Building a Javanese Gamelan

by Dennis Murphy

Gamelans in Java vary widely, from huge, expensive sets of instruments made of bronze, owned only by the very wealthy, to very small sets with iron keys, found in small villages. This does not mean that iron is a poor material from which to build a gamelan, for there are some iron-keyed gamelans in Java which are very highly regarded.

It is possible to build a small iron-keyed gamelan, capable of performing traditional Javanese music, using only a few very common tools, and materials available in any small city.

This article is based on the assumptions that the builder knows fairly well what every instrument in the gamelan does; that he does not need notated music, being able to obtain it elsewhere; and that he either has basic carpentry and metalworking skills or has a weekend carpenter friend to help.

Tools and Materials

The bars for the metallophones are made of hot-rolled steel. For most of the instruments it is preferable to use 1/8 inch thick metal in strips in various widths. This thickness is harder to work with than 14 or 16 gauge, but gives superior results, particularly in the higher range ones. Exceptions are the low-voiced slentem and bonang barung, which work well in 12 or 14 gauge. A very heavy metal-working vise and hopefully a drill press are needed. For names of metal suppliers consult the yellow pages of your phone book under such headings as "sheet steel," "steel distributors," and "steel warehouses." See Chart #1 for estimate of amounts of metal in each width. It is best to get a little extra, since there will be some waste and errors. However, exact widths of the metal strips are not critical; a quarter inch either way won't matter.

Some of the instruments need tubular resonators. These are easily made of tin cans, and you should begin saving cans of various sizes at once, as you'll need a surprising number of them.

The bars are cut from the long metal strips with a hacksaw. A bandsaw is even better. For the hacksaw, a 24 tooth blade works best, and you'll wear out and/or break about a half-dozen of these by the time you're through.

The cases for the instruments can be simply made using nominal one-inch lumber, one quarter inch plywood or masonite, casein glue (Elmers or similar kind), nails (preferably number 5 or 6 box nails and number 3 box or common nails), wire-cutters, slip-joint pliers, tin snips and an assortment of doweling.

Constructing the Melody Instruments

Melody instruments come in four octaves. From lowest to highest they are called slentem, demung, saron and peking. See Chart 2 for pitch ranges. Let us begin with the slentem.

Begin by cutting bars to approximately the lengths given in Chart #3, using a strip of metal 3½ or 4 inches wide. Note that the width of a bar does not affect the pitch in any way; we just try to keep the bars from being too skinny or too square-ish. The lengths are only approximate. In practice, the pitch of a bar can be changed a great deal in the tuning process.

The bars should be drilled and filed before tuning. Two holes are drilled in each bar for the cords which support them. Find the nodal points by measuring two-ninths of the total length from each end of the bar, and drilling there. Holes must fall midway in the width of the bar so that it lies reasonably flat in the finished instrument. Although it is possible to make these holes with a hand-powered drill, an electric drill is preferable. Make a dent with a centerpunch where you intend to drill, and put a drop of oil on the spot before drilling, and maybe once more, halfway through each hole.

After all the holes are drilled, remove the burrs from the edges of the holes, using a rat-tail file or the corners of an old, flat file. Another way is to put a 5/16 inch drill into a hand held bitbrace, and use it much like a countersink. The object is to avoid having any sharp spots which would fray the cords that pass through the holes.

The rough ends, corners and edges of each bar should be smoothed, using a bench grinder and wire brush, or else a fine flat file. While this seems a picky sort of job, it saves cuts and scratches when playing.

Now it is time to tune the bars. Measurements of tunings from a wide selection of gamelans in Java can be found in the charts of Jaap Kunst's *Music in Java*. If the builder has a good ear, he may be able to copy a tuning from a record of gamelan music, or if he has a portable tuning machine, to measure a set of instruments to which he has access. The tuning of Gamelan Voice of Thoom is listed in Chart #4. The measurements are expressed in mm of string sounding length on a homemade monochord 1 meter long tuned to A220 or A440 (see fig. 17).

Now lay the bars of the slentem over two pieces of clothesline on a table, with the rope contacting the bars at the drilled nodal points. Each bar will be found to be somewhat too low compared to the pitches on Chart #4. Tuning the bars is simply a matter of raising the pitch of each bar to the desired extent. This is done by putting a slight crease down the center of each bar. The more crease, the higher the tone that bar will produce. A bar can be raised as much as an octave from its original pitch, but the higher you raise it, the more likely you are to run into problems.

To bend a bar, first mark a line on it midway from either side. Then put it in the vise so that half its width sticks out at the top (see fig. 1). Strike with a hammer, gently and evenly so as to put a slight crease in. A wooden

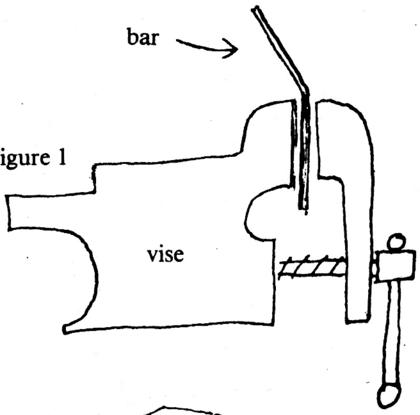


Figure 1

Figure 2

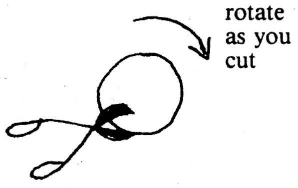


Figure 3

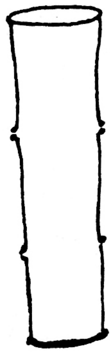


Figure 4

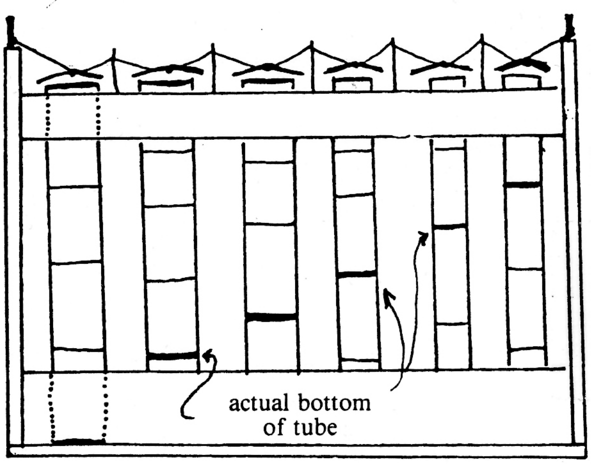


Figure 5

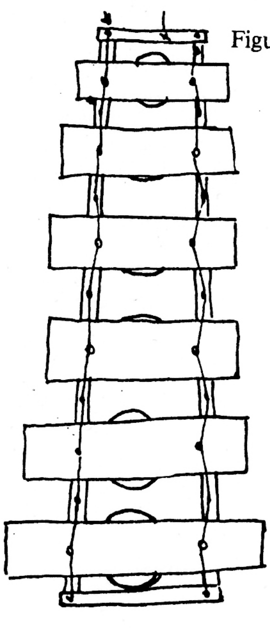
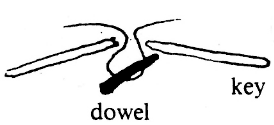


Figure 6

Figure 7



detail of stringing
(cross-section)

hammer which leaves no marks can be used on thin gauge. For the heavy gauge metal you have to hit harder and use a steel hammer. Most of the bars will be much longer than the width of the jaws on the vise, so start at one end and bend a little, then do the same at the middle, then at the other end, trying to crease the bar evenly. Test frequently by putting the bar back in its place on the clothesline and tapping with a tabuh (mallet) or a sharp rap with one fingertip. If you go too high, the bar can be flattened out slightly to drop the pitch by turning the bar around in the vise and retuning. Fig. 2 shows the average amount of crease in a bar viewed from one end.

Sometimes you'll find that a bar produces two tones when struck. This is almost always because there is a twist in it. Lay the bar on an absolutely flat surface to see which corners touch and which don't. The metal table of a table-saw or table-plane is truly flat. Then remove the twist. It isn't necessary to check all bars for twist, since this twist often does not produce any problems. Check and straighten only those which sound unsatisfactory. If all else fails, discard a faulty bar and begin anew.

Resonators

These tubes stand under the bars and greatly amplify the volume of sound. This effect is especially evident in the lowest pitches, and becomes less evident in the higher-pitched instruments, where the energy-output of the bars themselves is relatively high. In a traditional bronze Javanese gamelan only the slentem and genders are so amplified, but as we are using a different metal, it may be advisable to add them to middle-range instruments as well. If higher range instruments, a rectangular box-shaped case with an opening below the keys such as is found on traditional sarons may provide adequate amplification.

Tubes for the slentem are made of one-pound coffee-cans, two-quart juice-cans, or similar large tin cans, not over four or five inches in diameter. Begin with the tube for low pitch "1", the lowest bar. You will make a stack of cans, all of the same diameter, held together with duct tape, or masking tape sealed by a coat of paint. Soldering is the sturdiest, if you have the patience. Taped joints should be checked once or twice a year; they may require replacement. Be sure to align the cans carefully, so that you can get an airtight seal. One end is left in one can, and both ends are removed from the rest, so that you get a tube closed at one end (the bottom) and open at the other (the top). (See fig. 3)

Once you have stacked up and taped together two or three cans, you'll notice that you can hear a definite musical tone if you blow across the top, or bump the bottom edge against the table. (A piece of thin carpet laid on the table or floor makes an excellent "bumper"). Continue adding cans until this "bump-tone" is about the same pitch as the bar you are making it for.

Actually, you'll usually have to go too low, i.e., too long, and trim away the open end until it comes back up to the desired pitch. For a right-handed person: hold the tube across your lap, with the open end to the right. Using the tinsnips, start cutting off a narrow strip, beginning at the bottom edge of the can. (see fig. 4) Rotate the can in the direction of the arrow as you cut. Test frequently by "bumping" or blowing over the top, until you get the pitch needed. You do not have to tune the resonating-tube exactly to the pitch of the bar. In fact, it is undesirable to have the two perfectly matched, as this would give a very loud but very brief tone. I generally tune the tubes a little lower than the bars.

Building the resonators this way will result in a very tall slentem. In fact the player will have to sit on a chair, unlike any of the players of other instruments. A shorter, partially closed-over tube can be substituted for a longer, fully open one. In this way the height of the instrument can be reduced without losing pitch range. Unfortunately there is a practical limit beyond which one cannot go without sacrificing considerable volume of sound. Some closure of the lowest tubes should not be too problematic. To do so, tape on a round piece of very stiff cardboard or masonite with a small hole in the center—say ½ inch diameter. Be sure to get an air-tight seal with the tape. You will see that this produces a very low pitch, and that the pitch rises as you enlarge the hole. Test various bars over this resonator, and determine for yourself what you consider to be the practical limit for the size of the hole.

In order to stand evenly under the keys, the lengths of the shorter resonators must be increased to be approximately equal. This is done by taping extra cans onto the bottoms of each resonator until proper height is achieved: approximately level with the top edge of the top rail of the wooden case. (see fig. 5)

Assemble all the various cases of number two pine, or wood of similar quality, using casein glue and number 5 or 6 box nails at all joints. The bottom of the case is ¼ inch plywood, or ⅛-inch pressed wood (such as masonite). If you want to hide the resonators from view, cloth can be hung from inside the top rails, or panels of plywood or masonite can be slid down from above to cover the tubes.

All of the metal keyed instruments can be suspended from string as shown in fig. 6 and 7. Carpenters chalk line stretches less than nylon cord, but frays more easily. The former will require frequent replacement, and the latter, frequent tightening. The string is looped down through each bar hole and held there by a ¾″ or so piece of very thin doweling. The best suspension hooks are quarter inch dowels with a slit, or else you can use a piece of bent coat-hanger. (see fig. 8 a & b) The four ends of the cords are tied around dowel pegs inserted vertically in each end-board. Ends can also be tied in various other ways.

The cases can be painted any reasonable color, and all instruments in a set should be painted the same color. Red paint, or dark brown stain, or deep green paint would give a fairly traditional appearance to it all. Exposed resonators look better painted. And if you object to the look of iron, keys can be spraypainted to look bronze without sound loss. However this is really unnecessary.

Other key instruments

Once the slentem is built, you simply tune the demung an octave higher on each equivalent bar, the saron an octave higher than the demung, and the peking an octave above the saron. The gender can be built by extending the range of a slentem up through demung register to pitch 3 in saron octave. The gender panerus is the same but an octave higher. Since the genders have 14 keys, a much longer case will be needed. To amplify demung-range instruments, use smaller size cans, such as soup-cans. Bar width is 3 inches. Saron keys are of 2½ inch width and peking keys of 2 inch. Neither require tube resonators. An empty frame with a solid bottom is needed however to raise the instruments up to a convenient height.

Iron gamelans in Java often use squarish keys with bumps in them in place of kettles for the bonang. The bonang barung is essentially built as a demung placed back to back with a saron, with the keys in their traditional order:

slendro: $\frac{\dot{6}\ \dot{5}\ \dot{3}\ \dot{2}\ \ddot{1}\ \ddot{2}}{\dot{1}\ 2\ 3\ 5\ 6\ 1}$ pelog $\frac{\dot{4}\ \dot{6}\ \dot{5}\ \dot{3}\ \dot{2}\ \dot{1}\ \dot{7}}{7\ 1\ 2\ 3\ 5\ 6\ 4}$

Likewise, the bonang panerus, an octave higher, is a saron-peking pair.

To make the bumps, heat the center of the bar to red heat with an oxy-acetylene torch if you can get one, or else a propane torch. Hammer in the bump with a ball-pein hammer, using as your anvil a piece of 1-inch iron pipe held upright in a vise. Your bar will look like a figure 9. You can put in the bumps without heating the metal, but only at great effort.

Instead of a single hole in each end of the bar, I sometimes make bonang bars with two holes at each end (see fig. 10) which makes it easier to re-align bars when they slip out of place on the string or when the string stretches. This also damps the tone, desirable in a bonang but not advisable for the other key instruments. In order to further damp the keys and make them sound more like the traditional instrument, you can add a damper in the form of a rubber band slipped over one end of each bar with a small patch of cloth between it and the bar. The closer this is to the end, the more damping; the nearer to the nodal point, the less damping. Highest tones may need little or no damping.

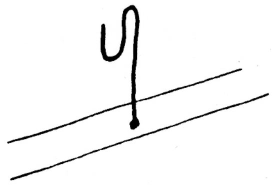


Figure 8a

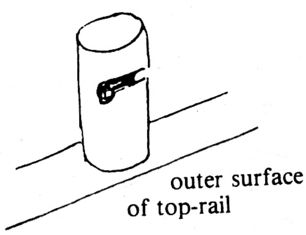


Figure 8b

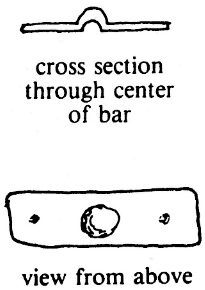


Figure 9

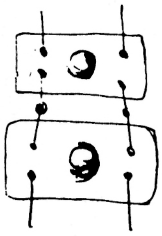


Figure 10

Once the bump is in, you can't tune a bonang bar in the usual way. Bending is done in two parallel lines at either side of the bump, as shown in figure 11. Keep in mind that the pitch can't be raised as much with this arrangement.

When building the frame, make both ranks of the bonang at the same height, as determined by the longest resonating bar. If you don't want it too high, use short, partially covered tubes.

Gongs and Punctuating Instruments

If you live in Vermont or an equally rural place, you may be able to find some ready-made materials for your gong family. A huge circular-saw blade works as a gong agung. Suspend it from holes at the nodal point, which should be a circle about ⅓ to ¼ of the way in from the rim. Another rural find I have used is old fashioned milk-strainers in place of kenongs. And if you find just the right sounding hubcap, it can be a ketuk.

More likely you may want to build some or all of your gongs. To make big gongs and kempuls, use 16 or 14 gauge hot-rolled steel. In a pinch, try automobile scrap, or any large sheets of iron that can be made relatively flat.

Cut a disc out of the flat iron, using an oxy-acetylene torch or a tool called a "nibbler" which can be found in many metal-working shops. Measurements for disc-diameter are almost impossible to give because there are so many variables in tuning. Start with a disc about 2 feet across, and go from there. Our biggest gongs are perhaps 42 inches across, our smallest kempul about 18 inches, all out of 16- and 14-gauge metal.

Next, cut a straight band of the same metal long enough to form a collar around the disc, as shown in figure 12. Weld the ends of the collar together, and weld the collar to the disc. If welding is out of the question, it might be worthwhile to experiment with soft-soldering. In this case thinner metal such as automobile scrap must be used. I've never tried soft-soldering, but there's no reason it shouldn't work: the function of the collar is not to join in the vibrations, but rather to provide inertia at the edge of the disc.

Figure 11

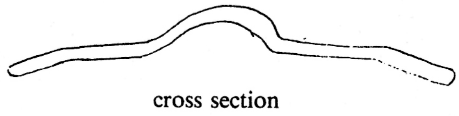


Figure 12

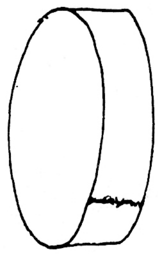


Figure 13

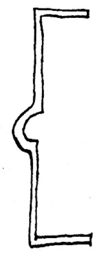
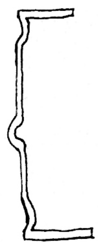


Figure 14



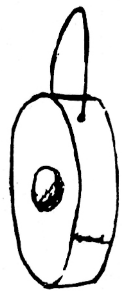


Figure 14a

With the collar joined to the disc your instrument looks much like a huge frypan with straight sides and no handle. Now heat the center red hot and hammer an outward bump into it, using for your anvil a piece of pipe (or a pipe collar) about 3 inches in diameter held upright in a vise. Pound with a three-pound or five-pound hammer. The result should look something like figure 13 in cross-section.

Next, one person goes slowly around the outer part of the disc with the torch, heating well (though not necessarily to red heat), and another follows behind with the hammer, depressing the heated area. When done the instrument should look something like figure 14 in cross-section. Actually it probably won't be all that neat, but try to keep the unhammered portion of the disc flat and smooth. This final hammering around the edge of the disc is not absolutely necessary: a gong shaped as in figure 14A will work.

Tabuhs

To make the slentem's tabuh (mallet), use nominal 1-inch lumber and cut a disc about 3½ inches in diameter. Drill a hole through the center, and glue in a handle of ½ inch doweling, about 14 inches long. Padding must be attached to the edge of the disc. One way to do this is to drill holes in the disc near the rim, as in fig. 15, and lace a cloth or felt strip to the edge with strong button thread or braided nylon fishline.

Demung, saron and peking all use wooden hammer-shaped tabuhs, without padding. Make a rectangular shaped head, round it off, drill a hole in the center and insert glue in a length of ½ inch dowelling for the handle. (fig. 16)

Bonang tabuhs, traditionally, are long sticks with heavy string wound around the end which strike the bosses of the kettles. Because bump-keys present a smaller target, we use versions of the slentem tabuh instead, with smaller heads, long handles, and less padding. Gender tabuhs are also like the slentem's, but smaller.

For the gongs, you can fashion a large, soft beater by starting with a rubber-headed hammer, winding a sock around it, and fastening cloth or towelling around the outside of the head.

Other non-metal instruments

Although the limits of this article leave no room to describe the full construction of the other important gamelan instruments, let me briefly mention a few substitutes I have devised.

The suling can be made from PVC tubing. Thick wall "Schedule 40" is advisable. The outer ring of the windway is made from a strip of tin.

Drums can be made or "borrowed" from among available existing drums such as bongo or conga. A nice sounding low-pitch drum can be made from a length of hollow porch pillar, which you may be able to get from a wrecking company. Vegetarian drum-heads can be made by coating a square of bedsheet with a thin layer of polyurethane. The head is then attached to a ring of pegs on the outside of the drum body.

Gambang keys can be made of pine in graduated dimensions, the highest key being thickest and shortest, (1½″ x 13″) the lowest key thinnest and longest (⅜″ x 26½″).

Javanese musicians, like most musicians throughout the world, have a lot of respect for their instruments. I'm sorry to say that we westerners are somewhat lax in this area, as a group. However, anyone who builds a gamelan and learns to play it is automatically going to look on it as much more than an assemblage of metal and wood that makes nice sounds. If you think of the instruments as deserving the same respect you would accord to people, you can't go wrong. One should not step over instruments, for reasons of safety as well as spiritual reasons. Shoes should not be worn in the gamelan area; it is not only disrespectful but creates dirt on the floor, which is where the musicians sit. And, in my opinion, dogs should not be allowed near the gamelan.

Figure 14a

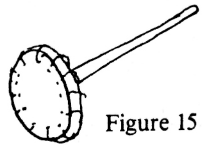


Figure 15

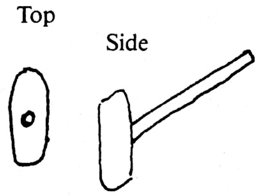
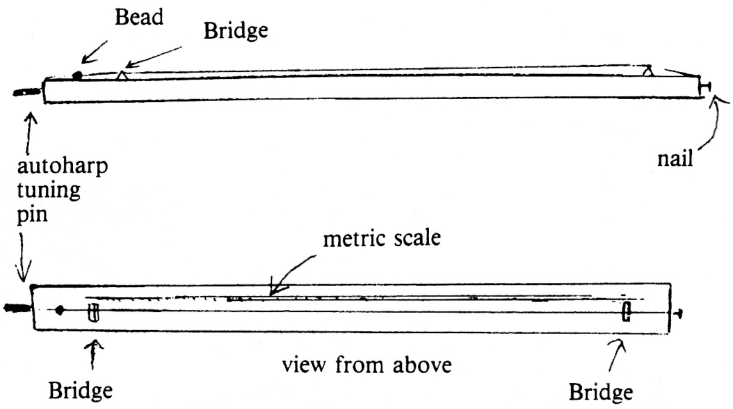


Figure 16

Figure 17



I've heard it said that there is an idea in Java that the music of the gamelan somehow always surrounds us, and that when the musicians sit down at their instruments, they are just making the music audible. When they stop playing, we cease to hear the music, but it goes on forever anyway.

DENNIS MURPHY's gamelan designs have been influential on the building of most of the American-made gamelans in the northeast. This article is an update and condensation of material from Murphy's doctoral dissertation, "An Autochthonous American Gamelan"— Wesleyan U. 1974.

CHART I Estimate of metal needed to build small slendro set in 14 gauge. Increase figures by about one third if working in ⅛″ (11 gauge)

strip width	length
3½ to 4″	10 to 12 feet
3	6 to 8
2½	20
2	6

Allow for more if you are planning to build genders. Also, you will need whole, uncut sheets to make gongs.

CHART II Approximate pitch ranges

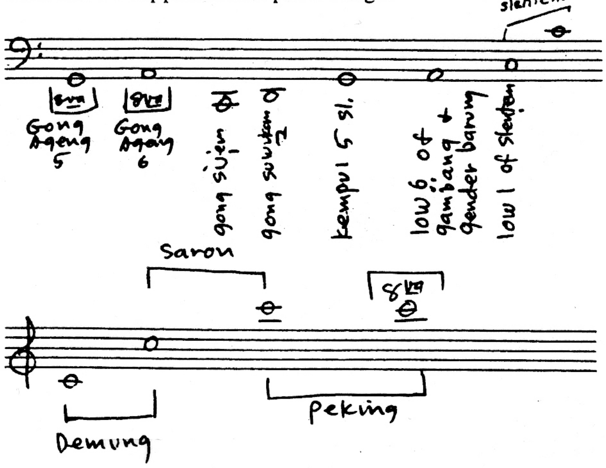


CHART III

	Lowest key SLENDRO pitch	/ length	Highest key SLENDRO pitch	/ length
slentem (14 gauge)	1	14 inches	$\dot{1}$	9½ inches
demung (11 gauge)	1	10½	$\dot{1}$	7½
saron (11)	1	7½	$\dot{1}$	5½
peking (11)	1	6	$\dot{1}$	4½
gender barang	$\underset{\cdot}{6}$	15¾	$\dot{3}$	6¾
bonang barang (14)	2	9	$\dot{1}$	5¼
bonang barang (11)	2	11	$\dot{1}$	6¾
bonang panerus (14)	2	5	$\dot{1}$	4

CHART IV Tuning of Gamelan Sir Voice of Thoom

pitch number	1	2	3	4	5	6	7
slendro	862	746	664		584	500	
pelog	784	728	670	586	542	500	448