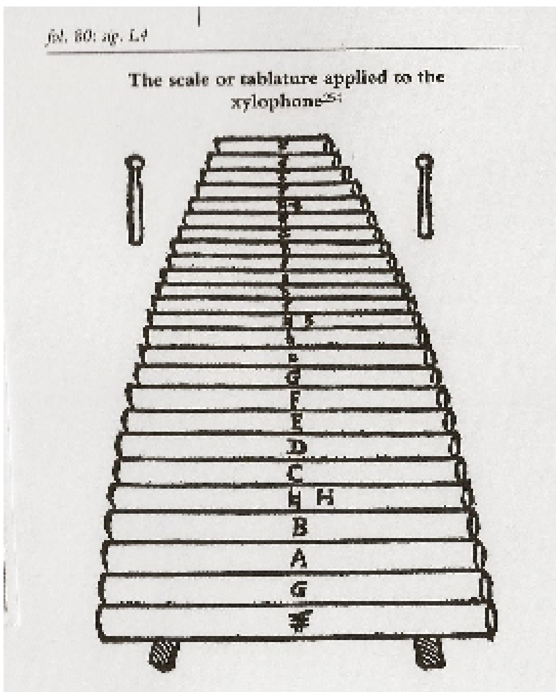
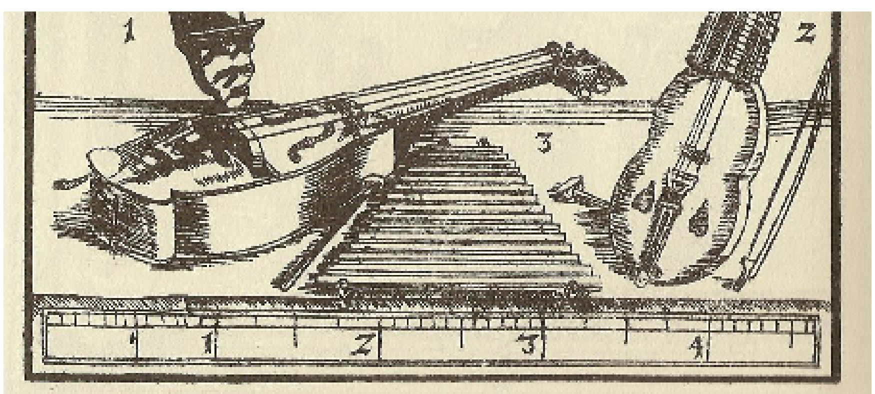
16th century Xylophone
by Lady Tangwystl verch Gruffydd

While we cannot be certain when the instrument we know as the xylophone was first invented, we know it existed in 16th century Germany. The first mention of it is from 1511 by the organist Arnold Schlick in *Spiegel der Orgelmacher und Organisten*, who called it a *hultze glechter*, or wooden clatter[1]. The instrument was also catalogued in Martin Agricola's Treatise of Musical Instruments in 1529[2], and Hans Holbein included a woodcut of a skeleton playing one in a collection called "The Dance of Death[3]." In addition, it appears in Praetorius' Syntagma Musica from 1619[4]. It was typically used in place of the hammered dulcimer, which had been in use since the 12th century[5], and likely was a descendent of the wooden cimbalom, found in Hungary[6]. The term "xylophone" was not used until the late 19th century[7]. It was an instrument particularly suited for traveling players[8], and while it seems to have first appeared in Germany, it soon spread throughout Europe[9].





1. Some Peasant Hurdy-Gurdies. 2. Keyed Fiddle. 3. Straw Fiddle [sic] (xylophone). 4. Hunting Horns. 5. Triangle. 6. Crotales. 7. Little Moorish Tambourine. 8. Bells. 9. Sleighbells.

Drawing from Agricola's Treatise, 1529 (top left), Hans Holbein's "Dance of Death XXX", 1538 (top right), Drawing by Praetorius, 1619 (bottom)

Materials

There are no extant xylophones from the 16th century, and there are no sources which state what kinds of wood were used or how it was constructed. As hardwoods produce better sound and can withstand repeated hitting, a hardwood is a better choice. Mersenne's *Harmonie Universelle* from 1627 states that "a resonant wood, such as beech, or whatever wood one wishes," could be used, which seems to imply that instrument-makers used whatever resonant hardwood was available[10]. I chose to use hard maple because it was available in Europe in the 1500's, and it is a commonly used wood, even today, for making musical instruments.

I finished the bars by coating them with three coats of boiled linseed oil. This was a commonly used material for finishing wood back then[11]. This finish protects the wood from moisture, which would change the pitch properties of the instrument.

In period, the xylophone would have rested on bound hanks of straw tied into tight bundles and placed at the nodes[12,13,14], which are the "dead" points of the bar. This is why the instrument was known as the *stroh-fiedel*, or straw fiddle, in Germany[15]. I was not sure where I could buy straw, so I purchased a straw wreath from a local craft store and took it apart. I then bound the straw into long supports using hemp cord, as this material was widely available at the time[16].

Mersenne suggested placing a small rosary bead between each bar to keep them separated[17]. I had difficulty finding beads that had a large enough hole for the rope I used for stringing, but finally found some wooden pony beads that were relatively small with a hole that was just barely large enough.

While I did not create my own mallets, I purchased some rock maple timpani mallets for playing this instrument. These mallets have approximately the same shape as Agricola's drawing, and as they are also made from maple, I thought they would be a good choice. The mallets used in period were discs, cylinders, or spheres of wood on wooden shafts[18].

Methods/Techniques

An instrument maker in the 16th century would have had to turn his own bars on a lathe or possibly purchase pre-turned dowels from a wood-turner. As I am not a proficient woodworker by any stretch of the imagination, I chose to buy maple dowels in varying diameters. To figure out how much I needed, and how long each bar needed to be cut, I discovered a relatively simple physics formula (simple in that it replaces all of the dynamic variables for things like wood density, which was different for every bar, and temperature, which was different from day to day, with a single "correction" factor of E) which calculates the approximate length needed for each note, assuming a specific diameter[19]:

L (inches) = (√ ((E*3.14159*K*V)/F))/2.54
Where:
L= Length of chime
K= Tubing size and wall thickness constant
ID = Tubing inside diameter (inches)
OD = Tubing outside diameter (inches)
E = Correction factor determined from measured data. Suggest 1.15
V= Velocity of sound (cm/s)
F = Frequency (Hz)
K = (√ ((ID*2.54*0.5)^2+(OD*2.54*0.5)^2))/2
1 in (inch) = 25.4 mm

I found another physics reference that said that the velocity of hard maple was 4110 m/s and used that for my V value[20]. I had a maple dowel that Lord Haraldr Bassi had loaned me. I used an app on my android phone to find out at what frequency it resonated, then used that and the dowel's measurements to get an approximate value to use for E. Since the "tubes" were solid rather than hollow, I used zero for the ID value in the equation.

To determine what pitch frequencies I wanted to use, I opted to begin with A=440, in order to be in tune with other modern instruments. At this time, there does not seem to have been a standard frequency definition for specific notes. If multiple instruments wanted to play together, they would simply pick which one they wanted to tune to so that they all sounded good together.

Modern xylophones are equal tempered, meaning that the distance between each half step is the same throughout the octave. However, equal temperament was not invented until the time of Bach. In the middle ages, instruments were tuned using the Pythagorean tuning system[21]. To implement this, they had someone called a monochordist, who would take a single string and divide it into varying segments, which resulted in the different notes desired[22]. What this means is that the ratios between steps are not all equal and instead correspond to specific ratios, the remaining intervals in the scale being obtained by calculating their inverse[23]:

Major Second	9/8
Major Third	81/64
Fourth	4/3
Fifth	3/2
Octave	2/1

I therefore calculated what frequencies each note needed to be, assuming base pitch of A=440. Once I had all the necessary numbers needed, I entered all of them into a spreadsheet so that I could use the equation to figure out what length of each diameter dowel I would need. As Martin Agricola's drawing shows the diameter of the bars being graduated, I chose to buy dowels in $^{7}/_{8}$", $^{15}/_{16}$", 1", 1$^{1}/_{16}$", 1$^{1}/_{8}$", and 1¼" sizes. I purchased all except for the largest size from a single source. However, it turned out that the 1¼" dowels from the different source had a much lower density than the other dowels, and as a result, their pitch was much too high for me to use them. Instead, I opted to use the 1$^{1}/_{8}$" dowels for the bottom 9 bars, rather than the penultimate 4 bars, as I had planned.

For range of the instrument, I used the same range shown in Agricola's drawing, which is three octaves from F to F, with all "white" keys and Bb. (In the drawing, "B" is Bb and "H" is B natural[24].)

Once I had a good guess regarding length for an individual bar, I worked with Lord Haraldr to cut the dowel down to size using his chop saw. We started off longer than necessary (as you can always cut more off, but can't add more back on), and I used the app on my phone to determine the frequency, having him cut off a little more until we had the right pitch. Sometimes the pitch was difficult to determine using the app, as xylophones do not sustain, and the app often picked up overtones rather than the fundamental. Therefore, I also was required to do some tuning by ear. In addition, I discovered that changes in temperature and humidity changed the pitch by a much more significant amount than I would have expected. Since the bars were not all cut and tuned in a single sitting, when I went back to work on it again, I had to have the new bars cut so that they were in tune relative to the previously cut bars, as tuning them to the exact frequencies I wanted would have made them out of tune with the others due to the change in pitch caused by the weather.

While Agricola's drawing does not show gaps between the notes, Praetorius' drawing shows the bars being slightly separated with a string going through each bar. Since the bars are round, I needed to have a way to keep the bars from rolling, as the pitch changes by as much as a half-step, depending on which part of the grain is being struck. In addition, bars that touch would interfere with the instrument's sound. Therefore, after finishing the bars by rubbing in three coats of boiled linseed oil, I opted to drill holes in the sides of the bars at the nodes (found at 2/9's of the bar's length from each end[25]) so that I could string a thin hemp rope through, keeping the bars together for easy transport. I used a wooden clamp to hold the bar in place while drilling the holes with a manual auger. Because the holes are drilled at the nodes, any variation in the pitch of the bar is negligible. In fact, since the location of the nodes is not known until the length of the bar is determined, it would not be possible to drill holes before the bar was cut to the correct length. Even if the pitch were affected, the relative pitch would not change, and the instrument would still be in tune with itself, even if the base frequency moved by a few Hertz. Given the lack of a standard pitch in the 16th century, this would have been perfectly acceptable.

To keep the bars from touching, I threaded wooden beads on the stringing rope between each bar, as recommended by Mersenne[26]. I opted to use the dark-colored beads in between the Bb and B natural so that the "extra" note would be easily spotted, as it is unlikely that both of these notes would be required in the same song. This also gives me a reference point for keeping track of where the notes are.

Complexity

As I have never built a musical instrument before and have not even had to tune one, given my background as a percussionist playing permanently tuned instruments (with the exception of timpani, which is tuned on the fly while playing), nor do I have any significant background in woodworking, this was a very big challenge for me to take on. Making sure the instrument was in tune was a difficult task, especially given the variance in temperature from day to day and the discovery that the rotation of the bar affected the pitch. However, having a playable medieval xylophone to use in the future is very much worth the effort.

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