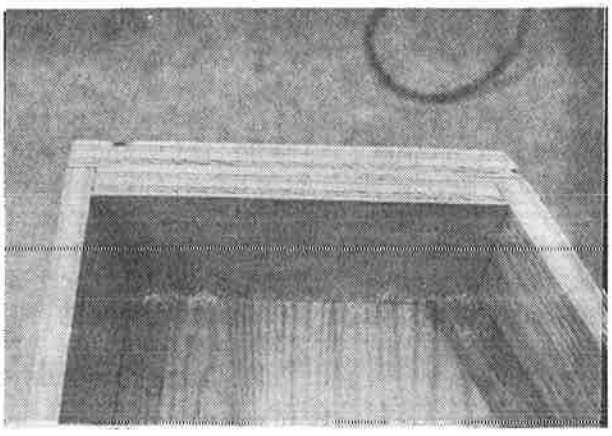
2. Marking a line in from an edge (for inner case lining strips)



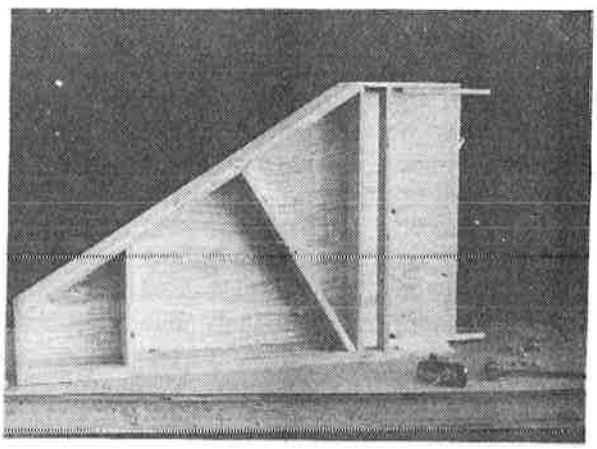
3. The inner case - bottom view



4. The slantside to cheek area. Note bellyrails, cheek cleat, and slantside to back strip.



5. The joints in the tail area. The tail cleat is inside.



6. The inner case - top view. Now the back, braces, and pin block supports are in place.

attached in the same way. Do this on a flat surface, because you don't want a twisted case. Now you can check the fit of the slantside and the cheek cleat. It is possible that the cheek cleat will need trimming, as it should sit right against the lower bellyrail and hold the slantside neatly against the inside of the cheek to form a flat surface with the angled end of the cheek. Although these pieces are milled pretty accurately, this is no reason not to check for proper fit and trim if necessary. It is easier to trim the square edge than the point. Now get a container with clean water and a clean paintbrush ready, and remove all the screws. At last you're ready to glue!

Modern gluesgive you about 10 minutes for assembly. This is sufficient, but if the assembly is involved, it doesn't leave too much to spare. For this reason, always make sure that <u>everything</u> is completely ready before spreading any glue. Novices routinely get into trouble this way.

In the same order as before, spread glue, assemble, and tighten screws. The slantside is installed like everything else, except that it useses nails instead of screws. You will also use two nails to tack the back to the ends of the spine and cheek in the keyboard area, where there are no reinforcing strips yet. We want all of these joints full of glue, and the only way to ensure this is to put on a little too much, and let the excess squeeze out. A damp (not sopping wet) brush can remove this excess glue almost invisibly. Keep this water and brush around permanently. It can be used where necessary on all white/cream glue joints throughout the construction. Although a glue drip on the inside of the case wouldn't actually hurt anything, clean them up anyway. It's not always obvious what areas will have pieces glued later on. Remember that screw heads sticking up on the outside will cause problems when installing the outer case. Last, make sure that the bellyrails are at right angles to the spine and cheek, and place the case on a flat surface overnight so as to let it dry without either getting out of square, or developing a twist. Voila! You already have the basic shape and structure of your harpsichord.

4. The next parts to install are the spine to back strip and the slantside to back strip. These mahogany strips are delivered too long, to allow you to cut them to fit snugly between the lower bellyrail and tail, and the cheek cleat and tail, respectively.

You will need:

1 spine to back strip	19 1" x #8 FH wood screws
1 Slantside to back strip	1 back

When you have the strips fitted, they are glued and screwed, using 3 screws each. As with most glue clamping screws, the precise location is not crucial. In this case, the obvious location is to put one in the middle, and one close to each end.

You are now ready for the back. Although it doesn't have to fit superbly, do any trimming that seems reasonable. Your plane is a good tool for this. The back is supposed to extend beyond the spine and cheek. Just like before, when it is ready, glue and screw it in place, using 13 1" x #8 FHWS, 5 each into the spine and slantside strips, and 3 up into the lower bellyrail. As mentioned before, you may use two small nails to clamp the ends of the spine and cheek to the edge of the back.

5. The two braces that go inside the case are thicker plywood (3/4"-19mm).
You will need:

1 long case brace	8 1" x #8 FHWS
1 short case brace	

Again, the precise location isn't critical. It is more important that they fit snugly between the slant side and spine, and so should be wedged firmly in place. When you first put them into place, it will become obvious that they

will require notches to let them go down over the mahogany strips. Although you could get away with a loose fit on these brace notches, its more fun to see if you can make a nice, close fit. Do make sure that the notches are large enough to allow the braces to fit down solidly against the back.

6. There are two more long mahogany strips to install, this time.
   You will need:

   2 spine to top or slantside to top strips 12 7/8" x #8 FHWS

   These strips are to be trimmed to fit inside the case against the spine and slantside. This ought to be easy, since you've had practice with the strips below. Notice that these thinner strips "stand up" against the inner case, with their wide surface gluing to the spine or slantside. It is fine for them to stick up a little higher than the case. If it happens that there is more than enough space, install these with a very slight amount protruding. Because it bears string tension directly, the slantside strip uses 7 screws, while the spine strip gets only 5. You will find that this gives about 6" and 8" spacing, respectively. When everything is ready, glue and screw these in place, and allow to dry overnight.

   When the strips are dry it is time to deal with the slight excess. I'm sure that you can see the typical problem. Even if every piece were milled perfectly, it would still be virtually impossible to measure and glue everything in place so perfectly that the strips are precisely level with the top of the case. So don't waste time trying. Get your plane out and plane down the strips. This is going to be a glue joint (for the soundboard), so plane this both flat and level. If you hold the plane at an angle (a common error) the surface that you generate will still be flat, but not level (not at 90° to the case sides). This will be troublesome when it is time to glue the soundboard on. So, you are simply planing the strips down to match the flat surface formed by the case pieces.

7. Now we're going to install some case pieces that go into the keywell area.
   You will need:

   2 spine/cheek end supports 4 7/8" x #8 FHWS
   2 pin block supports

   The spine/cheek end supports glue into the corner at the spine (and cheek) case pieces and the back. They reinforce this joint like their counterparts inside the soundchamber, but more importantly, they will support the outer case cheek and spine. The back does not come as far forward as the keyboard, so these will stick out beyond the edge of the back by about 3¼" (8cm). The plies of the plywood will be facing up to match those plies of the pin block supports, which sit on top of them.

   Speaking of the pin block supports, these are next. The notch faces in so that the narrow end slips under the upper bellyrail to touch the lower bellyrail. Before gluing, slip these in dry, set the pin block on top, and sit back and enjoy some visualization. The pin block should be 1/8" (3mm) higher than the case. This is to make it level with the top, which will sit on top of the case. The top will cover the case as far forward as the upper bellyrail. This leave a gap with ledges down inside each end formed by the pin block supports. The keys will reach under the pin block to lift the jacks (appropriately named) up through this gap to pluck the strings, which run from the pin block to the slantside. The jacks are guided by a two-sided ladder, known as a register, which fills this gap and sits down on the ledges.

   Enough woodgathering. The pin block supports are now glued and screwed into place with two screws each. <u>Do not</u> install the pin block at this time.

8. There is one more detail to complete the inner case. You will need:

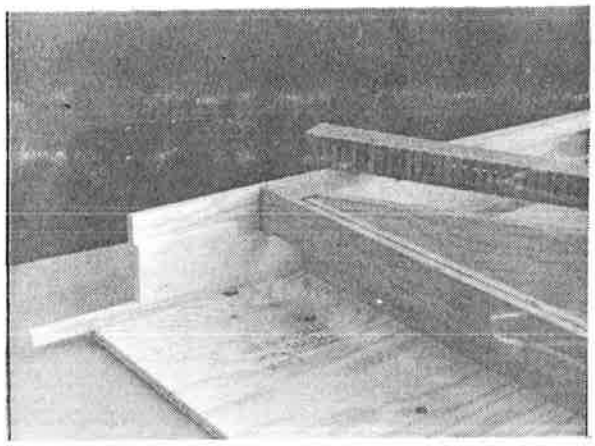
2 inner case cheek and spine extensions

These two blocks extend the inner case in the area covering both ends of the keyboard, often known as the cheeks. They are glued and clamped to the edges of the spine/cheek end supports, the back, and the ends of the spine and cheek. This is a joining surface for the outer case, so don't be afraid to plane across the cheek areas to give a perfectly flat surface.

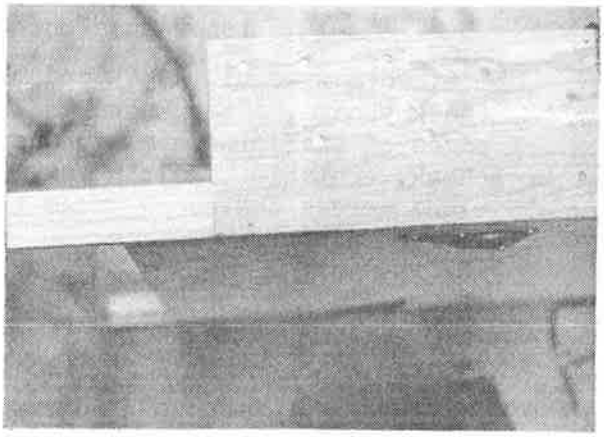
A note about the diagram:

I think it is worthwhile to explain why we included the full-size plan. Its primary use is to locate things, such as the nut bridge, hitchpins, bridge pins, and tuning pins. It is also quite useful for orientation and visualization. However, there is nothing that says your instrument must match the plan down to the nth degree. Harpsichords should not be built sloppily, but neither are they made to machine tool accuracy. As such, it is occasionally necessary to make little adjustments that do not seem apparent on the plan. If every part fits together and does its job well, that is enough.

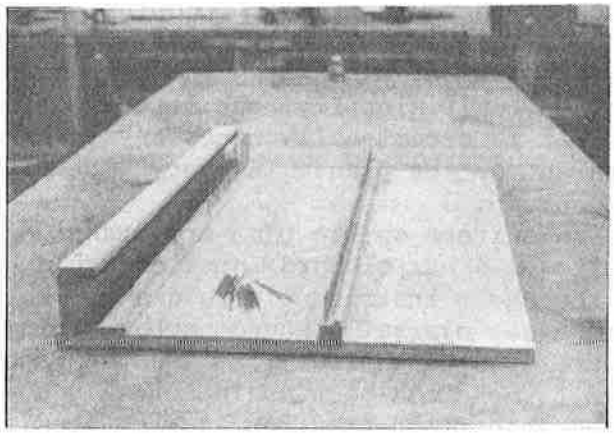
Because its purpose is to clarify, some items on the plan are drawn somewhat differently than textbook practice. A harpsichord top view would be confusingly cluttered if every part in the whole instrument were drawn. For this reason, things such as the keyboard base, overrail, soundchamber lining strips, music desk, jack rail, and lid are deleted entirely, as are the majority of the keys register blocks, and strings. The cross section is actually a longitudinal section through the keyboard and action area, and a right angle section through the slantside area.



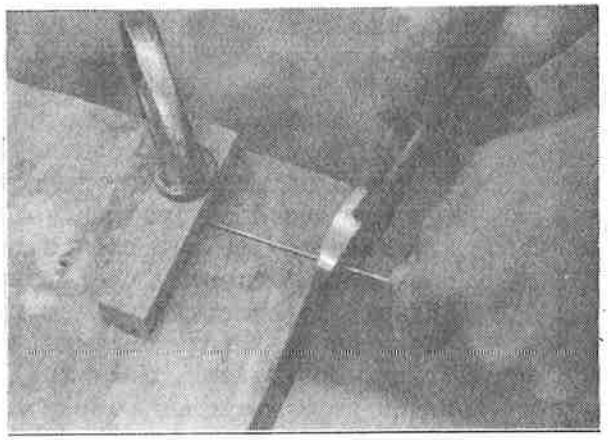
7. Detail of pin block support, and spine/cheek end support



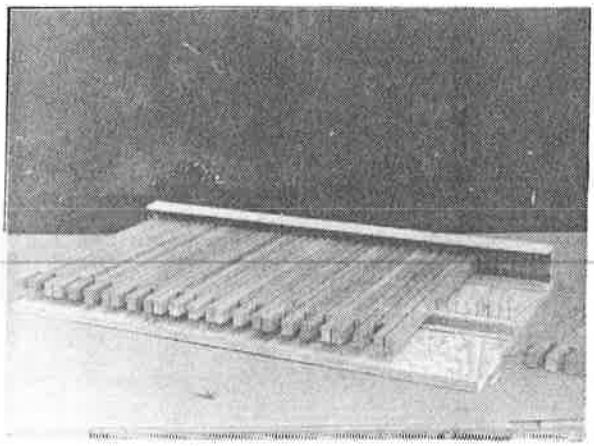
8. Outside view, showing cheek, and inner case spine/cheek extensions.



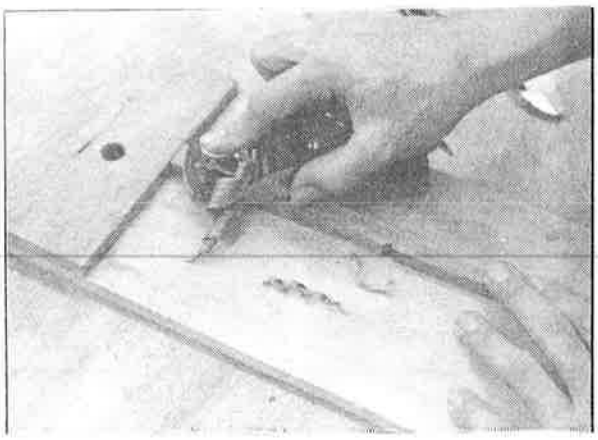
9.The keyboard frame with base, balance rail, overrail, & pins.



10. Cutting pins



11.The frame, with key blanks fitted.



12.Using a stop block while planing key blank to proper width.

THE KEYBOARD

9. The keyboard is next. It makes a nice change from all the structural work. You will need:

1 keyboard base	12 7/8" x #8 FHWS
1 balance rail	1 overrail top
1 balance rail dowel	1/16" (1.5mm) brass pin material
1 overrail support	1 keyfall spacer
1 pc. keyfall and keydip felt	

Examine the keyboard base, and you will see that the notch is not centered. The larger area will be to the rear, and the smaller to the front. Mark both plainly now.

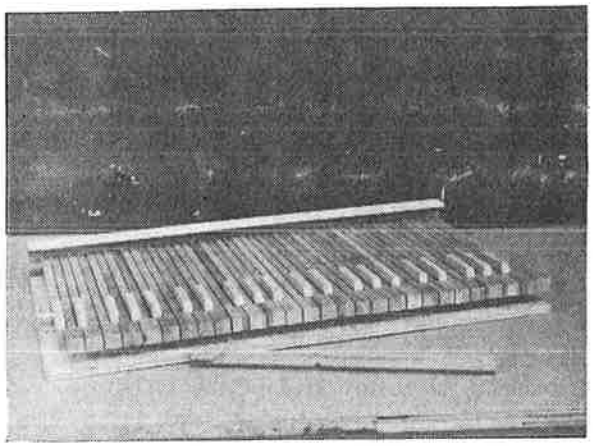
The balance rail dowel is first glued into the notch in the balance rail. Masking tape works well here. When dry, this is screwed and glued into the slot in the keyboard base, using 3 screws. Notice that the notch is not centered in the balance rail. Locate the rail so that this wider surface is closer to the rear, and the dowel closer to thefront. The photos show this and subsequent steps. Note: you may wish to drill holes before gluing.

The overrail assembly which controls how far the keys depress (key dip) is located at the rear of the keyboard. It does not, however, go flush with the back edge, but instead $\frac{1}{4}$" (6mm) in from that edge. So mark a line the right distance in, and then glue and screw the overrail support to the line, using 4 screws.

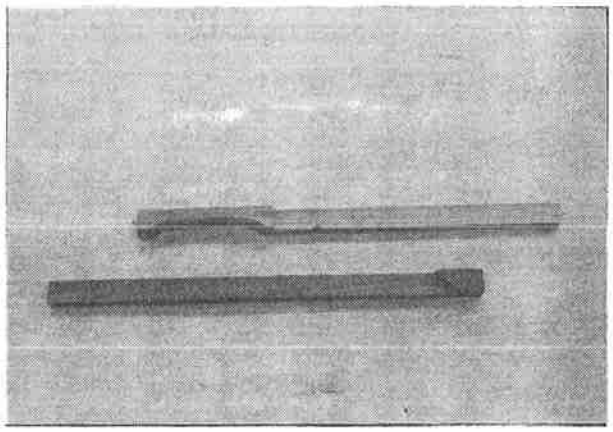
The overrail top uses screws only for its attachment to the overrail support. This will allow it to be removed easily. Install it now, using 5 7/8" x #8 FHWS. Now you can place a key blank or two on the balance rail, and see how it works. Right now, there are three problems. The keys are falling down too far, can move sideways, and are quite noisy. The keyfall spacer ensures that keys fall to the right point, just as the overrail gives proper key dip. Both the overrail and the keyfall spacer will have felt applied to eliminate noise.

10. This felt is ordinarily supplied as one wide piece which must be split with a sharp knife to give two pieces approximately 26$\frac{1}{2}$" x $\frac{1}{2}$" (68.5cm x 13mm). When gluing, the right amount of glue is important. You need enough to glue solidly, but you must avoid saturating the felt, which will make it hard and defeat its purpose. The traditional method for the overrail was to lace the felt on through holes, but gluing works quite well, too. You will find it easier to apply the felt to the keyfall spacer before gluing it in place by the overrail support. When ready, this is glued and nailed in place. If they are not driven fully down, these nails can easily be removed. Check to make sure that this keyboard frame will fit into the space for it in the case.

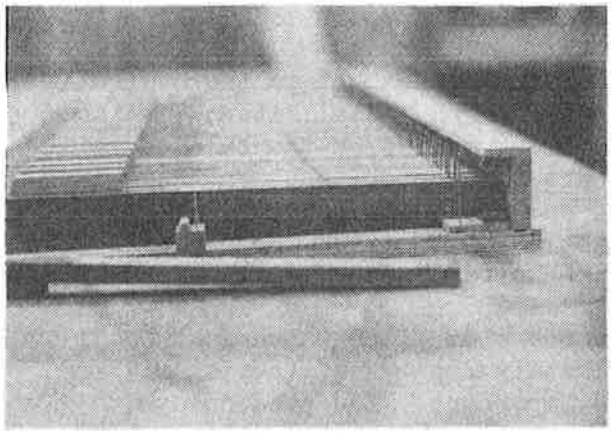
Now you're ready for the balance rail pins. There is a keyboard spacing template on your drawing. It looks like two lines, with the spacing marks shown like the rungs of a ladder. Because it must be used for several operations, it is worthwhile to transfer it to the edge of a yardstick, using your knife to get accurate marks. Now transfer this scale to that wider flat area at the back of the balance rail. The first pin should be 1/8" (3mm) in from the left hand (bass) end of the rail. Center punch all marks with an awl before drilling. Because the pins should be vertical, this is a good place to use a drill press. The hole diameter is 1/16" (1.5mm) and depth should be about 3/8" (9mm)



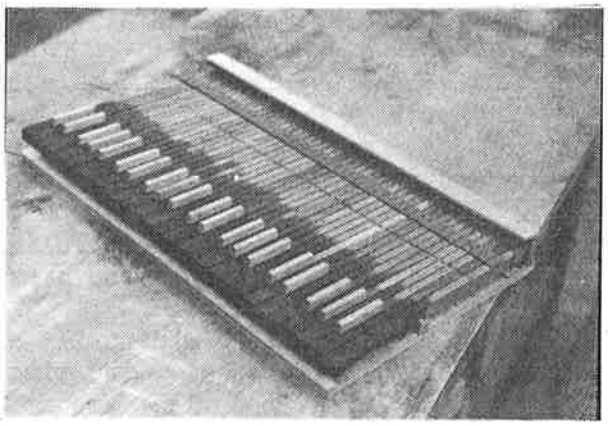
13.Entire keyboard glued up, with sharp tops and natural blocks



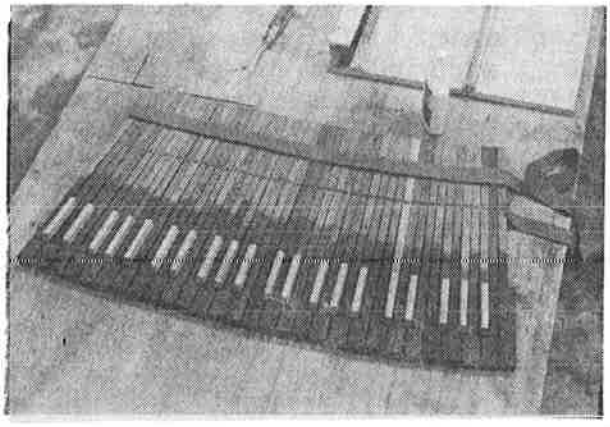
14. Lightening of keys. Lower is typical, upper is high "c" key.



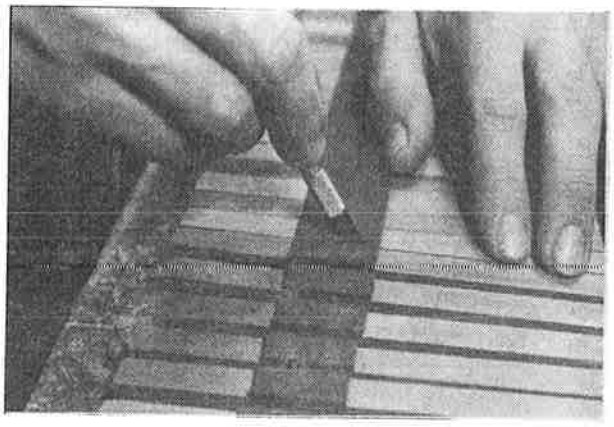
15.Keyboard detail, end view.



16.Completed keyboard!



17.The jack pad felt is applied as one long strip....



18. ..Which is cut apart while the glue is not fully set.

11. Now you need to cut 50 pins (plus some spares). A simple jig for cutting pins quickly to the right length is to clamp a block the proper distance from a table edge, and then cut to the edge of the table as shown. Last, use a file to ensure that there are no burrs on the exposed pin ends. They can be installed by tapping them lightly into the bottom of the holes with a small hammer or block of wood.

12. Now you will work on the keys themselves.
You will need:

29 natural key blanks	1 bag #1 key ends
20 sharp key blanks	1 bag #2 key ends
20 sharp key tops	1 bag #3 key ends

First, lay out the key blanks in the proper order. The keyboard both starts and ends with "C" keys. You will avoid confusion by looking at another keyboard. We include some extra keyblanks, so you may reject some. The most troublesome key is one that has developed a warp or twist after we do our selecting. The spares are all natural key blanks. If you need a sharp key blank, you should cut off the excess on the end where the sharp key top is to be glued.

Take the first key and see if it will slip in between the first two balance pins. If it doesn't fit (it probably won't), you need to narrow it down by planing until it will just fit between the pins, and work without binding. When it fits properly, put a number on it before going on to the next key. You will appreciate having all keys numbered sequentially. This fitting, like many other operations concerning the keyboard, is one that you will have to perform forty-nine times. An excellent rainy afternoon project. Would you like to know how to cheat just a little? Every so often, one gets carried away and makes a key too narrow. You can use several layers of a slick-surfaced tape to build up the width a little.

Now, remove all the key blanks, set them aside, and make 50 guide pins, 1/16" dia x 2" long (1.5mm dia x 51mm) . These are quite similar to the balance pins, but longer. The row of holes for the guide pins should be about 6-3/4" (16cm) back from the guide pins, which locates them near the edge of the key fall spacer. Like the guide pins, the first is 1/8" (3mm) in from the edge (bass), and the holes are 3/8" (9mm) deep. Install just as before.

13. You can commence fitting the tail ends of the keys. This is pretty much like fitting the balance pin area, except that you now have experience. Keep in mind that since the balance pin area is already fitted, any binding that won't let the key return should logically be caused by the guide pins. Every key should move easily and return quickly. You now have a sort of "ghost keyboard". All the sharps will get a light-colored top, and the naturals will get blocks added to widen them and fill the gaps.

Start by gluing on the sharp tops, with the bevel towards the front. Strong rubber bands make inexpensive, non-marring clamps. When dry, sand out any rough spots. Quite often the sharps are tapered slightly towards the top. This can be done with a plane or sander.

14. The little blocks that widen the naturals come in three thicknesses. The diagram on the large drawing shows where each size is to be used. The action will be better if you nip off the bottom inside corner of each key end block before gluing. Because it doesn't have a sharp beside it, the high "c" " key needs a long key end. Make this by cutting a 4-3/4" (12cm) piece from a rejected key blank. If all this weight were left on, though, the key would be sluggish, and so should be lightened as shown in the photo.

The last step is to tidy up all of the glued up pieces into a nice-looking keyboard. I'll admit that we use a power sander, but if you use one, be careful-things happen quickly. Hand planing and sanding are just about as

fast, and a lot safer. You want the tops to come out square and level. At the same time, you can plane the sides to give adequate clearance and matching gaps between keys. Last, it makes some sense (and is fun) to apply the keyboard finish now. Because a coating type finish will tend to scratched by fingernails, a better choice is an oil finish, such as Watco or Hoppe's. If you prefer even more contrast than the two wood species give, you could use a clear oil on the sharps, and a dark colored oil on the naturals. This will also tend to tone down color differences inherent in the wood. There is no point in finishing past the balance pins.

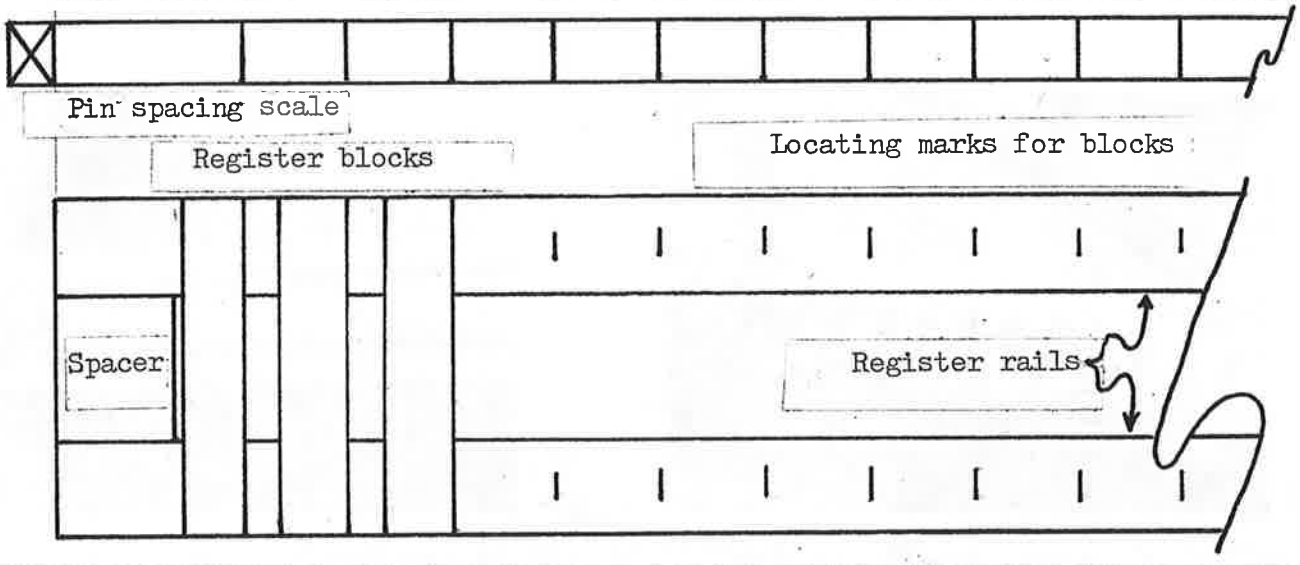
Set the keyboard aside and have a look at it. Isn't it pretty? You can slip it into the keywell to admire it more properly.

15. Remember the register that I mentioned earlier?
You will need:

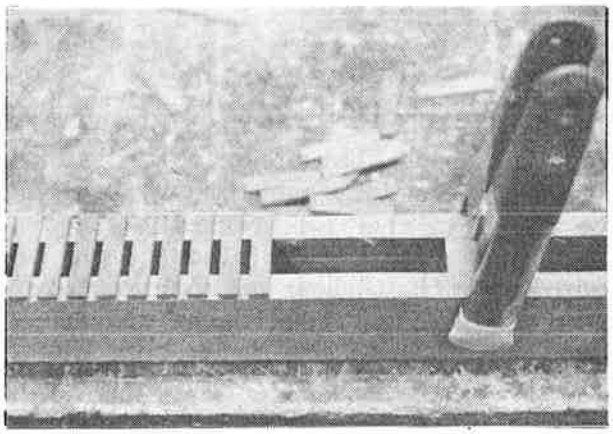
2 register rails	1 bag register blocks
3 register rail spacers	1 set jack bodies

The first step is to glue a register rail spacer between each end of the register rails. The wide, flat notches face in (towards each other), so that only the narrow surfaces will actually be glued to the register rail spacers.

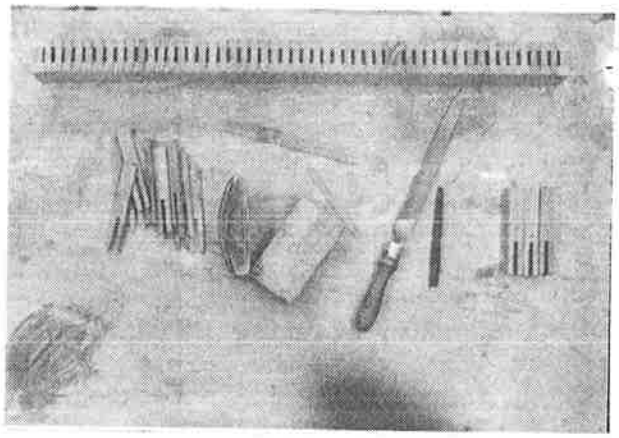
16. The layout marks for all the register blocks is another place to use your keyboard pin spacing scale. Mark both top and bottom edges of both register rails, starting 1" (25.5mm) from the left (bass) end. These marks now indicate where the left edge of every jack will be. Since the jacks come up through the holes between the register rail spacers, you will glue a block with its right edge on each mark. When the next block is glued at the next mark, this will leave a space just the width of a jack, with its left edge on the mark as required. The diagram should clarify this, and there is a photo of the actual pieces as well.



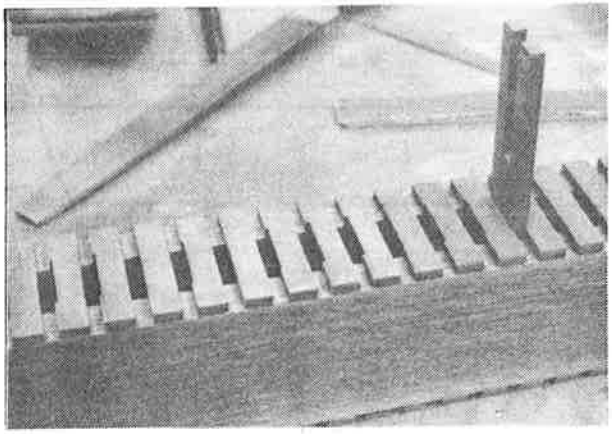
17. If this is not clear, glue the first two blocks on each side, and let dry. Set the register in on its ledges. Although the jacks won't yet fit down through, something like a popsicle stick will, and should come down onto the last bass key. There is some lateral movement possible in both the register and the keyboard assembly, which you will use to adjust the jacks to let them fall properly on the middle of the keys. At any rate, when you see how this works, glue all the register blocks. These do not need clamping. Use a dab of glue on each end, press into place, and remove excess with your damp paintbrush while holding the block with a finger. If the register rails themselves aren't quite straight, you may clamp the extra register rail spacer provided in between the register rails to hold them at the proper distance while the register blocks dry. If you use this method, glue the register blocks in bunches of about twelve and let dry thoroughly before moving the extra spacer. Of course, it must not be glued in place, as it would interfere with the jacks. Of course, the register blocks must be dry before attempting to fit the jacks to the slots.



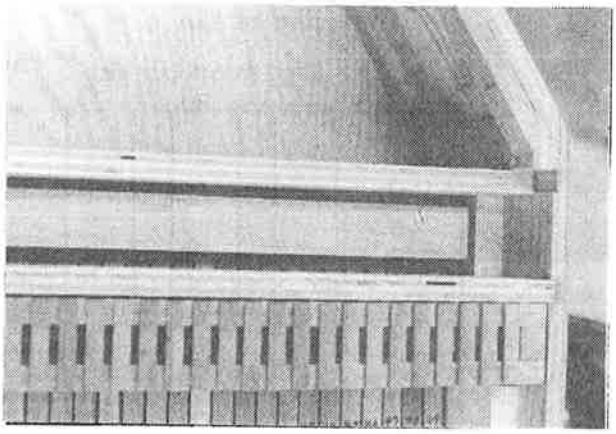
19.Gluing register rail blocks. Note temporary spacer held with clamp, and faint marks, which locate blocks.



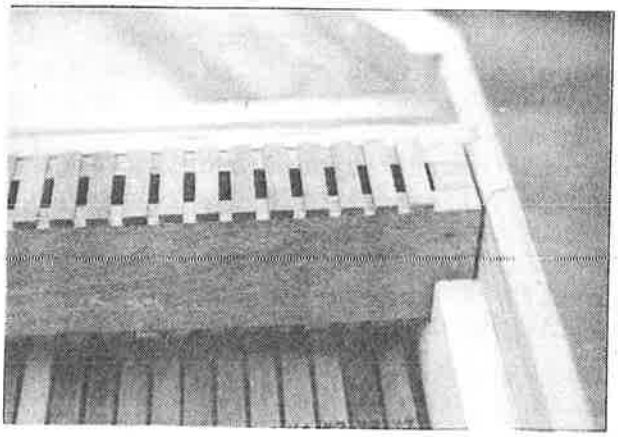
20.Materials ready for fitting jacks. Sandpaper for jacks, file and emery boards for slots, and pen for marking.



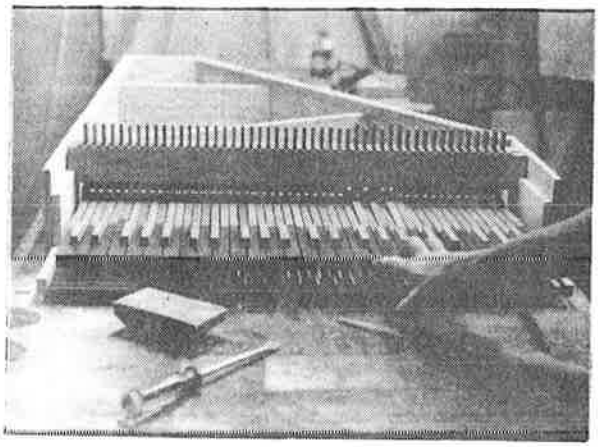
21.Fitted notches. Depth will vary according to position of glued blocks. Note that third slot required no filing



22.Register and keyboard in place. Overrail is visible in space between bellyrails. Register sits in front, in notches in pin block supports.



23.The register sits in the notches in the pin block supports, in front of both bellyrails.



24.Checking action pieces for smooth and free working.

18. Start by smoothing up the first jack body with 220 grit sandpaper, making sure that there are no loose shreds to catch. Now try to fit it into the first slot. Chances are that it won't fit in. This is fine because you want to have a little material to remove to give a perfect fit. A very useful tool for this is your 8 inch metal file. It won't cut wood very quickly, but there isn't a lot of material to remove. If you need to remove material a little more quickly, it is possible to make up a device like an emery board by gluing sandpaper to a wood strip that will nicely fit the slots.

Hold on for a moment for a note of caution. The fit between the register and jacks is one of the most precise in the entire instrument. So, proceed very slowly and carefully when fitting the jacks to the register, as it is much easier to remove a little more than to try to put it back. File only on the right-hand side of the notch, and stop frequently to try the fit of the jack body, and to make sure that the slot isn't becoming oddly shaped. The narrow ends should have a looser fit than the wide surfaces. What you are trying for here is as tight a fit as possible that still allows the jack to fall of its own weight. Pay particular attention to the corners of the slots. Fit first the top of the register and then the bottom, and then check both at once to see that the jack body will fall easily. Each jack body is then numbered to match the keyboard. Number all jack bodies on their right-hand (treble) side.

19. When all the fitting is done, it is time to install the register. For a nicer job, glue some extra register blocks (or equivalent) to the bottom of the register so that its top surface is even with the pinblock. Set the register in place, and drop the jack bodies in to let them sit on the key tails. As mentioned earlier, you can use the lateral play in both the register and the keyboard assembly to make sure that each jack sits properly on its key. Ideally, they will be right in the middle.

I find it easiest to clamp the register to the upper bellyrail to hold it solidly while drilling the holes in each end for the long screws which hold it in place. Because only about $\frac{1}{2}$ " of these long screws is actually doing any holding, make sure that the hole in the register is a little oversize. You can start the holes in the middle of the register rail spacers, and angle them outwards to keep the points well into the stock of the pin block supports.

For reasons not wholly explicable, some of the jack bodies that fit well before may now decide to bind slightly, necessitating a little more work like before. But when its done, it is a pleasure to see all of this hand made mechanism working smoothly.

20. There is one last keyboard detail that might as well get done now. There is felt to be applied to avoid that clatter when the jacks land. Mark where the jacks sit with two long lines across all the keys, remove the jack bodies, and then the keyboard. Remove the keys from the base, and lay them out on a flat surface with the key tails squeezed together to form a big arc. Now you can glue the felt as one long strip, following the usual "enough, but not too much" rule. The excess will tend to glue the keys together, though, so cut them apart within one hour as shown in the photo. You will find then you reassemble the action that things are much quieter. Occasionally the bottom end of the jack bodies will tend to snag on the felt. Sand this area lightly on all the jack bodies.

THE SOUNDBOARD

For a change of pace, let's build the soundboard.

You will need:

1 soundboard	2 short pieces bridge stock
3 pc. soundboard bracing	small nails
1 long piece of bridge stock	nailing pads

21. Yes, the soundboard is plywood. This is simply an example of modern technology making available something that performs all its functions very well. Virtually everyone is rather impressed with its acoustic properties in the final instrument, which is, after all, the most important consideration.

First, sand the entire top, and then use the full-size diagram to mark the locations of the three sections that make up the bridge, as well as the location of the tone hole.

The bridge pieces are stock, that is, they have the right profile, but must be cut to length, and have the ends mitered (angled) as shown on the full-size drawing. The drawing will be used both as a pattern for cutting the bridge stock, and to locate all the bridge pin holes. These are not centered, but should be avout 1/8" (3mm) from the higher edge of the bridge, which should in turn be nearer to the keyboard. Use a small saw to cut the stock, and an awl to mark all the holes. These will be drilled with a 1/16" bit, again preferably on a drill press.

Since you now have holes in the bridge, the easiest way to clamp it down is by nailing with padded nails. Get them ready beforehand, by having the nails driven slightly through the pads so that it is easy to get the points into the holes in the bridge. To do the actual nailing, you will need a large, flat surface that you can drive nails into. Someone will probably be upset if you use the dining room table. If you have nothing more convenient, it's fine to use the bottom of the upside-down harpsichord case for this (after you remove the keyboard and register). If the case pieces project beyond the back, and interfere with the flat back surface, plane them down. Again, make sure that all is in readiness before spreading glue. Your glue washing brush and water will be invaluable here.

22. At last you're ready to glue. Check the mitre joints to see that they join prettily, spread glue, and nail the bridges down to their proper locations, spacing nails every 4" (10cm), perhaps with more at the ends. Wash all edges carefully. Although it isn't usually much of a problem, the usual technique is to pull the nails within one hour, before they become obstinate and refuse to leave. When this is thoroughly dry, you use the same bit in your hand drill to extend the holes down through the top.

23. The tone hole should be located from the drawing, and marked using a compass. The diameter is 2-5/8" (66.5mm). It can be cut using a sharp utility knife, one layer at a time, gradually deepening the cuts around the circle. Cut slightly inside the circle to leave a little material for sanding. This sanding should be done by making a curved block to match the circle, and applying sandpaper to it with glue. Do a nice job, as this area is quite prominent. Now you can flip the top over, and apply the gold rosette to the underside. White glue is not good for this as it doesn't gond to metal. Epoxy glue will bond to both metal and wood, but be careful of excess, as it can leave ugly smears. Glue not only the three tabs, but the entire periphery, for it is possible for loose edges to vibrate.

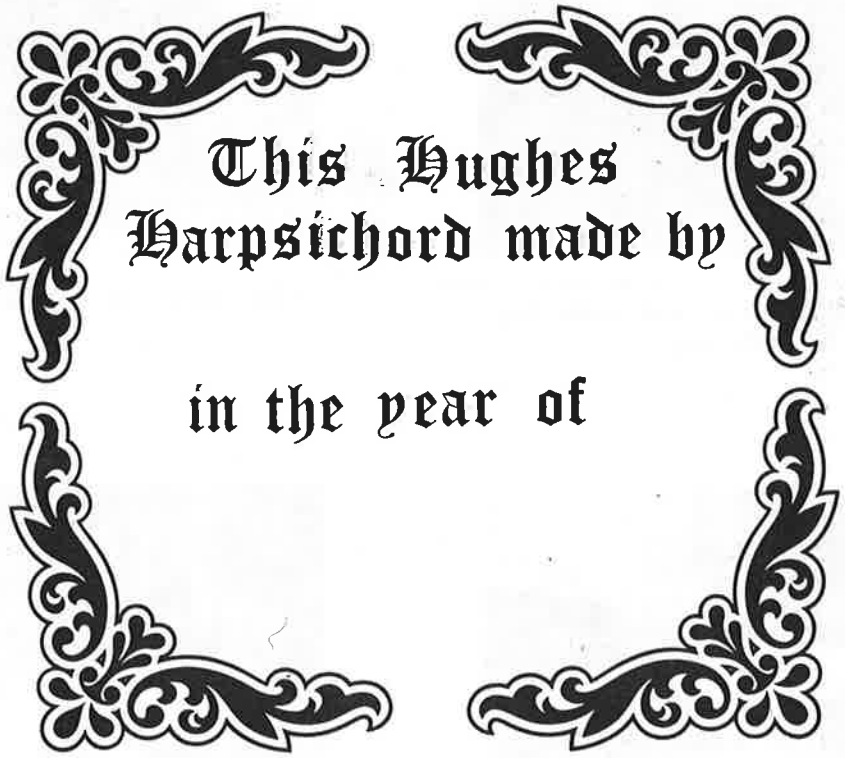
The location of the bracing is shown by the photos and the full-size

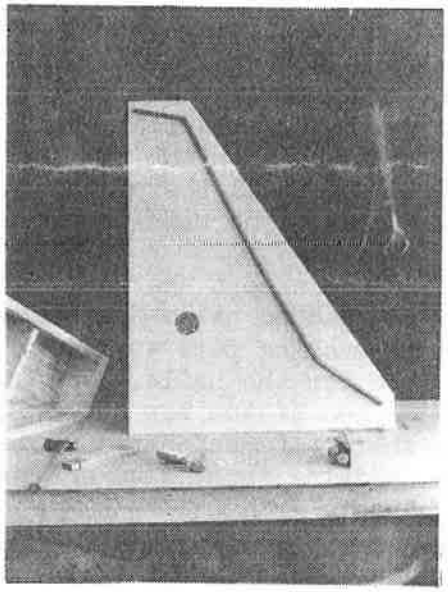
diagram. The three pieces do not need to join. You do want these glued quite thoroughly, if only because it's quite troublesome to repair once the top is in place. The ends are usually tapered as shown in the photo.

24. As long as the soundboard is completed, you might as well install it. Check the top edge of the case again for trueness and then set the top on and see how it fits. It may not be very flat (because of all the pieces glued on), but that will be tamed when you nail it to the case. The main problems here are jogs over joints in the case.

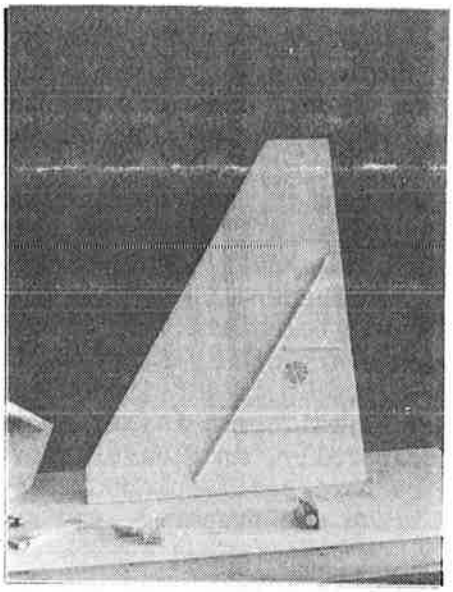
There will be molding on every edge of the top except where it joins the upper bellyrail. This means that we can use the padded nails for clamping on every other edge except the bellyrail, where masking tape will work very well. Up to $\frac{1}{2}$" (13mm) in from the edges is safe for the nails. Because the bellyrail area is harder to trim, line up the edges of the top and bellyrail carefully, and leave an overhanging edge elsewhere (if necessary) where they can be more easily planed. If your padded nails, masking tape, glue and washing brush are prepared, you are ready to glue - almost.

Harpsichord makers in past centuries signed their work, and so should you. Here is a label for you to fill in. It should be glued to the inside of the back to be visible through the rosette, facing the slantside. Make one last check, remove all your tools (yes, it has been known to happen) and glue and nail the soundboard in place. The molding will cover the nail holes later.

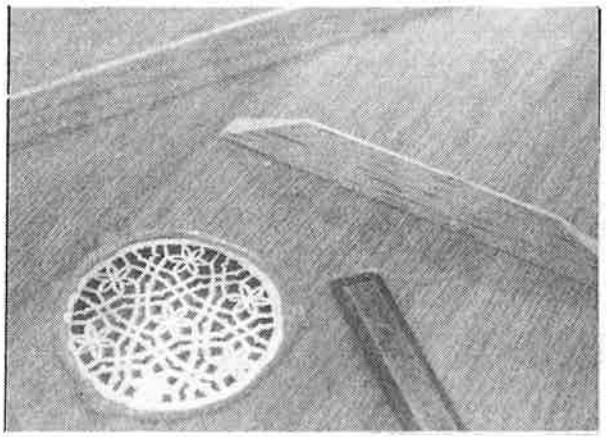




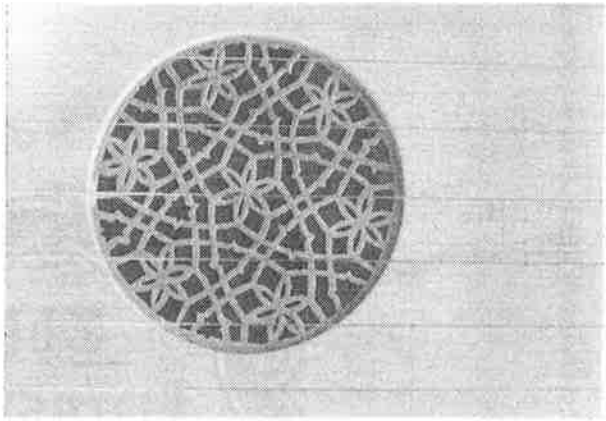
25.Completed soundboard, outside view



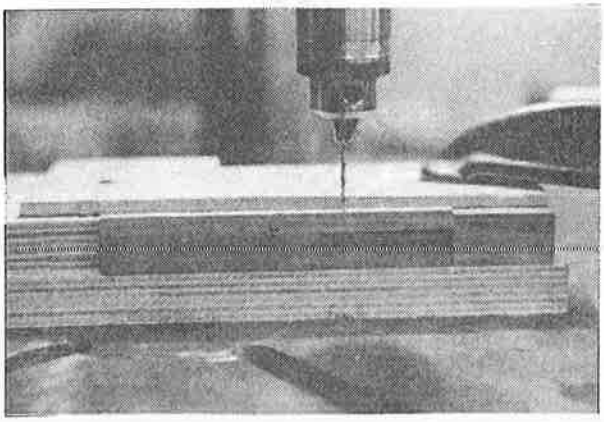
26. Completed soundboard, Inside view.



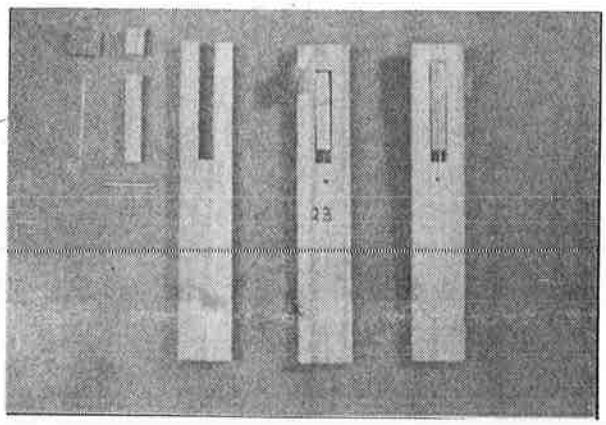
27. Detail of bracing and rosette, underside of soundboard



28. Outside appearance of rosette.



29. Typical drill press jig for drilling jacks. This shows axle hole drilling



30. Jack parts, and front and back views of completed jack.

Now let's get back to the action parts.
You will need:

1 set of jack bodies	#51 drill bit
1 bag of jack tongues	1/16" brass pin material
1 bag of jack tongue stops	jack spring material

Have a look at your sample jack to see how they're made. The jacks are the heart of any harpsichord, so work carefully.

25. Drilling the axle holes is the first step. However, the axle hole in the body cannot be the same size as the one in the tongue. One hole must be loose (to allow the tongue to rotate), and the other hole must be smaller and tighter (to keep the brass axle in place). Although it would be possible to reverse this, we prefer to have the loose fit in the jack body holes, and use a smaller, tighter hole to keep the axle captive in the tongue.

These tongue holes will be drilled with a 1/16" bit and will be 3/16" (4.75 mm) from the end. Notice that the tongues are slightly thinner in one dimension than the other. The axle goes through the thinner, narrower surface. Drill one hole, and make sure that it is a tight fit on a piece of de-burred axle material. Since there are almost 50 holes to drill, I think it is worthwhile to set up a simple jig for the drill press as the picture indicates. Although this picture shows drilling for the jack body axle hole, this basic idea of two blocks clamped on the drill press table will work for all four jack holes. Set up to get the hole the right distance up from the end, and exactly centered on the narrow surface, and drill holes in your tongues (yes, I know how it sounds) Last, each tongue needs a 45° bevel (angle) sanded on the end opposite the axle hole. A sandpaper block is the best tool for this. Make sure that the bevel is oriented correctly. These bevels do not have to come to a sharp point. In fact, a narrow flat surface left on the end is less prone to cause burrs.

26. The jack body holes are similar, although these pieces are easier to handle. These are the bigger holes, so you must use your #51 drill, which is a few thousandths of an inch larger than 1/16". This hole is also located in the narrow surface, with its distance from the top shown by a scribed line cut into one side of the jack body. Actually there are two scribed cuts. The higher line shows the level of the plectra. The axle line is the lower of the two (closer to the closed end of the slot). When you're sure, set up to drill the bodies. One advantage of a drill press jig is that it compensates for even the slight variations that are possible with the lines. Drill the extras, in case you need spares later.

The jack axles are made just like short balance pins. They are 1/16" dia. x 5/8" (16mm) long. De-burr the ends carefully, as they will have to slide in the jack body holes.

You are ready to start assembling all these pieces. First, use a file or fine rasp both to smooth the inside of the jack body slot, and to ensure adequate clearance for the tongue to work freely. Set the jack body on its side, line up the holes, and press an axle into them. It should slide in firmly, and stay there. It will have to be pressed in to get the end of the axle below the surface so that the tongue may move back and forth without the axle protruding. You can make a little punch for this by driving a small nail that is thinner than the axles into a block of wood, cutting the head off, and filing the end smooth. Leave 3/4" (19mm) protruding so that it can be used to press out the axle if necessary.

Let's pause again for some orientation. The string plucked by each jack is

to the left (or bass) side of that jack. Since the tongue must tip away from the string, they must tip out of the right (or treble) side. Since you numbered all your jacks on the right side, the tongue should tip towards the number. Look at your sample jack, and make sure that you see which way the bevels on the tongue and tongue stops face.

Check the tongue. It should fall back and forth perfectly freely. If it does not, the cause is probably one of the items that you were trying to avoid while working on the parts. Here are the common things that you should check.

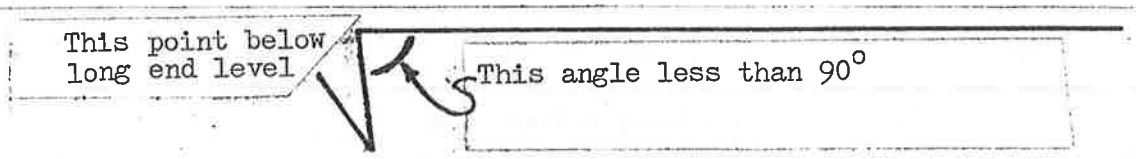
TROUBLE SPOT	REMEDY
1. Wood shreds clinging to tongue or slot	File or sand off
2. Tongue at slight angle on axle, and hitting sides of slot.	Sand tongue narrower or replace tongue
3. Burrs on axle shaft	De-burr with file or sandpaper
4. Holes in both sides of slot not in line	Align by re-drilling

Doing 50 jacks is definitely a sit down type project. Each jack must also have a tongue stop installed for the tongue to bump against. You already have sanded the bevels on them, but the blocks will also have to be narrowed slightly to fit the jack slot. This is most easily accomplished by sanding them against a sanding block, while holding the tongue stop with pliers. It should fit snugly in the jack slot, but without spreading the jack ends apart. Pay particular attention to this. The location where you glue the tongue stop affects the functioning of the jack. It does not matter if the end of the jack tongue stop is flush with the top of the jack. It may be necessary to place it either higher or lower. The important thing here is that the tongue be perfectly vertical (parallel to all edges of the slot). If the tongue stops too far in (or out), push the tongue stop down (or up) to adjust it to stop at the vertical position. When you see where this position is, remove the stop, put on two dabs of glue with a toothpick, reinstall, hold tightly and wash the excess. When dry, this area can be sanded smooth. We do want the jacks all the same length, so you will sand the tongue stop down to match the jack ends if it is higher than they are, but you should leave the jack ends alone if the tongue stop is lower. The end of the jack slot will then catch the jack when it bumps at the jack rail.

Keep going! There is only one more step on the jacks for now. This is the spring that holds the tongue closed on each jack.

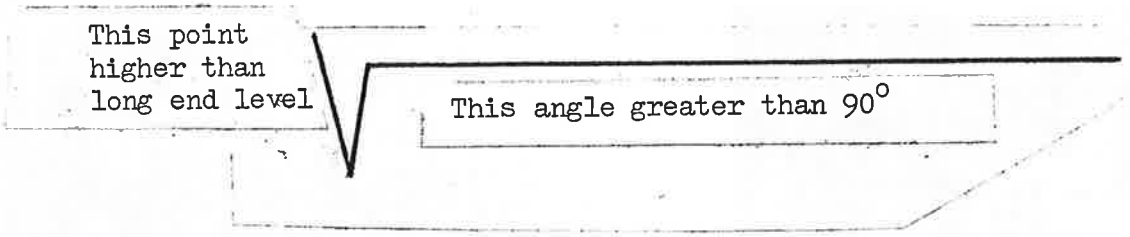
27. First is the mounting hole. This goes in the wide surface (at 90° to the axle hole). It should be centered, and located 2-5/8" (6.5cm) from the bottom end of the jack. It will be close to the bottom of the slot. The diameter of this hole is 1/16".

The springs themselves are made from small sized spring steel wire. As you can see from the diagram and photo, they each have two bends, and are shaped rather like a check mark. The "vee" shape and sharp end holds the spring in its hole, while the other bend keeps it from going on through, and keeps the long springy end in place against the tongue. This diagram is expanded to give you a getter idea of the characteristics wanted.



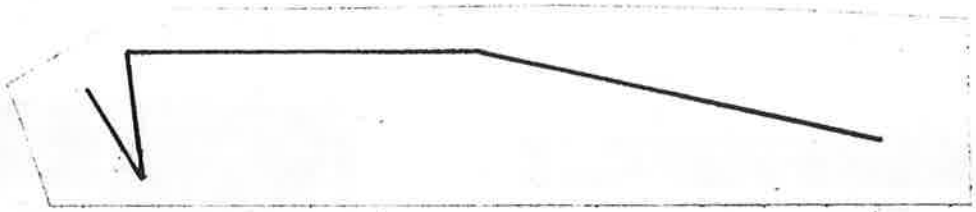
I recommend putting the two bends in the end of a long piece of spring

stock, and then cutting to length. You will probably ruin one or two learning. Don't worry - there is extra material.



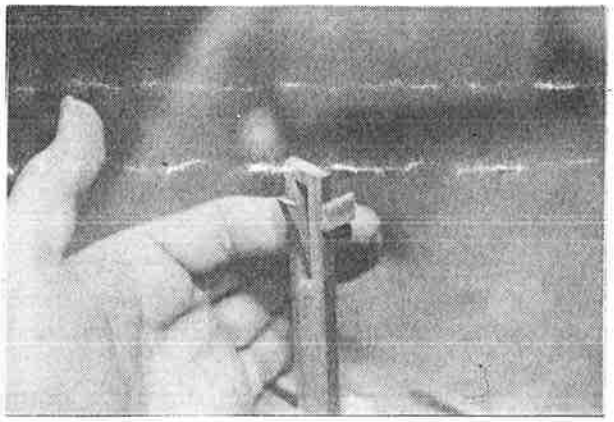
The spring sketched above has two things wrong. The short end is too high, which won't let it hook into the side of the hole, and will cause it to pop out. The angle of the other bend being too large will cause the long end to point away from the jack body and tongue.

28. Occasionally, even a properly bent spring won't quite reach down to contact the tongue. You can remedy this even after the spring is installed by slipping a small awl or screwdriver under the spring, and bending the spring over it to put a shallow bend in the long end like this:

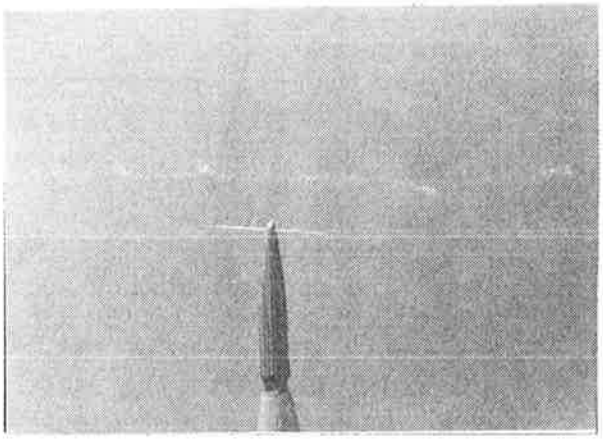


At any rate, a few tries will show you how they must be bent in order to work. The spring must hold the tongue very lightly, yet firmly against the stop, and it should return smartly with a slight click when held open and then released.

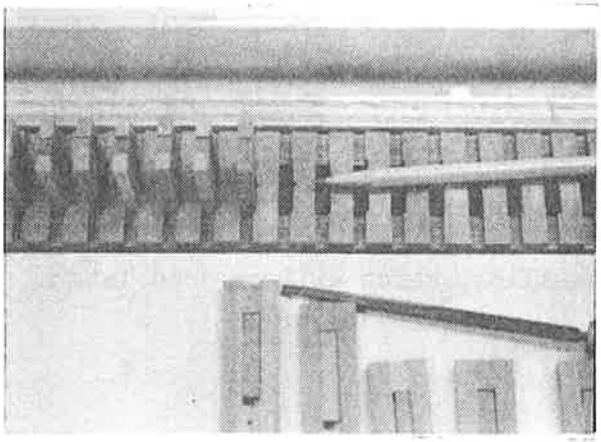
You may now congratulate yourself, for the jacks are constructed. They need only to have plectra and dampers installed, which will be done later.



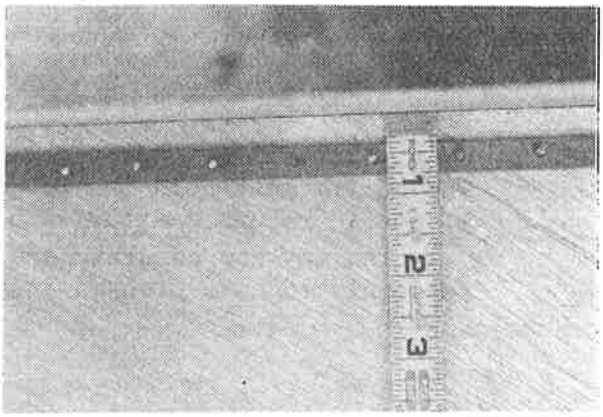
31. Jack tongue pivots, showing bevel



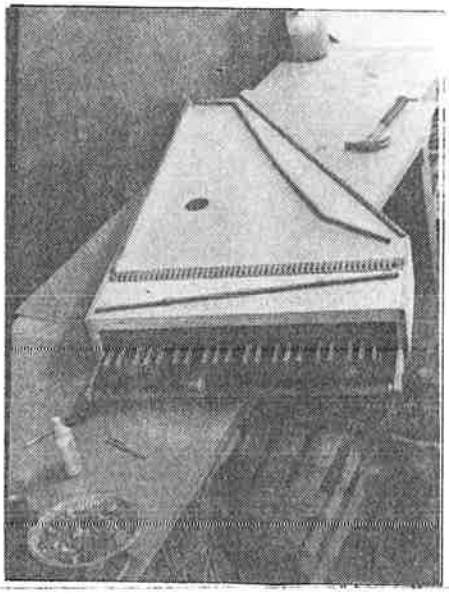
32. Jack spring.



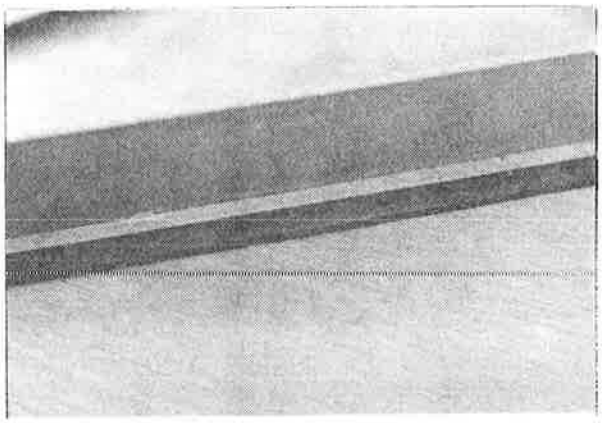
33. Jack spring relief notches



34. Exactly 3/8" (9.5mm) must be left on set back of hitchpin rails from case edge.



35. The instrument so far. The top, pinblock, and register are in place. Note padded nails holding nut.



36. The first outer case piece goes on the outside. The setback is to leave space for other pieces.

29. Your freshly built jacks now get another fitting to the register. Since the bodies worked smoothly before, again logically, any binding will be caused by the new parts that you have added. One very definite cause will be the springs, which stick out of the side of the jacks. The photo shows the cure. A small triangular file is used to file a vee-shaped notch to provide clearance. Keep in mind that the jacks will be installed with the springs on the right hand (treble) side. The springs are the only part that should stick out, but occasionally inanimate objects get obstinate, so if a jack tongue exceeds its boundaries, sand it off, and get all the jacks sliding smoothly again.

30. The legs could be installed at any convenient time. The two front legs should have their centers about 4" (10cm) in from the spine and cheek edges, and about 3" (7.5cm) forward from the lower bellyrail. The single back leg should be about 9" (23cm) in from the tail, and centered between the slantside and spine. The mounting screws for the leg plates can sometimes come through into the keyboard base. Although there is nothing wrong with having the keyboard solidly in place, you probably should file the tips off so it will slip in and out easily. If you want the keyboard secured, do it later with screws up through the back. Some builders prefer having the instrument on its legs from here on, and others prefer to leave it on a bench.

31. Up to now, we haven't secured the pin block for reasons of increased visibility and access to the keyboard and jacks. Since it bears all the string tension, though, it does need to be secured rather well. Its main attachment is glue and screws down into the pin block supports, but we will also glue and screw it to the case.

You will need:

Pin block
6 1-$\frac{1}{4}$" x #8 FHWS
4 2-$\frac{1}{2}$" x #10 FHWS

Before it is installed, though, you should drill the tuning pin holes with the drill of the proper size (3/16"). They are located from the large diagram, and centre punched. Also mark (but don't drill) the four centres for the main mounting screws. Drill slowly to avoid lifting splinters. The hole depth is 1-$\frac{1}{4}$".

Each side of the pin block will be held down by two vertical 2$\frac{1}{2}$" x #10 FHWS, and by three horizontal 1$\frac{1}{4}$" x #8 FHWS. Drill and install the center horizontal screw through the case and into the pinblock on both sides. These will hold the pinblock while you drill first the holes marked on the pin block, and then the horizontal holes. Make sure that these last four holes do not intersect either the vertical main screws or the tuning pin holes.

32. The installation of the six screws through the case is just like all the others- properly fitting holes with countersink head a little below the surface. The four pinblock screws, though, we want countersunk a little differently. Instead of the conical countersink, drill a 3/8" (9.5mm) diameter hole 5/16" (8mm) deep for the screw head, which will pull down completely inside. This will leave space for us to glue in a short section of dowel over the screw head to hide it. These dowels will then be cut off and sanded smooth. Proceed when ready, and make a good, solid glue joint here.

Once the pinblock is installed, its last detail for now is the nut. This corresponds to the bridge, and has the same profile. Cut it according to the diagram. Its high point is placed closer to the rear of the instrument. Unlike the bridge, the nut is not drilled before installation. It can be clamped with nails, though, if you drill nailing holes in the middle, which will keep them out of the way of the nut pin holes, which will be closer to the high edge.

33. It's now time to start planning for the outer case. It will be formed, not of $\frac{1}{2}$" (13mm) material as it appears, but of 1/8" stock. We already have a nice,

solid inner case, so there is no point in adding another thick outer case. We will simply add the thin walnut plywood to the outside to give the case a nice appearance. However, the outer case will extend above the inner to enclose the strings. As the 1/8" material would not be stout enough here, we will add narrow strips to the inside of the walnut outer case pieces to make this adge a full ½" thick, with a matching walnut inner surface. Last, we will add a thin piece of solid walnut tape to conceal the exposed edges. This gives us a case that shows only the pretty walnut, along with the dual advantage of being able to fit the inside and outside corner joints separately, and having all of this at something approaching a reasonable price. Notice that this means that the outer case will sit partially (3/8") on the edge of the soundboard. We mention all of this now because it affects the location of the hitchpin rails, which are to be installed next.

You will need:

1 set hitchpin rail stock	1 bag of hitchpin nails
padded nails	

34. Because of the overlap of the case onto the top, we must first locate and mark the edge of the top exactly 3/8" (9.5mm) from the outer case surface. The tri-square, set properly, works very well for this, as shown in the photo. Mark all four edges, even though you would actually only have to install those that carry hitchpins now. As before, the hitchpin stock is cut according to the diagram, and the hole locations marked. Drill holes for padded nails at about 4" intervals. These holes will be re-drilled later to enlarge and angle them to accomodate the hitchpins. By now you're getting pretty experienced, so I won't repeat the standard gluing instructions. If you don't wish to drill holes in the pieces that don't carry hitchpins, they can be clamped using masking tape or weights. When dry, the hitchpin holes are re-drilled using a 3/32" bit. I like to angle them slightly away from the string tension to help the string loops stay on. The angle is not critical, and can be discerned from the photo. The hitchpin nails need to have their heads nipped off, and the end filed flat before installation. Then they are simply driven into place like any other nail. Leave only about 3/16" (5mm) exposed above the hitchpin rail.

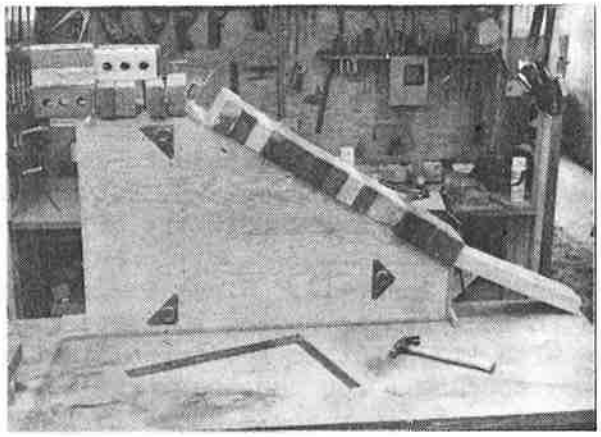
You have now assembled virtually all of the playing parts of the instrument. I won't tell you that you can't skip ahead to the stringing and adjustment section. I will tell you that if you succumb to that almost universally irresistable urge to hear the first sound, it will be all too easy to let the instrument sit unfinished for a long while. Now is the logical time to finish the casework. If you're not feeling logical, I'll meet you at the stringing section.

35. The main outer case pieces are next.

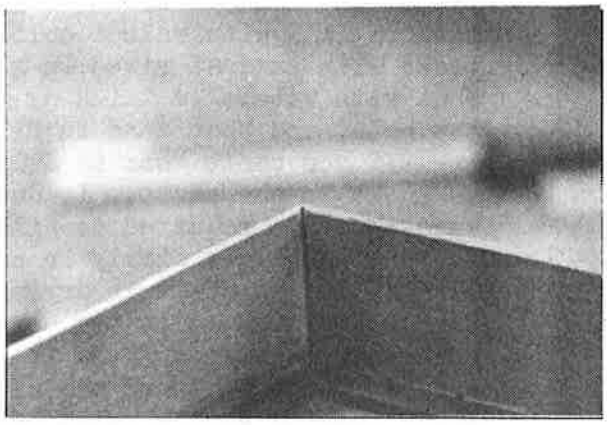
You will need:

1 outer case outside spine	1 outer case outside slantside
1 outer case outside tail	1 outer case outside cheek

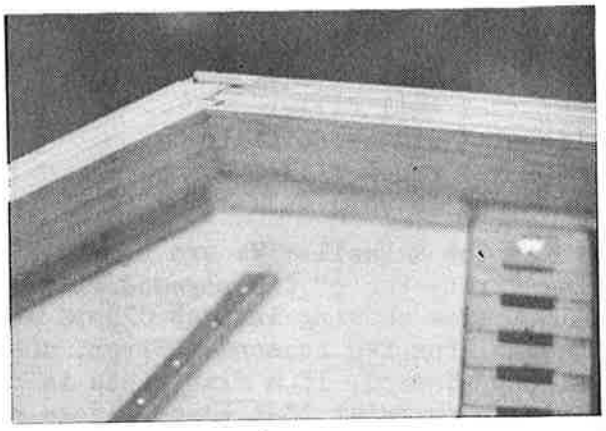
Start with the spine, as its right angle joint with the tail is easier to visualize, and because it needs to be fitting on one end only. The excess can be left on the front to be trimmed off later. Since this is a 90° angle, each piece should be planed to a 45° angle for a perfect fit. However, since only the outside shows, you may trim these to more of a point to ensure that the outside fits solidly. A gap on the inside (see photo) won't hurt anything, and will make it easier to achieve a nice, tight looking joint. With some care, it is possible to make a virtually perfect looking case. If your joints are not quite perfect, we have included material for back bands to cover the joints. These back bands are simply two pieces of walnut, which can be mitered (angled) to fit over the outside corner. This makes the final case look rather like an antique paneled door. You should trim and fit both pieces (spine and tail), even though only the spine will be glued now.



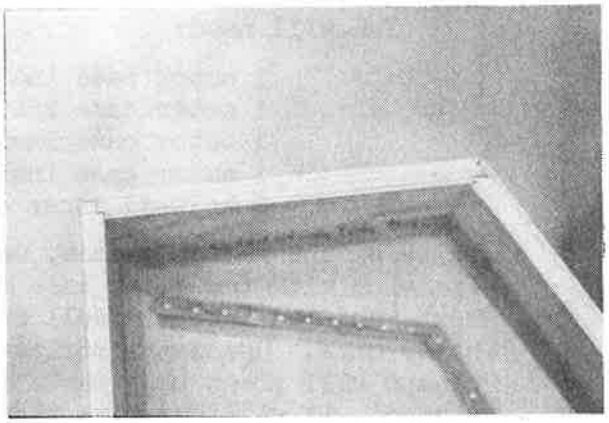
37. One way of clamping outer case is using bricks. Board keeps them from sliding down.



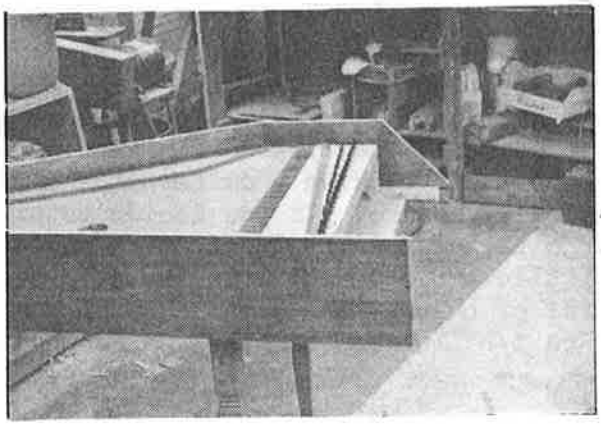
38. Typical outer case joint. You may cheat on the inside to get a tight outside joint.



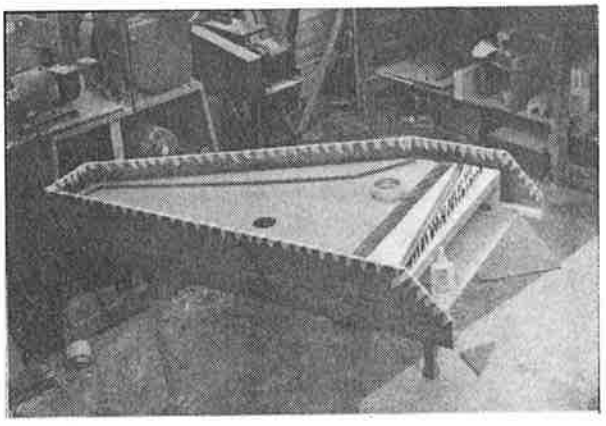
39. Overlap of outer case pieces at cheek/slantside joint.



40. Overlaps of joints at tail



41. One cheek is trimmed, the other isn't. Which do you prefer?



42. Masking tape will hold walnut edging tape nicely.

Are you remembering dry runs? They are especially important here, because there is so much more area to glue. There is no easy, tidy way to clamp these pieces on. Padded nails work well, but do leave nail holes to be filled. Some workers fill with walnut colored plastic wood, others get involved and make a paste with sawdust mixed in glue, while others get scientific and swell them shut with water. A trick my grandfather taught me was to put a dab of glue in the hole, and then sand to fill the glue with dust.

If you can't bear to drive nails into walnut, it is possible to use weights as shown in the photo. It does take some messing about to set up, but you do save the time required to fill nail holes. It does take a fair bit of weight to get the pieces firmly in contact.

36. While the spine is drying, you can consider the tail. Since it joins at both ends, it must be the correct length in addition to having the proper angles on each end. Hold it in position with its joint to the spine tightly closed, and mark where the end of the case touches. You can then trim to this line, leaving enough extra lenth to allow for the outer angle where it joins the slantside. You should be alternately trimming and then checking the fit. Next, the slantside is fitted to match the tail, and the opposite end angled to fit at the cheek. Padded nails are about the only way to attach the tail.

The other two pieces are pretty much a repetition of the first two. The slantside is fitted on both ends like the tail, and the cheek is just a short version of the spine.

Next we install the inside pieces.

You will need:

1 outer case inside spine	1 spine filler
1 outer case inside tail	1 tail filler
1 outer case inside slantside	1 slantside filler
1 outer case inside cheek	1 cheek filler
2 keywell inner ends	2 keywell fillers

37. For the inside pieces, we start down in the keywell. We are making a sandwich with the outer case outside spine first, the $\frac{1}{4}$" fir plywood filler next, and the inner keywell end last (walnut side showing inside) Clamps are handy here. Use extra strips of wood, though, for two reasons. First, unpadded clamps will press ugly marks into the walnut. Second, if a flat piece is clamped, it will serve to flatten out any warp or twist that these pieces might have. The glue will then keep them flat. Once the first inner keywell end and its filler piece are dry, you start working around the inside of the case much like before. The joint between the inner keywell end and the inside spine piece is a butt joint (flat, with only the ends touching). This joint will be largely hidden under the nameboard. Because the corners are inside facing, you do not have to make mitre joints. You may simply butt the pieces, and still have only walnut exposed. The photos show typical overlaps. This method lets you fit only one end of each piece in a location that shows. Work on around the inside of the case, and end up with the keywell end on the cheek side.

Now you get to make a decision which affects the appearance of the final instrument. The end of the spine and cheek (often known simply as the cheeks) are supplied square. If you like this appearance, they may be finished off in this shape. It is also possible to cut these off to give a different shape. The photo shows one angled and the other still square. If you decide to trim, a 45° angle starting $\frac{1}{2}$" in front of the joint between the inner spine and cheek pieces will work well. It does take a little nerve to cut into the case that you've laminated so carefully. Be careful of chips. Last, the ends of the cheeks are cut to length. These should be 1/8" longer than the fronts of the keys when the keyboard is installed.

The next step is to hide all of the careful work that you've done in joining the case pieces. You will need your bundle of walnut tape.

38. All of your various gluing steps have by now probably produced some unevenness is the edge surface of the walnut outer case. Even if it looks pretty good, now is the time to plane all the edges to get them absolutely flat and square. A sharp plane can plane over a joint. Be careful of corners, as it is possible to knock splinters out of them. When you are sure that the surface is ready, glue the tape on (white/cream glue), and clamp it with masking tape. Make sure that it is pulled down snugly, and remove when dry.

Now stop for a moment, because I'm going to caution you again. The walnut used is something of a miracle of modern technology. The walnut itself is 1/80th of an inch thick! Even sandpaper can remove 1/80th very quickly. So, you must be very careful when trimming the tape down to match the case pieces. If you sand too heavily, you will expose the layer below. Although this won't hurt anything, it doesn't look nice, There is no very good way to hide this particular error. Now relax and go to it - the case really is pretty when done. Now we go on to some other case pieces.

You will need:

1 nameboard
1 music desk base
2 music desk support blocks
2 key end blocks
2 key end block supports
1 lockstrip
1 lockstrip stiffener

1 music desk top
1 music desk bottom
3 music desk dowels
1 music desk lip
2 $1\frac{1}{4}$" x #8 FHWS
4 7/8" x #8 FHWS
2 1" x #8 Brass RHWS
small nails

39. From all of these pieces, we are going to make a music desk, a nameboard, a lockstrip, and key end blocks. You may notice that the music desk base and the nameboard are the same size. The short ends of both are hidden, and do not need to be taped. The long edges of the music desk base are exposed, and should be taped as before. The nameboard actually only needs its top edge taped. It fits against the edge of the pin block, and covers the area just above the keys. Careful fitting will give a nice looking fit to the inside of the keywell. The nameboard is held using only two brass wood screws placed about three inches in from the ends, and threaded into the edge grain of the pin block.

The music desk base will sit on top of the edge of the nameboard and will cover the tuning pin area. You should trim it a trifle short to allow space for felt on its ends to avoid scratching the inner case when it is removed for tuning. While you are getting this ready, you may install the music desk support blocks, which are glued into the corner to the inner case, and the ends of the top of the pinblock. Their top edges can be felted to avoid scratches.

40. The music desk itself consists of a top and bottom piece which are supported by three dowels that are glued into holes drilled in the edges. The bottom piece is angled to tip the desk, while the top piece can be scalloped decoratively. When the top and bottom pieces are ready, lay out the dowel holes carefully, one in the middle, and one $1\frac{1}{2}$" (4cm) from each end. While this is drying, you can glue the music desk lip with its thick edge flush with the front edge of the music desk base. The music desk itself is placed just behind the lip, and held with glue and two screws going up into the bottom edge of the music desk bottom piece. If you wish the desk to be removable, it is possible to replace the screws with short 5/8" (16mm) dowels glued only into the music desk.

The area in front of the keys is still open. This is covered by a piece of walnut (known as the lockstrip), which is in turn supported by the mahogany lockstrip stiffener. The narrow edge of this piece is glued to the back surface of the lockstrip, and clamped with nails. They should be set (heads driven in below the surface), and the holes filled. This assembly is screwed to the front edge of the keyboard base, with the screws going up through the stiffener, and into the base of the keyboard. Now is also a good time to secure the keyboard with two more 7/8" x #8 FHWS

41. The last pieces of trim are the key end blocks. They are trimmed to cover the last bit of the inner case that shows by the ends of the keys. If they were glued directly on top of the spine and cheek supports, they would be too low to hide the area intended, so they are instead glued on top of two key end block fillers, which in turn are glued to the spine and cheek end supports. These slip in under the nameboard, where there will be a small gap on top of them. Trim all pieces to fit, and glue in place. It may be necessary to cut some small relief notches to allow you to remove the keyboard if the key end blocks or fillers interfere.

Although it's more than just a trim piece, make the jack rail now.

You will need:

1 jack rail top
2 jack rail sides
1 pc. jack rail felt

42. The jack rail consists of three pieces which are glued together to form a U-shaped trough, into which is glued a wide strip of felt. This catches and muffles the jacks when they spring up after plucking the strings. You may either clamp or nail it together, and then sand its surfaces smooth. You will find that the jack rail felt is too wide. You must trim a 5/16" (8mm) strip from one edge with your sharp knife. Don't throw this strip away. The jack rail strip should be about 2" (5cm) shorter than the jack rail to allow a 1" space at each end. Glue the felt in place. The jack rail is held up on small felt-covered blocks attached to the inside surface of the case. It's just as convenient to wait until the stringing is complete to install these.

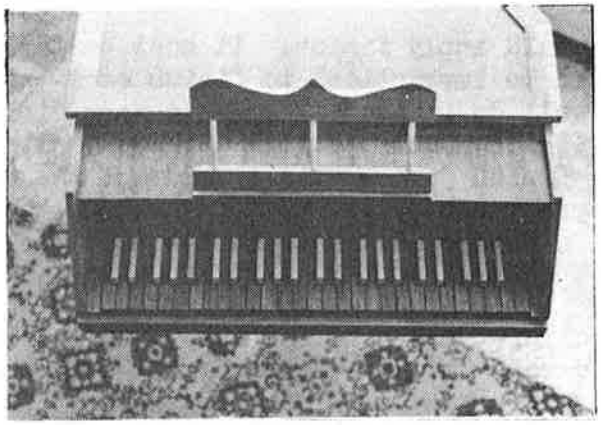
The last case piece is the lid! It is formed from two thin walnut plywood panels, edged by solid moldings.

You will need:

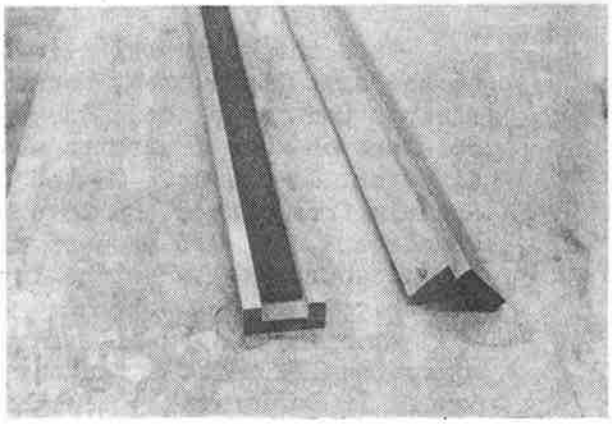
2 inner and outer lid panels
1 set of lid hinges and screws
5 pcs. lid edge molding
1 lid stick

43. First glue the inner and outer lid panels together (walnut exposed, right?) This should be done on a flat floor, using plenty of very heavy weights to make certain that they are solidly and evenly glued together. Pay particular attention to the edges, as these must fit into the molding slots. When dry, the moldings go onto the edge in the obvious way. It will require some ingenuity (again) to get a workable clamping system. If you have a nylon band strap clamp, this is a good place to use it. If not, it is possible to drive nails in to a wood bench top (or scrap plywood) outside the periphery of the lid, and use wedges in between the nails and lid molding to force things together, while holding the whole thing flat with weights. Improvise!

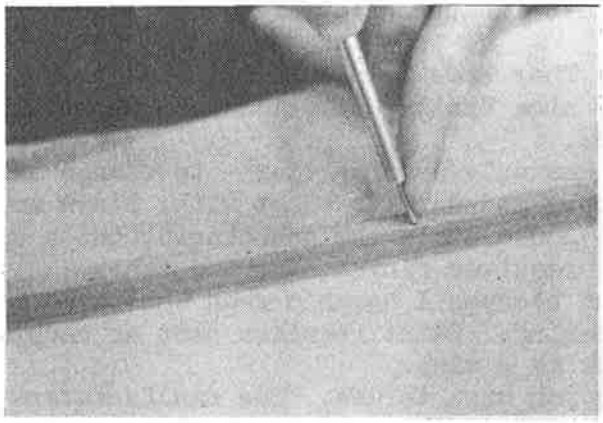
The hinges are installed with one leaf on the outside of the spine, and the other on the underside of the lid. Draw a straight line on the underside of the spine edge of the lid, and install the hinges on this line on the lid first, because hinges won't work properly if their pins are not exactly in line. Then the lid with its hinges can be installed on the case, and screws driven in. Get the overhang approximately even all the way around, and be careful not to drill through the case for screw holes. The lid stick should be pointed at both ends to sit against the lid molding at the top, and the inside cheek at the bottom. You've finished the woodworking!



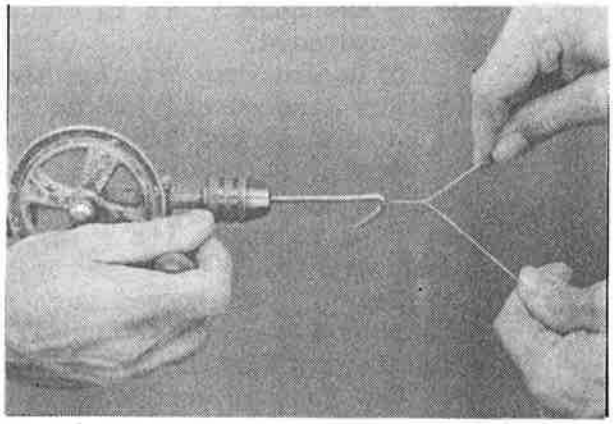
43. Finished appearance of the keyboard area.



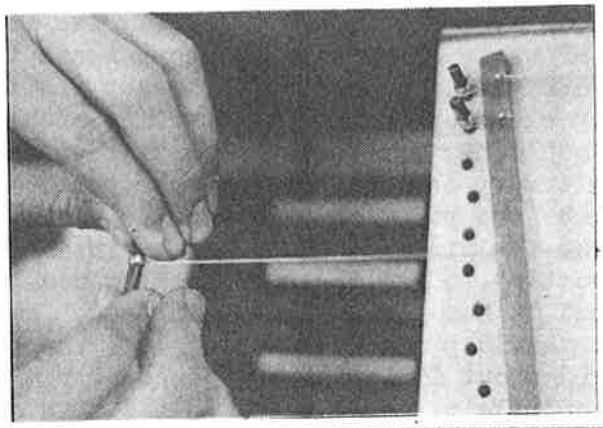
44. End views of the jack rail and lockstrip.



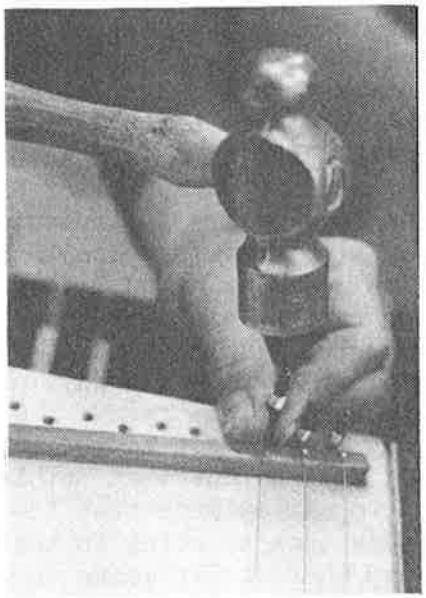
45. Pushing in bridge pins, using the brass tool



46. String loop forming. The hook can be a cup hook, or a bent nail



47. Rolling the tuning pin in the fingers to smoothly wind the string onto the pin....



48. ..which is then turned, and hammered down into the hole.

FINISH

Once the woodworking is done, you should apply finish. It must be applied to the soundboard area, because this would be impractical to finish once the strings were in place. So you might as well do it all. There are many differing opinions on what finish to use, because finish should perform different jobs in different locations. On the outer case, finish just serves to protect the wood (mainly from dirt), and to enhance the appearance of the wood grain. On the soundboard, it must protect without adding a thick heavy layer that could reduce sound, while on the keys and legs, it must protect from abrasion and chipping.

44. Varnish. Especially in the newer polyurethane formulations, this can be an exceptionally durable finish, which would make it quite workable for the outer case. It is generally thought of as being too heavy for soundboard use. In any usage, you should consider diluting it about 15% with mineral spirits. You will have to be more careful about curtains (drips), but it is worth the trouble in that it goes on much more smoothly.

Shellac. This is commonly used as a soundboard finish. It is quite thin and light,but not very durable. It takes some care to get a smooth job.

Lacquer is nice because it goes on nicely and is quite light. Its drying time is amazing, because instead of one or two days between coats, you need only one or two hours! It is one material that is appropriate for both case and soundboard.

Oils are,very popular these days. They have been much improved over straight linseed oil and do give a very nice finish, especially on walnut. They are not considered ideal for soundboards.

Stain. As the name implies, stain has only one function - to change the color of the wood. Since walnut is pretty and dark to start with, stain would only tend to muddy its appearance. You could stain the soundboard, but a dark soundboard isn't that pretty, and still requires finish over the stain.

Paint. I won't say much about paint because I haven't seen that many paint jobs that I thought were really nice looking. Paint requires just as much work as a natural finish, and painting walnut is a sin.

Now you can decide what finish(es) you want to use. The manufacturers instructions are written by the people who know the most about their product, so follow them. They seldom mention, though, that a nice finish should be worked on as much between coats as during application. Most people try to simply bury the lumps and bumps that tend to form in the first coat under still heavier layers in sucessive coats. A far superior method, though, is to smooth each coat before the next is applied. Generally people are too timid about this. Use sandpaper! A worn down piece of moderately smooth paper will work much better than the extremely smooth types, which should be saved for the final coats. The idea here is to work finer and finer on sucessive coats. You may use 400 grit on the last coat, and then apply a coat of wax. After this, you may treat the harpsichord as any other piece of fine furniture. Before applying any finish, go over the entire instrument, and carefully clean up any and all problem areas that you might have overlooked before. You should pay particular attention to any glue spots or drips. They probably aren't very obvious now, but the problem occurs that since they can't absorb finish (the pores are filled with glue), any glue will show up as white spots under the finish. Glue fingerprints are especially bad this way. Now is the best time to get the case looking really right. You can remove the keyboard, since it has already been finished. Because they tend to get bumped in use, the legs should probably be oiled like the keys. You will notice that nothing has been said about finishing the jacks or register. It is our opinion that these should be left plain, as it seems that finish can cause them to stick in the register. Enjoy this finishing, as it is the final step that really seems to make the woodworking project into handsome furniture.

STRINGING

At last you are ready to install the strings and action parts and hear the instrument play.

You will need:

1 tuning pin set	1 tuning wrench
1 pin pushing tool w/ handle	1 coil of plectra material
brass pin material	1 #67 drill bit
stringing material coils	1 buff stop rail, w/ deco. nails

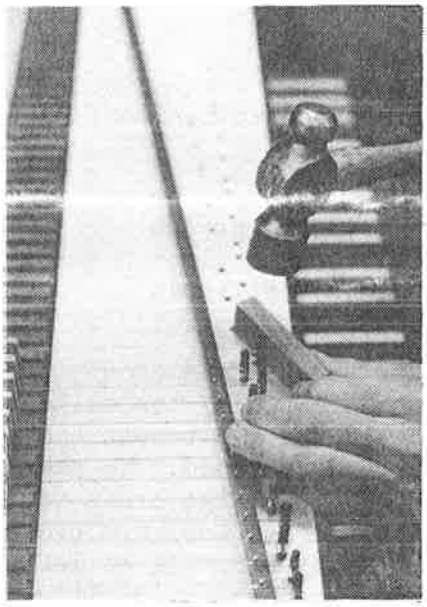
45. First we need to install all of the bridge pins. Make about 150 of these, all $\frac{1}{2}$" (13mm) long x 1/16" diameter. These pins are really too delicate to hammer in as you did the hitchpins, so you should use a hitchpin tool that will press them in properly, and leave the ends properly exposed. To make this tool, Drill a #51 hole 3/16" (5mm) deep into the end of the large brass rod. The bridge pins will fit in this hole, and when the pin and tool are pressed down until the tool end touches the bridge surface, every pin will be left exposed the same amount. The other end would be painful to push on, so it gets fitted with a simple wood handle. Drill a $\frac{1}{4}$" (6mm) dia. hole 1" (25mm) deep into the end of the handle piece, and then round off and smooth all corners to make a comfortable handle.

Now you may install pins in every bridge hole. These look better if filed flat and de-burred before installation. Do not drill or install the nut pins yet.

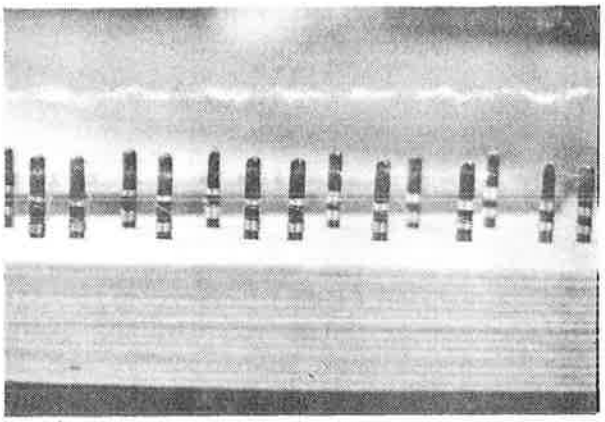
One piece that is easy to forget is the buff stop rail. I prefer to install only the rail now without its handle, felts, or end stop nails. Simply place it in position by the nut, and drive three decorative nails alongside. The nail shafts will hold it against the nut, while the heads hold it down on the pin block. If the rail has a little warp, place it so that it separates in the middle, and touches at each end. This will let the nails hold it straight. It should slide firmly from side to side.

46. I usually do all of the final steps on each note individually, although other builders prefer to do one step on all notes, and then proceed to the next. At any rate, I would suggest starting at the top note, as the shorter, smaller strings are easier to handle. Get the first coil of wire (it will be the smallest diameter steel wire) as shown in the stringing table. Be careful when dealing with music wire, as it will tend to spring apart. Clothespins help. The wire first needs a loop end wound in it to secure it to the hitchpins. The arrangements for making the loop vary from the simple; a nail driven into the edge of the bench, through a hand-powered drill with a hook in it's chuck, to the elaborate; a rigidly mounted drill motor with a variable speed foot control. Whatever equipment you use the important part is to get a string loop that is wound properly to hold string tension. There is a sample string loop, which is wound very tidily, and illustrates the most important point. The end of the string must not be just wrapped around the long portion beyond the loop, but must intertwine with it so that both portions are bent equally, forming a helix. If one is simply wrapped around the other, it will slip and tighten on the hitchpin (and will be difficult to keep in tune). Again, you will probably have to make a couple for practice before you get one that you will be pleased with using.

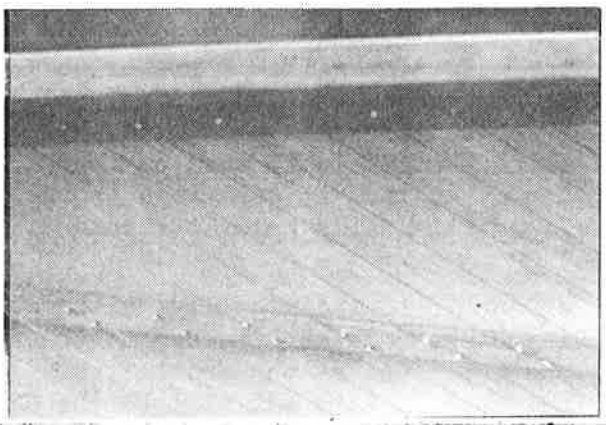
Now you are almost ready to actually install the first string. Once you have started, you <u>can't let go</u> of the string, so make very sure that every tool that you will need is within easy reach. You should have your tuning pins, hammer, tuning wrench, string cutting nippers, and a clothespin. When ready,



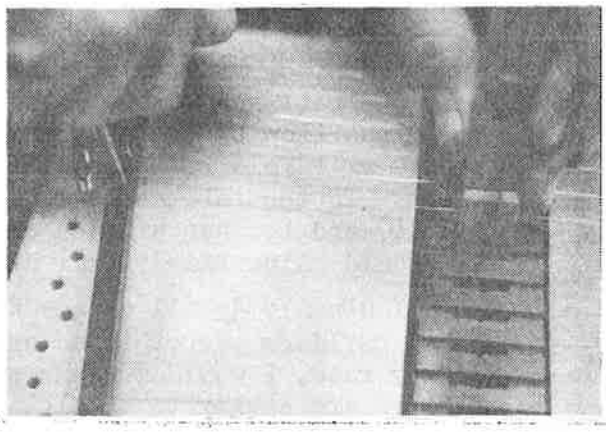
49. Now a block of wood can be used to leave the pins at the proper height.



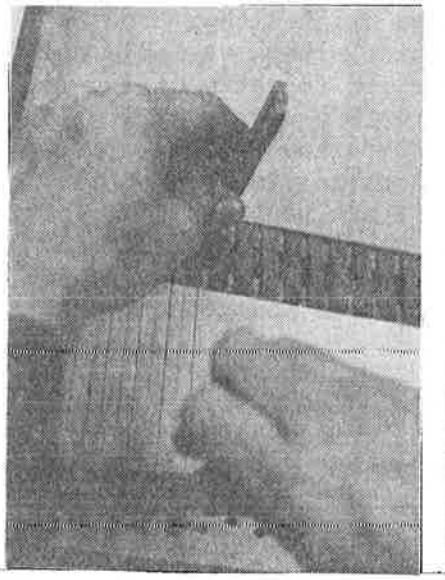
50. To give adequate bearing on the nut, the strings should be wound down on the pin, even though the hole is higher.



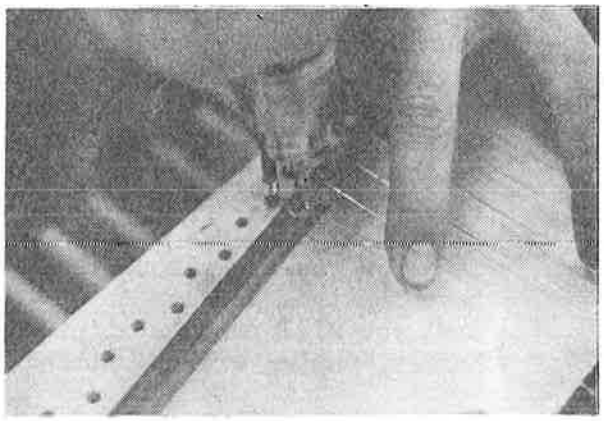
51. Typical section of soundboard and case, showing strings, hitchpins, bridge pins, and backpinning.



52. Marking the nut for pinning, using an awl for marking, and an extra jack for spacing the string from the jack.



53. This is what the nut pin marking looks like from where you are. Again, it is marked with an awl...



54. ..And then it is drilled, using a sharp 1/16" bit.

slip your neatly wound end in place over the hitchpin, and clip the clothespin over it to keep it in place. Lead the string around its bridge pin, and sit down in front of the instrument. Now is the time to cut the string to length. Cutting it about 6" (15cm) in front of the lockstrip will give you plenty to wind on the pin. Hold a tuning pin horizontally, with its threads to the right, and stick the end of the string down through the hole. If you leave the end sticking out the other side, you will find that it is sharp enough to be vicious, so insert only enough of the string to make the opposite end of the string even with the other side of the pin. Now, bend the part of the string that sticks out of the pin (the long section leading all the way back to the hitchpin)sharply, right on the edge of the tuning pin hole with your thumb, and then roll the tuning pin in your fingers to roll up the string. You must keep tension on the string and pin at all times, or the coils will spring off the pin, and you get to start all over again (but now with a curly piece of wire). When the pin has been "reeled" untilit is near the hole in the pin block, turn it vertically, and use your hammer to drive it into the first tuning pin hole. The string should be winding onto the right hand side of the tuning pin, so that a clockwise turn of the wrench will tighten. The tuning pins do require solid blows to start them in, so don't be afraid to make a little noise. The next step is even noisier. The pins must be driven in until only 1" (25mm) protrudes. This must be done for 49 pins, so it's worthwhile to make a block 1" high from scrap to use as a gauge. This same method is used on all the rest of the strings, using material according to the stringing table.

47. Insert the first jack. You haven't yet drilled or installed the nut pins, because you want to measure to the front surface of the jack you just installed, to ensure that the distance to the string is proper. This is adjusted by the location of the nut pins. As it happens, the proper distance from the jack to the string is exactly the thickness of a jack, so you may conveniently use an extra jack body for a gauge. Put enough tension on the string with the tuning wrench to keep it taut, but with enough slack to let you move it back and forth on the nut somewhat. Hold the extra jack (gauge) against the front of the jack in the register with one hand, and move the string with the point of an awl until it is just in line with the other edge of the gauge. When positioned, simply tap the awl to mark the location of the pin. The row of nut pin holes should be 1/8" (3mm) back from the high edge of the nut (to match the bridge pins). After marking, drill with your 1/16" drill, and install a pin with the pushing tool as before. These operations will be duplicated for each note.

48. The strings of the lower two and a half octaves run straight over the bridge to their hitchpins. These require back pinning, which is putting in a second bridge pin near the back edge of the bridge on the opposite side of the string, close enough that it forces the string into a small detour, thus holding it tightly against the bridge pins. Backpinning is used up through "e", where the strings divide suddenly to the treble hitchpins.

It will be awfully quiet until you install plectra. Here is how. You might recall that there are two marks on the edge of each jack; one for the level of the exle hole, and the higher one for the level of the plectra. The plectra material is round in cross section, and will hold quite nicely in a round hole, if it is the proper size, which in this case is drill size #67. This is a very small drill. If you are going to drill the plectra holes with a hand held drill (you must be careful), put most of the bit inside the chuck with only enough protruding to get through the jack tongues. A drill press again increases accuracy, and reduces drill breakage. Being of a suspicious nature, I don't even trust the marks totally - it is possible for small

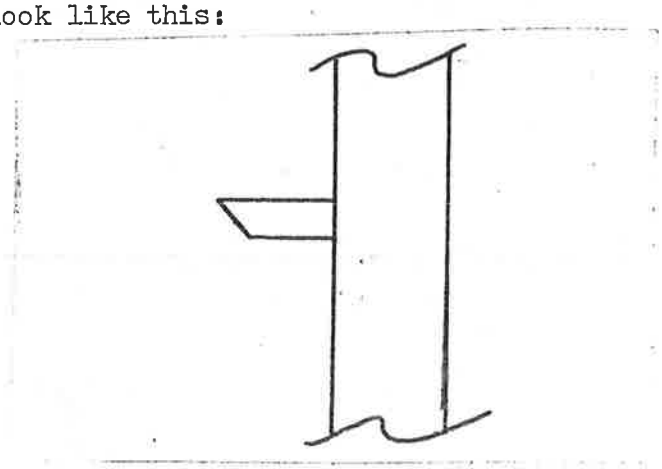
variation to creep in, which would give varying plectra height. So, I use a simple drill press jig, just as mentioned when you were drilling the other jack holes. It is best to drill the jacks "face down" so that the pressure of drilling will tend to hold the tongue against the tongue stop. Hold the tongue down with a finger when removing the drill. If you don't, the tongue will pivot, and break the drill bit. For now, drill only one jack that belongs somewhere in the middle of the keyboard. This is the final check on the assembly. If everything were to go together text book fashion, the top of the plectra will be 5/32" (4mm) below the string, which should be the level indicated by the upper jack marking. If it does not for some reason, don't worry, for nothing says that mark is absolute. You may compensate by drilling the plectra holes a little higher or lower than the mark to get the plectra the proper distance from the string. If you move it much, you should replace the tongue in that first jack that you drilled.

49. If you examine a piece of plectra that has been nipped off with nippers, you will find that the crushed end formed will not enter the plectra hole. You must trim the end of the plectra material with a sharp knife to get a clean edge. Insert from the back side, using pliers if necessary. You may use nippers to cut the piece from the long stock roll. The next one will require trimming with a knife as before. The crushed end is no problem on the back, and in fact can be pushed into the hole, where its shape will wedge the plectra even more solidly. This end can even be used to hook a jack spring that wants to try pivoting in its hole and getting off the back of the tongue. Of course, you do want to leave enough plectra on the front side to allow trimming and voicing.

This trimming (voicing) of the plectra is responsible for the harpsichord's sound. This is a complex area, with many contrasting opinions, and advocates of differing methods, none of which will make much sense until you have voiced a harpsichord, and have had time to listen a lot and consider. So, we'll describe a nice simple method to get everything playing properly. You can always go back and re-voice if you find some idea you want to try.

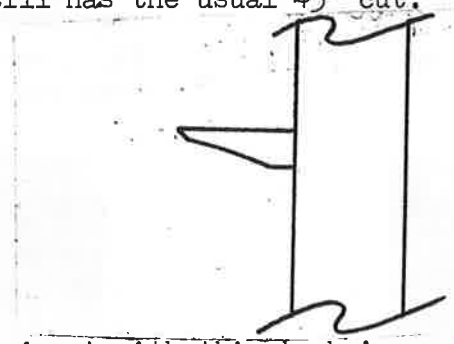
The most important factor is simple length. If the plectra is too short, it will miss the string, and if much too long, will not even be able to get by the string to pluck it. In between these extremes, is the condition where it will pluck on the way up, but is too long to slip back past the string on the way back down. Although this is also affected somewhat by the strength of the jack springs, these must be just strong enough to hold the tongue closed solidly, because it will be really impossible to voice if the tongue has play to use up before it contacts the spring.

50. One detail to notice is that the end of the plectra is not trimmed squarely, but is instead cut so that it will form a point. Hold your knife at about 45° to make these cuts, and make the proper angle. When voiced, the plectra will look like this:



The usual sequence is to try the note to be voiced, remove the jack and invert it with the top of the plectra on a small block of wood (such as a left over register rail spacer), trim the plectra from the underside, re-install, and repeat the above steps (and repeat, and repeat...) If you overcompensate and get the plectra too short, remove the offender, and try again. Though a bit tedious, it is a job worth doing well. Don't try it when you are tired or impatient.

51. Let me get in a few words about the (somewhat) finer points, and I promise to stop. The longer you leave the plectra, the stronger the attack and louder the sound. However, it will also make the action stiffer, and make it more difficult to get good return on the jacks. If you want a lighter touch, and smaller sound, you may even change the angle of your cut, in addition to trimming the plectra shorter. Trimming to a sharper point as shown will give more change in this direction, Notice that this method actually involves two cuts, as the tip still has the usual 45° cut.



If you wish to experiment with this technique, try a few high notes, as it is more appropriate there. The ideal for most people would, of course, be strong sound and very light action. Like most ideals, though, its pretty hard to attain.

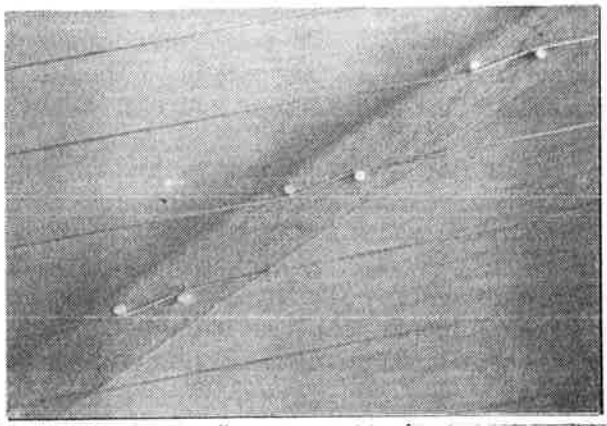
A non-traditional, but workable method for thinning plectra is to sand them to shape. Remove the little shreds that form at the edges. While this method works for shaping, I still recommend that you use a knife for the final voicing.

Last, the most important part of voicing is uniformity. Experiment with the little tricks above, but remember that a uniform keyboard is much nicer to play, regardless of the sound it produces. Every note should sound the same, and play the same.

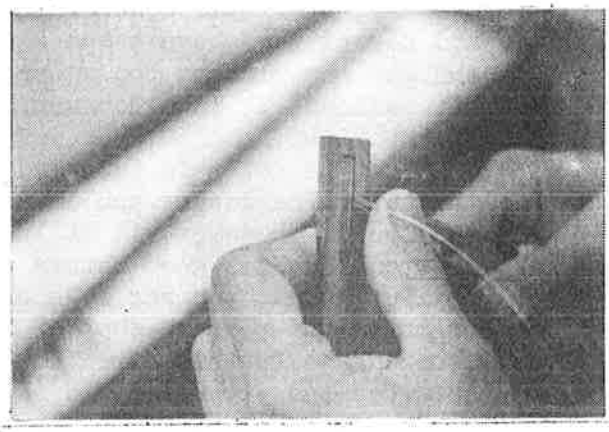
STRINGING TABLE

Your harpsichord should be strung using the sizes and locations in the table below. The numbers run from bass to treble, so #1 string is the low "CC". Actually, it is more convenient to start at the highest note, as the shorter strings are easier to manipulate.

String Number	String Diameter - Material
1 - 7	0.022" Brass
8 - 14	0.018 Steel
15 - 20	0.016" Steel
21 - 32	0.014" Steel
33 - 44	0.012" Steel
45 - 49	0.010" Steel

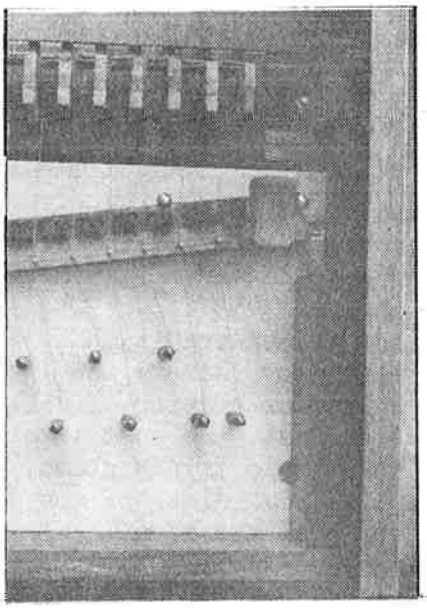


55. Closeup of backpinning.

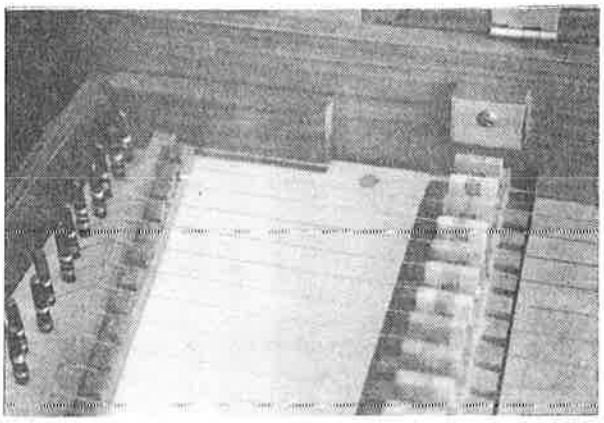


56. Inserting the plectra material from the back side of the jack.

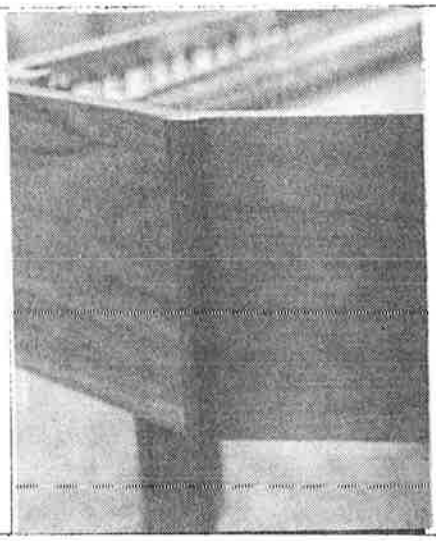
57. Voicing the plectra. This is done from the underside, on a small block of wood.



58. Details of inside, right-hand area



59. And details of the other side.



60. Typical back band for outer case.

52. You are definitely on the home stretch. After you install the jack dampers, there are only a few finishing details. So, let's install the dampers.

You will need

1 roll of jack damper felt Glue and sharp knife

Look at your sample jack. The little felt "flag" on its edge follows the jack up and down. When the jack is down, it will damp the string, and when the jack is raised by the key, it comes off the string, working automatically every time a key is pressed. Although it would be possible to cut slots or make brackets to hold the dampers, it works just as well to simply glue them to the back edge of the jack. It is very convenient to use one of the electrically heated "hot glue" guns, as this bonds very quickly, but still has some pliability even when set. You will find that glueing two layers of the damper felt together will form a more rigid damper. Keep the glue near the middle, to leave the edges soft to do their job of damping. Mark the back edge of the jacks at the same level as the strings, and glue the felt there. It must be low enough to damp the strings, but the damper should not be hanging the jack on the string when the key is down.

53. The jack rail is supported on each end by little felt covered blocks. It will take some measuring, but the jack rail should be positioned so that there is 1/8" (3mm) of space between the jack rail felt and the top of the jacks in the raised position. Ordinarily, the jack rail top surface will wind up about 1/8" below the outer case top edge. The support blocks themselves are held on with two 7/8 " x #8 RHWS each. If you have trouble doing the locating work, it is possible to enlarge the screw holes into slots, and make the jack rail blocks adjustable. The felt is wrapped around all four edges, and joined on the underside.

Felt is also to be applied to the buff stop rail. It takes the form of 49 small blocks glued to the top of the rail, which can slide back and forth until these small felt blocks muffle the strings slightly, giving the characteristic buff stop sound. The buff felts are cut from the narrow strip that you trimmed from the jack rail felt. Cut the blocks about $\frac{1}{4}$" (6mm) square,and when gluing them, keep in mind that you must leave enough space for the knob shaft at the treble end, and for a stop nail on each end. Be careful with glue here, as drips look bad, and can tend to glue the buff rail to the nut. You will need to drill a $\frac{1}{4}$" (6mm) hole in the right-hand end of the buff rail for the knob shaft. This should be as deep as possible, without actually going through the bottom of the buff rail. A similar hole is needed in the underside of the knob. It should be located so that the handle will not touch either the music desk base or the jack rail when installed. Although it isn't essential, it is a nice touch to round the surfaces of the buff knob to fit the fingers. The shank should be cut to leave the top of the buff knob slightly higher than the music desk base, and then then the shank and knob should be glued together, and glued to the buff rail. Last, a stop pin is installed at each end of the buff rail to center the buff felts between the strings in the off position, and to provide a positive stop for the on position.

TUNING

54. Once you have all the construction completed, it is time to tune. When I mention this, everyone seems to be instantly apprehensive. It amazes me that people can get through all the difficult building steps, and then be nervous about tuning. Tuning is only the rather simple art of matching pitches to other pitches. It can be a little frustrating until you realize that it takes some experience to recognize what portion of the sound you are listening to. You are hearing a sound which has volume, timbre, attack, decay, (and more), and sorting out only one part - pitch.

The easiest method of tuning is to simply tune to match something else. If you have never done much (any?) tuning, this is a good place to start. A piano has every note you need (and some to spare). Other devices that are more portable would include: an inexpensive chromatic pitch pipe, a set of chromatic tuning forks, or now, electronic tone generators. Each has its advantages, but all will get you started. As you get to be a more accomplished tuner, you will find that you need less equipment, rather than more. You will also want to properly temper the scales instead of relying on the comparison scales. Read on.

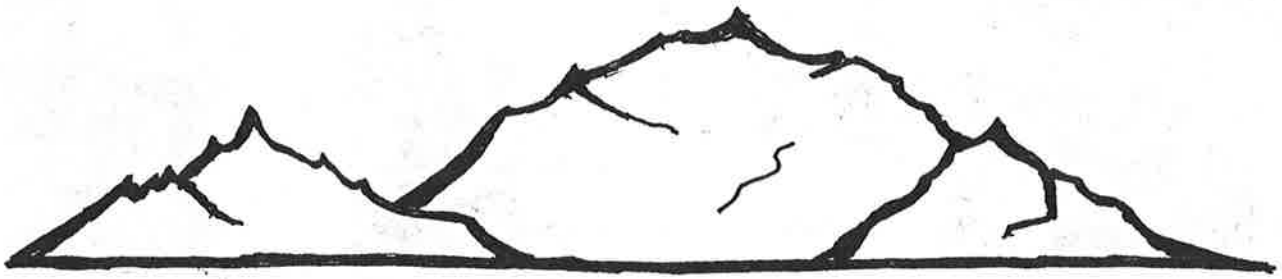
55. Tuning is done by matching intervals between notes. The most obvious interval is a unison, where both strings have the same pitch. The next is an octave, where one pitch is twice (half) that of the other. This is the interval from one do to the next, and could be described as a ratio of 2:1. These are pretty easy to hear accurately, as is the next most useful interval, the fifth (do-soh), where the ratio is 2:3. We mention these ratios as a bare mention of all the centuries of debate concerning the tuning of the scale. Because all these ratios are fractions, it is impossible for all these series of fractions to come out even. This means that it is also impossible for all the intervals between all the notes to be perfectly in tune! Although there have been libraries full of debate on the subject, it basically means that all the octaves of each note must be exact, and all the other intervals squeezed to permit this. To be able to adjust this, you will need to become aware of the phenomenon known as "beating". If two strings that are exactly in unison are sounded together, all that you should hear is one louder tone. If, however, they are very slightly out of tune, you will hear a sound that varies according to how large that difference is. This is caused by the two sets of sound waves interfering, and is usually described as a "wah-wah" sound. If the two tones are quite close, the timing of the "wah-wah" will be slow, and will be faster, the farther out of tune the two tones get. You will use this speed of beating to judge and adjust these very close intervals. As mentioned, the octaves will be exact, while the fifths must be adjusted very slightly flat. This compensating is what is actually being referred to in the "tempering" of a scale. "The Well-Tempered Clavier" was not referring to a good-natured instrument.

The most basic method of tempering a scale is to use a "circle of fifths". If you had a very large keyboard, and started with a low A, and then played successive fifth intervals all the way up, you will eventually (after 7 octaves) get back to A. The notes would be: A, E, B, F#, C#, G#, D#, A#, F, C, G, D, A. Even if you had a keyboard this large, the high and low notes are difficult to hear, so this can be compressed in to the middle by going up by fifths, and then going down an exact octave periodically. By this method the entire chromatic scale can be covered. Then the high and low notes are tuned by precise octaves. If you can judge the exact amount by which to flat the fifths over and entire circle, and still make the octave come out precisely, you are already a good tuner. If not, try again!

That is basically what tuning is about. Please remember that is a very brief description of one method. If you want more, there are good books in libraries.

And that completes the building of your harpsichord! The instrument that you've built should give enjoyment for literally generations. We are aware that this manual probably didn't tell you everything that you wanted to know, despite the fact that we honestly tried to include everything that we thought you would need to build it. There is a way to help, though. We would like you to write down what changes you would like to see made, even including exactly how you would re-write those sections that didn't seem quite right. You see, anyone who is qualified to write the manual totally lacks your special viewpoint as a first-time builder. So, if you will help, we can improve this manual for future builders. I hope that you have enjoyed building your harpsichord as much as we enjoyed making it available to you.

Thomas R. Hyler



At the Hughes Dulcimer Company, we specialize in the making of stringed instruments, both completed and kit form. Please write if you do not have a copy of our current catalog.

HUGHES DULCIMER CO.

4419 West Colfax Ave.
Denver, Colorado, 80204