J. Acoust. Soc. Jpn. (*E*) **14**, 6 (1993)

Several peculiar structural devices of Japanese musical instruments and some aspects of timbre taste in Japanese music common with western ones

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In structure of Japanese musical instruments, there are several devices which reflect special features of traditional Japanese music. On the other hand, common aspects of taste in timbre between Japanese and western instruments can be observed. This is regarded as an expression of the similar sense of beauty in sounds with each other's music. As examples of those peculiar devices, this paper describes (1) those for delicate and smooth pitch change observed in tall bridges and the frets of string instruments as well as in the large mouth holes and dented surface of wind instruments, (2) the peculiar bore shape of a Nohkan formed by insertion of a slender pipe called the "throat," and (3) a device called the "Sawari" which generates inharmonic components and prolongs the decay time of harmonic components and can be observed in a Biwa and a Shamisen. The common taste in the timbre described here are (1) similarity in frequency characteristic of bodies of a violin and a Biwa, both of which are evaluated as superior and (2) desirable features of spectrum pattern observed in Baroque recorder music and classical shakuhachi music.

Keywords: Japanese musical instrument, Structure of musical instrument, Nohkan, Shamisen, Biwa, Shakuhachi

PACS number: 43. 75. Ef, 43. 75. Gh, 43. 75. Cd

1. INTRODUCTION

In the structure of Japanese musical instruments, several devices exist which reflect the special features of traditional Japanese music. On the other hand, common aspects of taste in timbre between Japanese and western instruments can be observed. This is regarded as an expression of the similar sense of beauty in sounds with each other's music.

In this paper, three peculiar structural devices and two similar aspects of timbre taste are described which were found in the author's study.

2. SOME STRUCTURAL DEVICES

2.1 Structural Devices for the Delicate and Smooth Change in Pitch—Tall Bridges and the Frets in String Instruments and Large Mouth Holes and Dented Surface of Wind Instruments

A "Soh" (called the "Koto" commonly), a representative Japanese string instrument, is a kind of board zither (Fig. 1 upper left figure). A "Biwa" is another kind of Japanese string instrument which has the same origin as European lutes. (Fig. 1 upper right) However, these two Japanese instruments have those bridges or frets which are very different from those of European long zithers or lutes. The bridges (called the "Ji") of a Soh and frets (called the "Juh") of a Biwa are 3 to 4 cm in height and function not only to determine the vibrating length of the strings but also to control their tension. The control used frequently is tension increasing. As shown in the bottom left of Fig. 1, it is performed by pushing the non-vibtating part of the string of which tension is to be increased with one's fingers in a downward direction. In addition, in Soh playing the pitch shifting down technique is

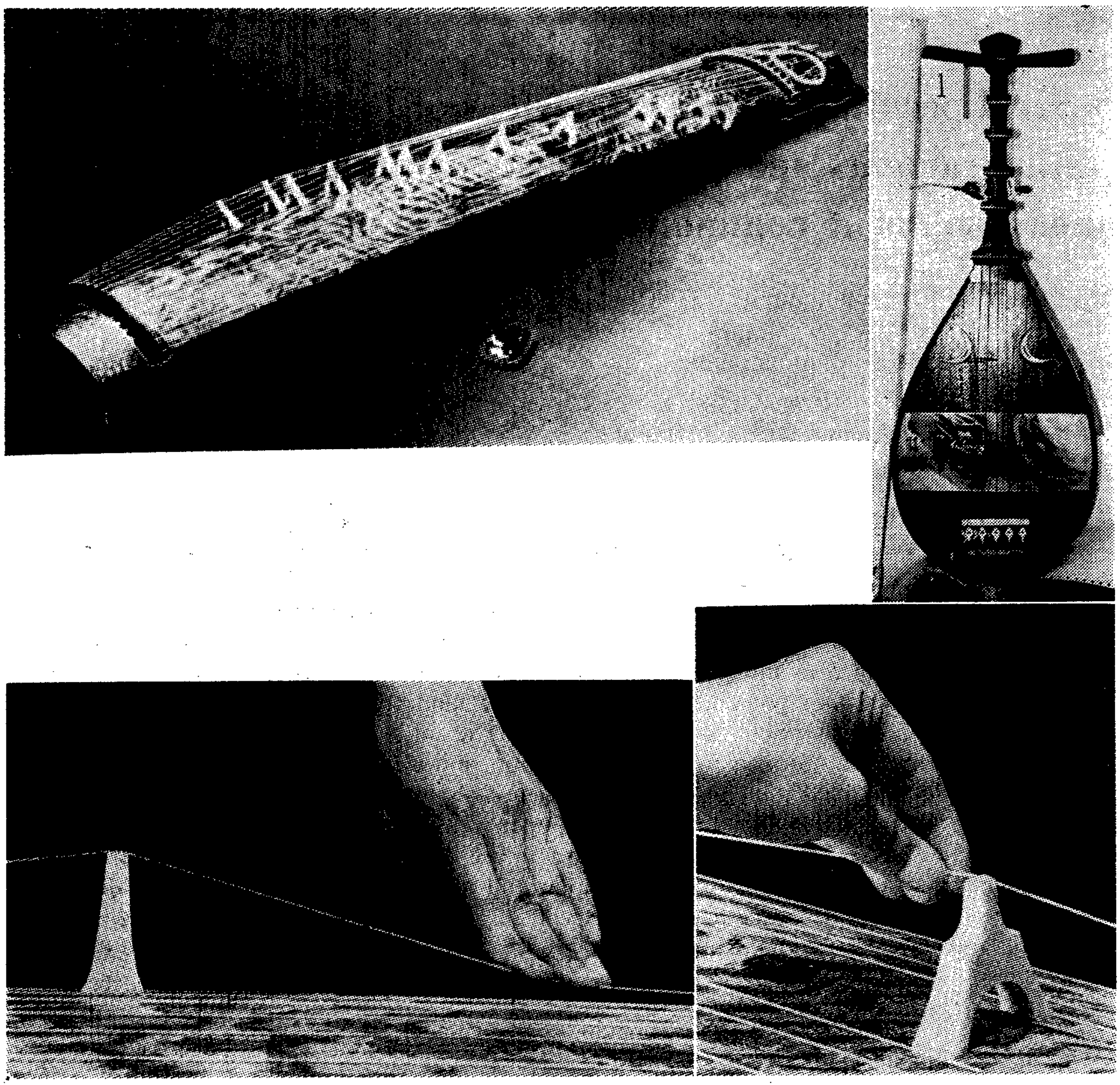

Fig. 1 Top left: Soh (from *Koto no Hibiki* by T. Hirata & S. Kihara, 1988). Top right: Biwa. Bottom: Oshide (left) and Hiki-iro (right) (from *Ikutaryu no Sohkyoku* by Masateru Ando).

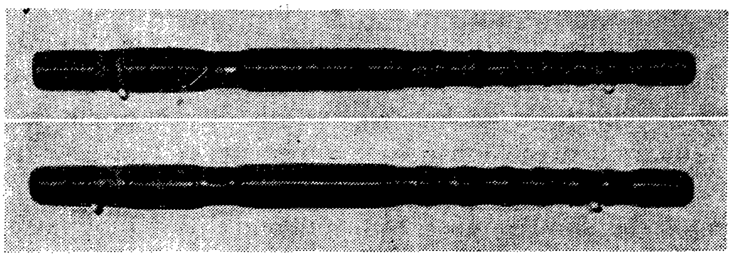

Fig. 2 Ryuteki (top) & Nohkan (bottom).

also employed. In the technique, the player draws the non-vibrating part of a string towards the bridge by a picking motion, and decreases tension of its vibrating part. (see bottom right of Fig. 1.)

Also, in wind instruments, device for delicate and smooth pitch control can be observed. Bamboo flutes used for "Noh" drama ("Nohkan") and for "Gagaku" dance ("Ryuteki") are these type of examples. (see Fig. 2) They have a mouth hole about twice as large as that of a western flute. By way of changing one's face angle in connection to the instruments, the player can shift the pitch down or up beyond a whole tone. The pitch of these instruments is changed continuously also by a finger technique. As seen in Fig. 2, their surface is dented around each finger-hole. This makes the gradual opening or closing the holes quite easily. The pitch control range obtained by the gradual finger technique extends over the perfect fifth. However, this device for delicate and smooth pitch control is not advantageous for quick melody movements through a wide pitch range. These structural devices reflect a feature of traditional Japanese music which attaches importance to a fine and smooth change of pitch intonation as a way of musical expression rather than quick and wide movement.

2.2 Peculiar Bore Shape of a Nohkan—Insertion of a "Throat"—

A Nohkan, used in "Noh," stemmed from a Ryuteki which was brought from China and has been used in Gagaku, a kind of musical drama played in a Japanese Court. In fact, they have closely similar appearance with each other. However, the pitch temperament of a Nohkan is far different from that of a Ryuteki, which is in a systematic temperament. The temperament difference originates from a slender pipe (whose outer diameter is equal to the bore diameter) which is inserted tightly in its bore part between mouth-hole and the first finger-hole. The slender pipe called the "throat" is about 10 cm in length as shown in Fig. 3 and makes narrow the bore diameter of the inserted part by some 4 mm. By insertion of the throat, pitch of the lower range (the 1st mode) tone, which is played with more opened finger holes than closed ones, is shifted up. This pitch shift up is caused by the fact that the pressure loop of the standing wave is located at narrowed bore part when most of the finger holes are opened. The similar relation between the location of the pressure loop and the throat occurs for the 2nd mode tones which are played with more closed finger holes. Namely, for this mode, among 2 pressure loops, the mouth hole side one is located around the throat. The shift amount reaches to about 300 cents in case of an average shaped throat.[1] The shift brings about extension of the lower pitch range (the range played on the 1st mode), and contraction of the higher pitch range (the one played on the 2nd mode) simultaneously. As a consequence, the octave interval between the lower and higher ranges (the pitch ratio of the 2nd mode to the 1st mode) is stretched in those tones which are played with more closed finger-holes, while the

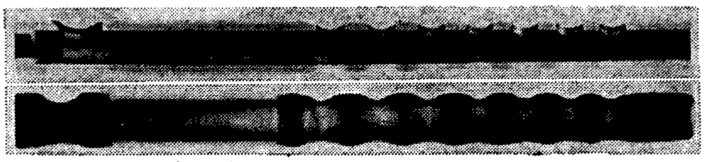

Fig. 3 X-ray photogram of a Ryuteki (top) and Nohkan (bottom).

interval is contracted in those played with less closed finger-holes. The more the number of closed holes, the more magnitude of the stretch is, and vice versa. The octave stretch and contract in case of all the finger-holes are closed and opened reach to about 300 cents, respectively. Such deformation of regular pitch temperament is based on a quite different thinking from other ordinary wind instruments whose important property is how to tune the intervals among each other mode precisely.

The advantage of temperament deformation regarding Noh music playing is the following two aspects. One is the facility of playing Nohkan melodies which originate in recitative chanting of Noh drama texts. Because of the origin, the melodies are free from any fixed pitch temperaments and are frequently sought to be played very smoothly. Since in most part of each Noh drama, Nohkan melody are played on the higher pitch range, contraction of the range may be advantageous to play those melodies smoothly. Smooth and fluent movement has been said to be a characteristic of other traditional arts of Japan than Noh music.[2] Another is to get some "blue" timbre in the lower pitch range. The above-mentioned stretch and contract of octave interval is, in other words, tuning of the 2nd resonance frequency off from the double of the 1st one. This out-of-tune makes weaker the 2nd harmonic component of the tones of the 1st mode (the lower pitch range). Therefore, the timbre of the tones is, so to speak, gloomy in contrast to that of the higher range tones. The lower pitch range is used for calm and slow melodies which are placed frequently between live and rhythmic melodies for Noh dance, and bring about a change in feeling from a brisk to a quiet one.

Alike to the pitch temperament, this timbre contrast between the two ranges is quite different from the feeling of western music in which an abrupt change in timbre at the boundary of the pitch ranges is unfavorable.

2.3 Structural Device to Generate Inharmonic Components and to Prolong The Decay Time of Harmonic Components—"Sawari" in String Instruments—

Some Japanese string instruments, for example, a Shamisen or a Biwa, have a mechanism which generates inharmonic components and prolongs the decay time of harmonic components. Such a mechanism as well as the tones generated by it are called "sawari" (In this paper, the name "Sawari" is only used for the sawari mechanism. Tones generated are denoted as "sawari tone"). The word "sawari" means contact or touch, and comes from the phenomenon that a vibrating string touches a part of an instrument, and this generates inharmonic components and prolongs the decay time of higher harmonic components. Sawari is found also in Indian instruments as a Vina. As shown in Fig. 4, the mechanism in a Shamisen is on the end of the neck. Among the three (low, middle and high) strings, the low string has no nut and the end of movable part is on a peg. When the open low string is in vibration, it touches the "ridge (Yama) of sawari." This occurs also in case when the middle or high string vibrates in those pitches which makes a perfect fifth or an octave interval with the open low string and this vibration of the higher strings causes the resonant vibration of the low one.

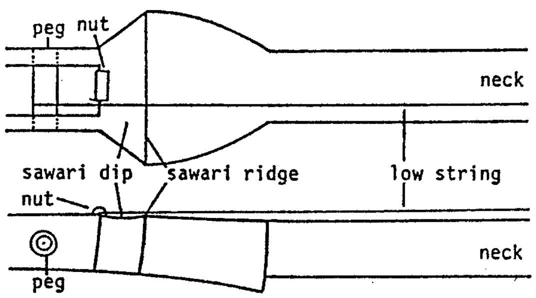

Fig. 4 Sawari mechanism of a Shamisen.

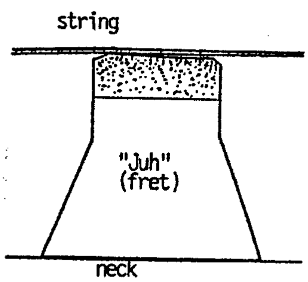

Fig. 5 Sawari mechanism of a Biwa.

In a Biwa, sawari is a slight upward curvature given to the surface of the frets as seen in Fig. 5. (Curvature in the figure is exaggerated to be noticed easily.) The right side of the fret surface which is apart from the string at rest, touches with the string when it vibrates.

The physical meaning of the touch of sawari is regarded as an exertion of periodic driving force on the string very near its end. The period of the force is equal to that of the fundamental component of string vibration immediately after the beginning of the vibration, but may be perturbated soon by the anisotropy of the terminal impedance of the string ends and the vibration of the body or the neck. This gives rise to inharmonic components.

Such a positive use of inharmonic components for material in Asian music is a feature which can not be found in western music. If we heard a sound like a sawari tone on a western string instrument, we would feel its body has a split.

Figure 6 shows decay rates of harmonics observed in two tones of the open low string of a shamisen.[3] One is played naturally (sawari is kept alive), and the other is produced under the condition that one of the string ends is fixed at the sawari ridge but not at the peg so that the sawari will not function. Prolongation of the decay time of higher harmonics can be noticed obviously.

The function of sawari can be regarded as energy transmission from the fundamental component of the string vibration to higher components as well as to inharmonic components. As a result, the timbre of tones generated becomes brilliant and complex.

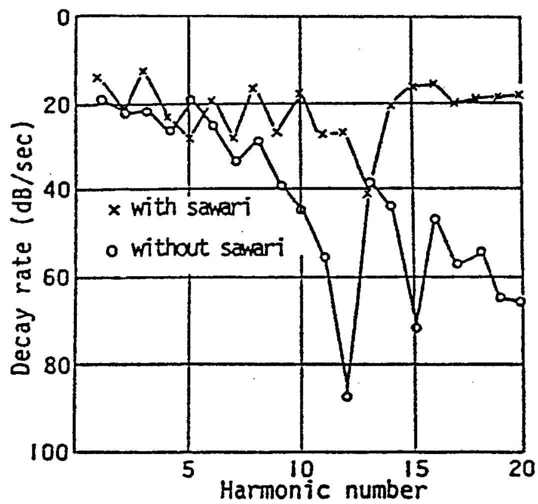

Fig. 6 Decay rates of harmonics of an open string tone of a Shamisen.

3. SOME ASPECTS OF TIMBRE TASTE COMMON TO THAT OF WESTERN MUSIC

3.1 Frequency Characteristics of Biwa Bodies Compared to That of Violin Ones

Yankovskii reported that transmission-radiation characteristics (1/3 oct. spectra of tap tones) of a body of a violin, whose timbre was appreciated as excellent and standard (classical mean), was arced shape of which the peak was loated at 1 to 2 kHz.[4] The similar relation between subjective appreciation of timbre and 1/3 oct. spectra of tap tones was found in biwas, whose pitch range is nearly the same as that of a violin. The similarity was found as a result of investigation of about 20 Chikuzen-Biwas.[5] Figure 7 shows some examples of the 1/3 oct. spectra obtained. As seen in the figure, the spectrum of a biwa of excellent timbre quality has its peak about from 1.2 to 2.5 kHz. While for low quality, the peak is located about at 800 Hz.

It is interesting if there is a common feature in spectrum envelope patterns between musical instruments which are used in each other's different musical culture.

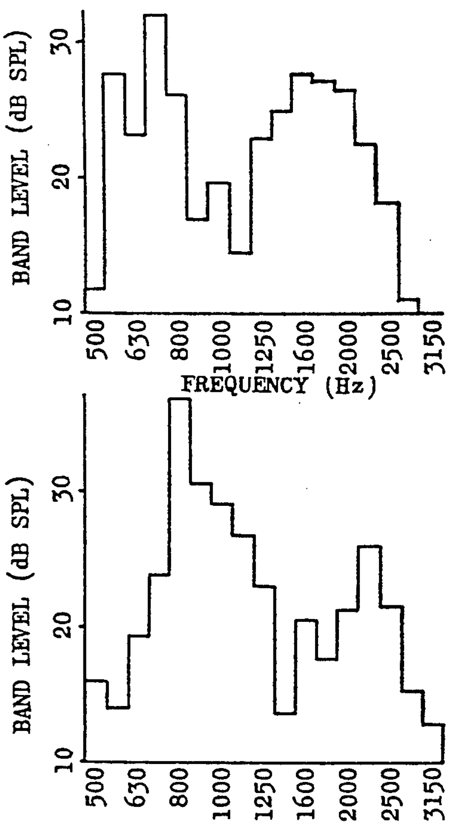

Fig. 7 1/3 oct. tap-tone spectra of a Biwa evaluated as high quality (top) and one done as low quality (bottom).

3.2 Desirable Spectrum Pattern for Classical Shakuhachi Music and Baroque Recorder Music

The author reported previously that dominance of low odd harmonics was a desirable feature of harmonic structure for playing Baroque recorder music.[6] This was found as a result of a psychological judgement test in which the desirable extent of odd-dominance of harmonic structure was determined. The paneller were 4 representative recorder players and tested tones were synthesized treble recorder tones. The result showed the most desirable extent was 10 dB on the average through low 6 harmonics (the 2nd to the 7th). After this study, a similar feature was found as for classical Shakuhachi music. Also, the desirable extent of odd-dominance was the same.[7]

However, structural device for getting the odd-dominance is quite different between the two instruments. As for a Baroque recorder, the device is "voicing" which is a slight cutting off of its windway outlet at an angle.[8] While for a Shakuhachi, that is resonance characteristics, which is determined by its bore diameter pattern and finger holes condition.[9] Figure 8 shows an example of the voicing effect on odd-dominance with the following parameter ($L_e^{(H} - L_0^{(H)}$).

$$L_e^{(H)} - L_0^{(H)} = (L_2^{(H)} + L_4^{(H)} L_6^{(H)})/3 - (L_3^{(H)} + L_5^{(H)} + L_7^{(H)})/3$$

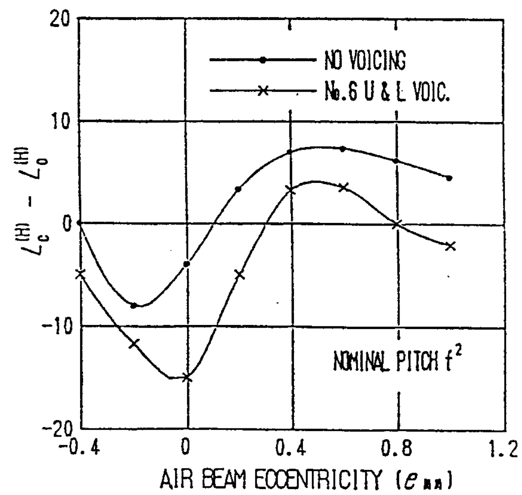

Fig. 8 Effect of voicing on odd-dominance of harmonic structure.

where $L_i^{(H)}$ is the relative level of the ith harmonic to that of the fundamental. The curves marked by circles and crosses indicate no voicing and with voicing cases, respectively. The horizontal axis indicates the eccentricity of windway direction against the edge. As seen in the figure, odd-dominance changes remarkably with the eccentricity of the windway. This relation between odd-dominance and air beam direction is a common phenomenon to all kinds of air-reed instrument. However the curve marked with crosses is located always under that done with circles. This indicates the effect of the voicing on odd-dominance obviously. On the other hand, in case of shakuhachis, ruling condition of odd-dominance is resonance characteristics, which is determined by its bore diameter pattern and finger holes condition.

Figure 9 is a comparison of resonance level at each harmonic frequency relative to that of the fundamental ($\bar{L}_e-\bar{L}_0$).

$$\bar{L}_e-\bar{L}_0=1/6\sum_{j=1}^{6}\{(L_{2j}+L_{4j}+L_{6j})/3 -(L_{3j}+L_{5j}+L_{7j})/3\}$$

where L_{ij} is relative resonance level at the ith harmonic frequency of the jth fingering. (The elemental fingerings of a Shakuhachi is six.) No. 7 Shakuhachi has timbre desirable for classical music and its resonance characteristics shows odd-dominance. ($\bar{L}_e-\bar{L}_0$ is small). While No. 9's timbre is desirable for contemporary light music, and not odd-dominant. As observed in the figure, $\bar{L}_e-\bar{L}_0$ of a Baroque treble recorder is nearer to that of No. 9 shakuhachi than that of No. 7.

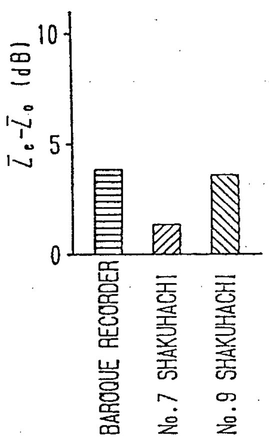

Fig. 9 Comparison of odd-dominance of resonance characteristics between a Baroque recorder and 2 Shakuhachis.

4. CONCLUSION

In this report, the author described several structural features which are regarded to be devised to fit the characteristics of traditional Japanese music. Also some aspects of timbre taste in traditional Japanese music which are common to that of western music are mentioned.

Music is an direct expression of a culture in which it has been born and matured in. Therefore, it reflects the history, social conditions, sense of beauty and of value of the cultural region. At the present time, the progress of information technology and globalization of the economy are making the mutual understanding with our cultural regions more and more important. The core of the mutual understanding may be to know and feel actually what is evaluated as precious by people in the other culture and what move their minds.

The author hopes that cooperation among researchers of musical acoustics and musicology with musicians will enrich and deepen that mutual understanding.

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