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Modernization of traditional Asian free reed instruments: Comparing the sheng and the khaen

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Abstract

Two Asian free reed mouth organs operating on similar acoustical principles have had contrasting histories: the Chinese sheng and the Laotian khaen. Both are multiple-pipe mouth organs constructed from pipes with a free reed in each pipe. The sheng has a two thousand year recorded history in China, and in the last century modified versions have been developed and appeared in the Western concert hall style setting of the Chinese orchestra. The khaen, while remaining a strong cultural symbol of the Lao people, has not undergone similar developments as once prevalent traditional performance styles have almost disappeared. One common modification of the sheng is the attachment of cylindrical metal pipe resonators attached to most of the pipes. Of particular interest in the current study is a sheng in a traditional 17-pipe configuration, but with these resonators attached. The resonators both amplify the radiated sound and alter the tone quality. Calculations of input impedance have been made for the pipes, with and without the resonators attached. These calculations are compared with the measured pipe impedances as well as the measured sounding frequencies and sound spectra. [Work partially supported by United States National Science Foundation Grant PHY-1004860]

Keywords: free reed

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1 Introduction

The sheng is an ancient Asian mouth organ consisting of a number of pipes arranged in a circle around the edge of a wind chamber with an attached mouthpiece. The instrument can be played by exhaling or inhaling through the mouthpiece and covering small finger holes on the pipes that the player wants to sound. Typically multiple pipes are played simultaneously, and due to the instrument's symmetric free reeds each pipe sounds at the same frequency whether the player is inhaling or exhaling. The sheng used in this study has 17 pipes with lengths between 15 and 40 cm. Figure 1 shows an example of a single pipe, which in this instrument has a cylindrical metal resonator attached. The complete instrument is shown on the right in Figure 2 along with a similar instrument without the added resonators.

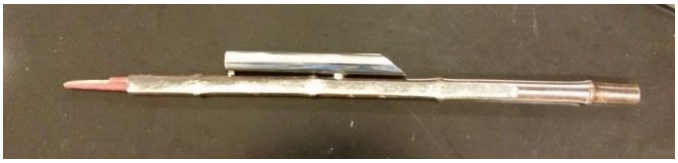

Figure 1: A sheng pipe with resonator

Figure 2: A 17-pipe sheng without resonators (left) and with resonators (right)

While the sheng is an ancient instrument, the addition of metal resonators only came about in the twentieth century. These resonators both amplify the sound of the instrument and modify the sound quality, and are usually tuned one octave above the sounding frequency. They are

typically 10-20 cm long and about 1 cm in diameter, with the connection to the pipe about 0.5 cm in diameter. In some of the calculations reported here, the method of transmission matrices has been used to method to investigate the effects of the resonator on the input impedance and the sounding spectrum of the pipes. This work is a based on earlier work done by Dieckman on sheng pipes and other free reed pipes without resonators. [1]

The khaen, although operating on the same acoustical principles as the sheng, has had a different history. Ancient references to this instrument are rare, and it did not become the object of “modernizations” such as those that occurred with the sheng. The khaen is the signature instrument of the Lao people of northeastern Thailand and Laos. The version of the khaen most common today consists of 16 open pipes with free reeds mounted in the pipe walls. All of the reeds are in a carved wooden wind chamber. As with the sheng, it is customary for multiple pipes to be played simultaneously, and each pipe sounds at the same frequency whether the player is inhaling or exhaling. The khaen is illustrated in Figure 3.

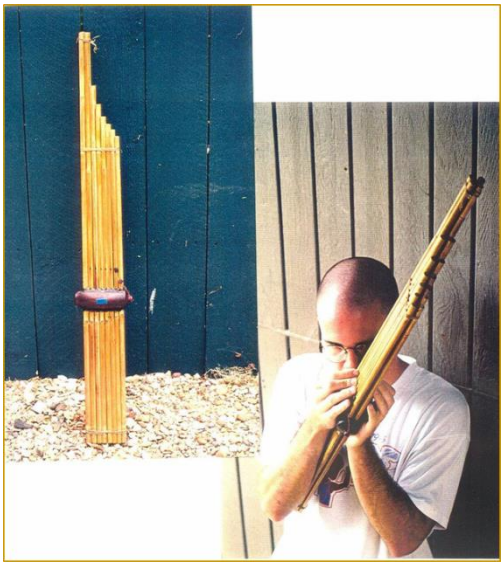

Figure 3: A khaen and khaen player

2 Traditional and recent performance practice

2.1 The sheng

Mouth-blown instruments employing free reeds coupled to pipe resonators have long been used throughout East and Southeast Asia. Details of the origin and development of these instruments are not known, but are closely connected with the history and prehistory of a multitude of ethnic groups. Beginning from presumed folk instrument origins, the free reed mouth organs have been used in a variety of contexts including simple signaling, courtship, local entertainment, civic or military processions, and sophisticated court music.

The sheng and the khaen, two instruments operating on similar acoustical principles, have had contrasting histories. The sheng has a two thousand year recorded history in China, and is reputed to have been played by Confucius. In the last century, however traditional sheng playing appeared to be disappearing. Terry Miller reported the following in 1981: “In China now sheng are rarely seen or heard. Recordings of them are rather scarce, and some Chinese, even musicians, have never heard of the sheng, much less played one.” [3]

Two trends in China, however, have revived interest in the sheng. In one case there has been concentrated interest in preserving traditional forms of Chinese music. In another development, expanded and modified versions of the sheng have been developed and appear in the Western concert hall style setting of what has become known as the “Chinese orchestra.” This kind of ensemble employs a variety of traditional Chinese instruments, sometimes including Western bowed strings as well. Included are larger and more elaborate versions of the sheng, often employing key work as well as added pipe resonators, Figure 4 illustrates some examples of these modernized sheng.

Figure 4: Some examples of recent development of the sheng

2.2 The khaen

The khaen, on the other hand, while remaining a strong cultural symbol of the Lao people, has not undergone similar modernizing developments, while once prevalent traditional performance styles have almost disappeared. There seems to be no mass manufacture of high quality instruments. Professional musicians, including a number of Western composers and performers, rely on individual craftsmen for construction of high quality khaen. Figure 5 shows scenes photographed by Terry Miller of construction of khaen in a village in northeastern Thailand in 1988.

Figure 5: Construction of khaen near Roi-et in northeastern Thailand (Photo by Terry E. Miller)

3 Sheng pipe with added resonators

The following section describes briefly recent research on one of the simpler twentieth-century "modernizations" of the sheng: the connection of cylindrical external pipe resonators to most of the pipes of the standard 17-pipe sheng.

3.1 Pipe input impedance and sounding frequency

By comparing the output of sheng pipes with and without the attached external resonators it is clear that the resonators amplify the radiated sound and also change the sound spectrum. The effects of the attached resonators were explored by LeDuc, et al, who calculated the input impedances of the pipes in both configurations using a method of transmission matrices. [2] These calculations were verified by comparison with measured impedance curves. Comparisons were then made between sound spectra and impedance curves.

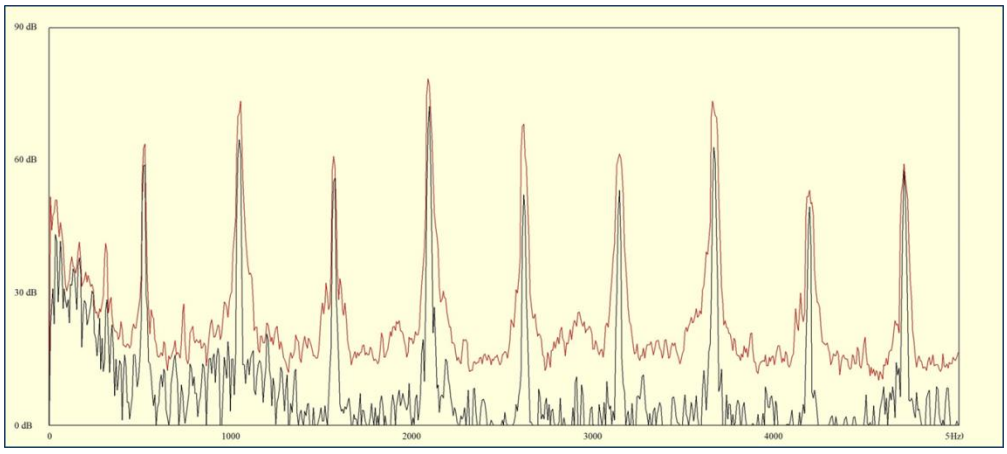

Figure 6: Sound spectra of a note sounded on a sheng pipe. The spectrum in red is for the pipe with external resonator; the spectrum in black is with the resonator blocked

3.2 Effects of the resonator on input impedance

Adding the resonator to the pipe amplifies the radiated sound and also changes the timbre. This is evident in comparing the calculated input impedance curve with the impedance curves of the pipe without the resonator, as well as comparing the impedance curves of each pipe with and without the resonator attached. Figure 7 shows the input impedance curve for the added resonator together with the impedance curve of the pipe-resonator system for Pipe 5. It can be seen that the main features of the resonator are reflected in the impedance curve for the pipe-resonator system.

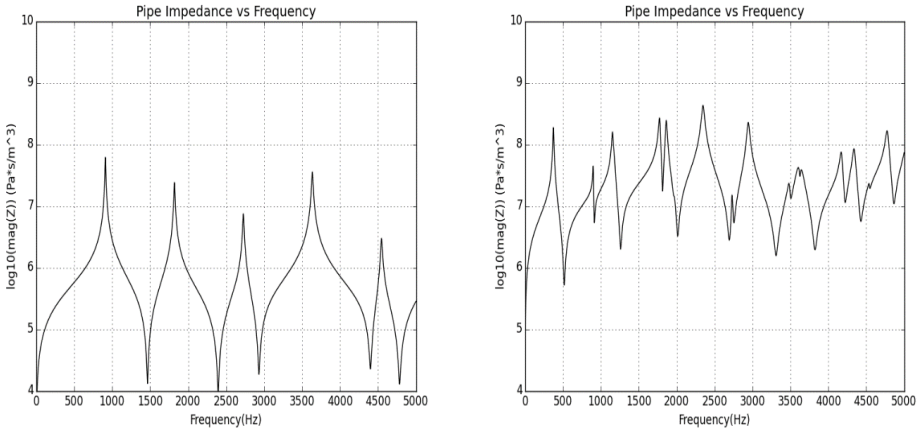

Figure 7: Impedance curve of the resonator alone (left) and the impedance curve of the pipe with resonator attached

In particular, the principal peaks in the impedance curve of the resonator appear clearly in the curve of the combined system, for example, the prominent peaks near 900 Hz and 1800 Hz. By comparison, we see that these features do not appear in the impedance curve for Pipe 5 without the resonator as shown in Figure 8.

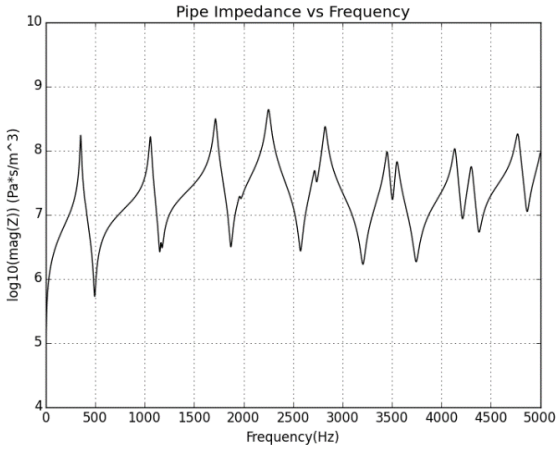

Figure 8: Pipe 5 impedance curve without its resonator

3.3 Sounding spectra

In addition to amplifying the radiated sound from the sheng, the external resonator, which is tuned one octave above the sounding frequency, influences the timbre by changing the sound spectrum. This is illustrated in Figure 9, which compares the amplitudes of the harmonics of the radiated sound for Pipe 14 of the sheng. In this case, the presence of the resonator lowered the amplitude of the second harmonic and raised the amplitude of the fourth harmonic. In the figure the amplitude of the fundamental for the pipe with the resonator attached has been normalized to 1.0, and the other amplitudes adjusted accordingly.

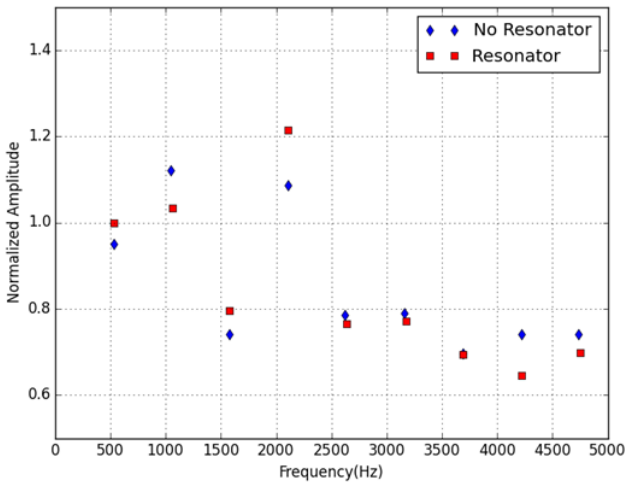

Figure 9: Sounding spectra of Pipe 14 with and without the resonator

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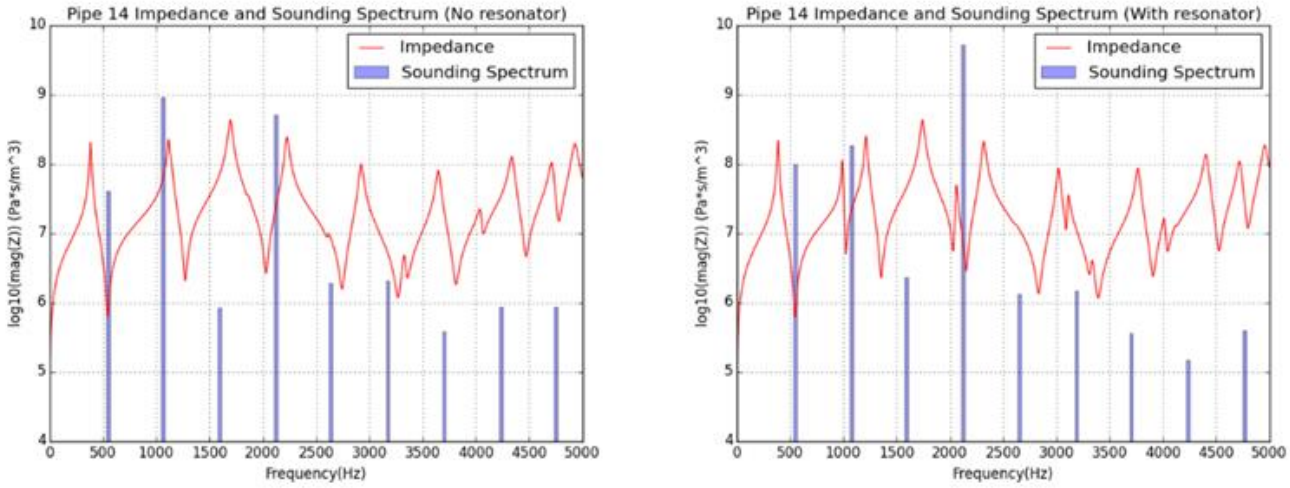

Figure 10: Impedance curves and sounding spectra of Pipe 14 without the resonator (left) and with the resonator (right)

Figure 10 shows the sounding spectra and input impedance curves for Pipe 14 plotted together. The amplitude of the fundamental for the pipe with resonator attached has been normalized to 8.0, with the other spectral components adjusted accordingly. In this particular case the second harmonic falls near a minimum of the impedance curve of the pipe and resonator, and the fourth falls near a maximum. This leads to the empahsis of the fourth harmonic and relative weakening of the second harmonic in the spectrum shown in the figure.

4 Final remarks

We have briefly surveyed how the khaen and sheng followed different paths of development in the twentieth century, and the acoustical effects of one of the simplest modifications of the sheng have been explored. It will be of interest in the future to look in detail at the acoustical effects of more elaborate modifications.

Acknowledgments

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