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Design, construction, and material of an ancient Indian string instrument

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Abstract

Ekatantrī vīṇā is a one-stringed fretless tubular zither from ancient India whose descriptions and representations are variously found in musicological texts and sculptures, respectively, between 11th and 15th century AD. The present work is a first of its kind attempt to study one of these sources to understand the precise structural and material nature of the *vīṇā*. In particular, we use a Sanskrit text where *ekatantrī vīṇā* is unambiguously described, and prepare accurate computed aided models of various parts of the *vīṇā* as well as describe their assembly. Our work is motivated, on one hand, from an aim to establish historicity of certain unique design features of the present day Indian stringed instruments and, on the other hand, to initiate a systematic study towards reconstruction of ancient Indian instruments. Our investigations also provide grounds for further study in acoustics, mechanics, and materials, all in the context of ancient Indian science.

Keywords: Ancient Indian zithers, Reconstruction, *Ekatantrī vīṇā*

1 INTRODUCTION

Ekatantrī[1] *vīṇā*[2] is an ancient Indian, one-stringed, fretless, tubular zither with a rounded gourd resonator attached to one end of a long hollowed wooden tube. At the other end, a large wooden peg is inserted which, in turn, supports a bulky, doubly curved, bridge engraved with a thin metallic plate. The playing string, made of animal gut, clamped towards the gourd side of the tube, and wrapped around the wooden peg at the other, vibrates while facing a unilateral constraint in the motion due to the finitely curved bridge. A bamboo thread is suitably inserted between the metal plate and the string such that the latter makes a grazing contact over the former. The *vīṇā* is played being held in a slanting position while placing the gourd over the left shoulder and tactfully positioning the bridge on the right heel. The string is plucked with fingers of the right hand, close to the bridge, whereas the variations in pitch are obtained by sliding a little wooden rod, held in the left hand, along the string. The above description, summarized from the early 13th c. text *Saṅgīta-ratnākara* (hereafter SR) [1], is qualitatively consistent with the *vīṇā* in the hands of the 12th c. *Sarasvatī* (Figure 1) where, even with a broken tube (in the central region), all the essential structural features, and the mannerism of playing, are unambiguously discernible. The simple structure of the instrument notwithstanding, it is an extremely difficult instrument to play requiring advanced techniques to produce a rich array of notes all from a single string.

Our aim is to prepare precise structural drawings, and study the material nature, of the *vīṇā* parts, leading to their assembly and a complete computer aided digital reconstruction of *ekatantrī vīṇā*. Our work, which uses SR as the primary source text, provides all the technical details for an actual reconstruction of the instrument (see also [2]); it can be, in fact, immediately used for 3D printing of a visual replica of the *vīṇā*. Our findings can be also used to establish the historicity of various design features in the present-day Indian stringed instruments; e.g. the doubly curved bridge in *tānpurā*, *sitār*, *rudra vīṇā*, etc., the thread between the string and the bridge in *tānpurā*, the metallic plate in *Sarasvatī vīṇā*, among several others. Besides formal reconstruction and historical benchmarking, there can be several other implications of our work. Our discussions, for instance, provide information on the workmanship, material culture, and musical traditions followed in 13th c. India and, at the same time, are potent in initiating a further study in acoustics, mechanics, design, and materials, all in the context of ancient Indian science and craftsmanship.

[1]The italicized words in this article are in Sanskrit. They are written using the International Alphabet of Sanskrit Transliteration (IAST) scheme.
[2]The word *vīṇā* has been used in ancient Indian parlance for all kind of string instruments.

Figure 1. *Sarasvatī* holding *ekatantrī vīṇā* from Gorakhpur, Uttar Pradesh, 12th c.; presently at Lucknow State Museum.

The earliest Indian *vīṇā* were of the bow-shaped harp-type with a hollow belly covered with stretched leather and furthered by a curved, and hollowed, wooden arm [3]. The strings, stretched from arm to the belly, could vary in number; e.g. both *citrā* and *parivādinī vīṇā* had seven strings but *vipañchī* had nine. The strings were plucked either with fingers (*citrā*) or with a plectrum (*vipañchī*). These harp-like *vīṇā* find widespread mention in the earliest Indian literature from Vedic, Epic, Buddhist, and Jain periods [3, 4, 5]; both *citrā* and *vipañchī* are also mentioned as important *vīṇā* in the *Nāṭyaśāstra*. They appear in the reliefs at *Sāncī*, *Bhāja*, *Bharhut* (all around 2nd c. BCE), *Amrāvatī* (1st c.), *Nāgārjunakonda* (2nd-4th c.), and in the famous Samudragupta coins (4th c.). Certain lute-like *vīṇā* also appear at *Amrāvatī*, *Nāgārjunakonda*, *Pawāyā* (Gupta period), and *Ajantā* (4th-6th c.), although there is no clear description of such instruments in the ancient literature [3, 4, 5]. Another widely mentioned *vīṇā* is a 21 stringed, dulcimer-like, board zither *mattakokilā* (the main *vīṇā* of *Nāṭyaśāstra*), with a structure similar to the modern day *svaramaṇḍala*.

The earliest tubular zithers with gourd resonators are noticed at *Ajantā* and *Bādāmī* (7th c.) [4]. They gradually acquire a dominant presence both in plastic art and literature, including several extant musicological texts. Almost until the turn of the millennium, the tubular zithers were fretless, had a cut or covered resonator (mostly made out of bottle gourd), were both with and without the thread (inserted between the bridge and the string), and sometimes had a broad curved bridge [4]. Noticeable among the early tubular zithers was a simple, single stringed, instrument with a cut gourd on one end to be pressed against the chest while playing (yielding the human body as the resonator); such a design survives today in *tuila* [5]. The evolution of fretless tubular zithers culminated in the development of *ekatantrī vīṇā*, which was not only larger (in appearance) than its predecessors, but also had well developed parts, most of which survive in several Indian string instruments. The importance of *ekatantrī vīṇā*, and its role in the development of subsequent instrument forms, cannot simply be overstated (SR 6.53-54).[3]

2 THE STRUCTURE OF THE *VĪṆĀ*

2.1 Metrology

The musicological text of our interest use three classical length scales for various measurements: *aṅgula*, *vitasti*, and *hasta*. One *aṅgula* is usually understood as the breadth of the middlemost joint of the middle finger of a medium-sized man or equal to the thickness of six husk-less barley grains put together width-wise one after another; moreover, twelve *aṅgula* make a *vitasti*, and twenty-four make a *hasta* [6]. One *aṅgula* is approximately equal to three-quarter of an inch or 1.905 cm [6]. We take it to be 2 cm. Consequently, *vitasti* becomes 24 cm and *hasta* becomes 48 cm. Our design can be easily rescaled for any change in measurements for an *aṅgula*.

2.2 Parts of the *vīṇā*

(a) **Tubular fingerboard**. The fingerboard of the *ekatantrī* is made out of a single piece of wood through which air columns, of various arrangements, are bored in the longitudinal direction; see Figure 2. The wood should be from *khadira* (Acacia Catechu) tree, straight, free from knots and bends, smooth, polished, well rounded, and well-seasoned (SR 6.29). The length and the circumference of the tube should be 144 cm and 24 cm, respectively (SR 6.29-30). The longitudinal air column can be either (i) a single cylindrical cavity (diameter 3 cm), (ii) two cylindrical cavities chambers, meeting to form a single hole (diameter 3 cm) at the bottom but two holes each of diameter 1.8 cm at the upper end, or (iii) three chambers meeting to form a single hole (diameter 3 cm) at the bottom but three holes each of diameter 1.5 cm at the upper end (SR 6.31-32), see Figure 2. The entire fingerboard therefore serves as a resonator. The bottom hole is jammed by inserting a wooden peg, over which a bulky bridge is placed.

(b) **Wooden peg**. The peg, made of strong wood, when inserted into the fingerboard, provides it both structural stability and strength. Most importantly, it acts as a sound post transmitting the string vibrations via the bridge, which it carries on itself, to the tubular fingerboard. The peg is a 16 cm long cylinder and has a circumference of 6 cm in one half and 3 cm in the other (SR 6.37); see Figure 3. The latter half is completely inserted inside the fingerboard while the former is elevated like a tortoise back to prevent the bridge from falling down (SR 6.38).

(c) **Bridge**. The bridge of the *ekatantrī* is carved out of a rectangular block of *khadira* wood (SR 6.32). The

[3] The number refers to the verse in our primary source text.

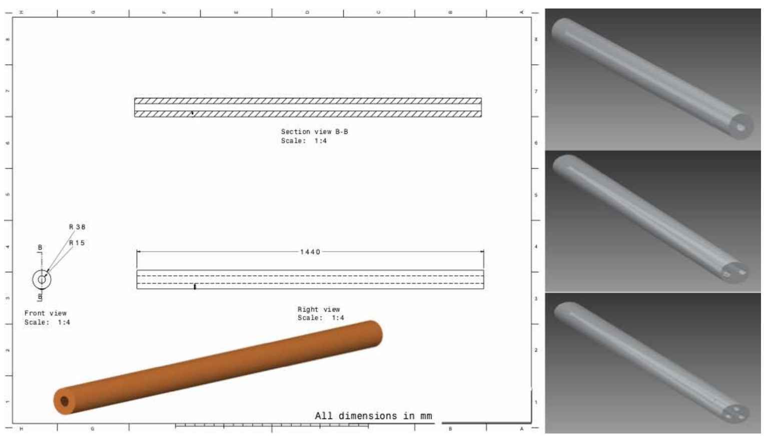

Figure 2. The tubular fingerboard with three possible arrangements for the longitudinal bore.

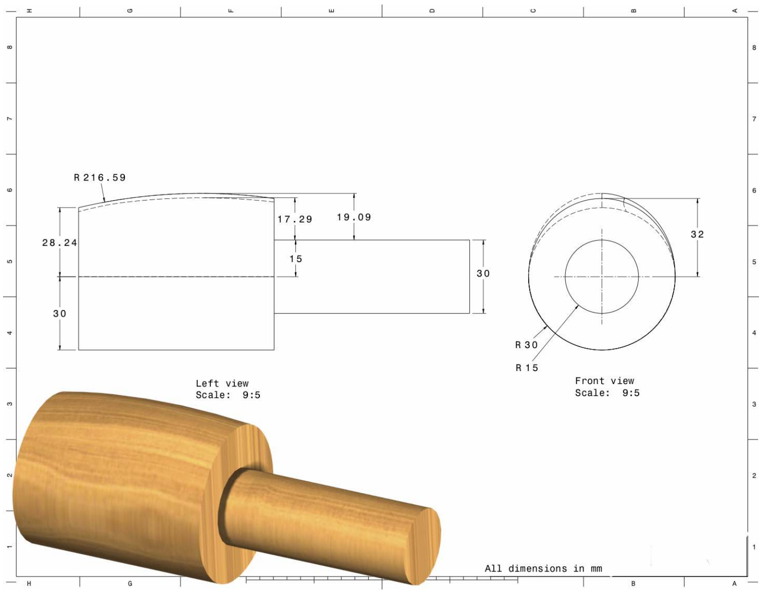

Figure 3. The wooden peg, the narrow part of which is to be inserted into the tubular fingerboard.

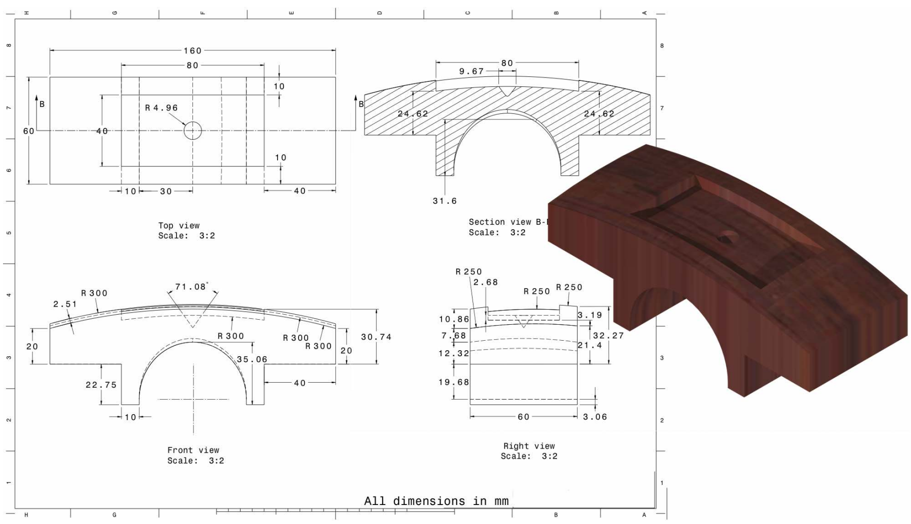

Figure 4. The bridge with a groove for placing the metal plate.

two footed bridge has an intricate shape which ensures that it sits stably on the peg (without being glued) and supports a rectangular convex plate of metal on top (SR 6.37-38). With a curvature like a tortoise back, it has a length of 16 cm, width of 6 cm, and has sides around 2 cm high (SR 6.33); a detailed dimensioning can be seen in Figure 4. A rectangular groove and a conical pit are provided at the elevated high portion of the bridge to support the metal plate (SR 6.34), see Figure 4.

(d) **Convex plate**. A convex plate, made of brass (SR 6.35) is fitted seamlessly within the groove provided on top of the bridge; the plate should be 4 cm wide and 8 cm long (SR 6.35-36). The seamless placement of the plate is clearly visible in the bridge assembly in Figure 5. The overall curved bridge is a standard feature

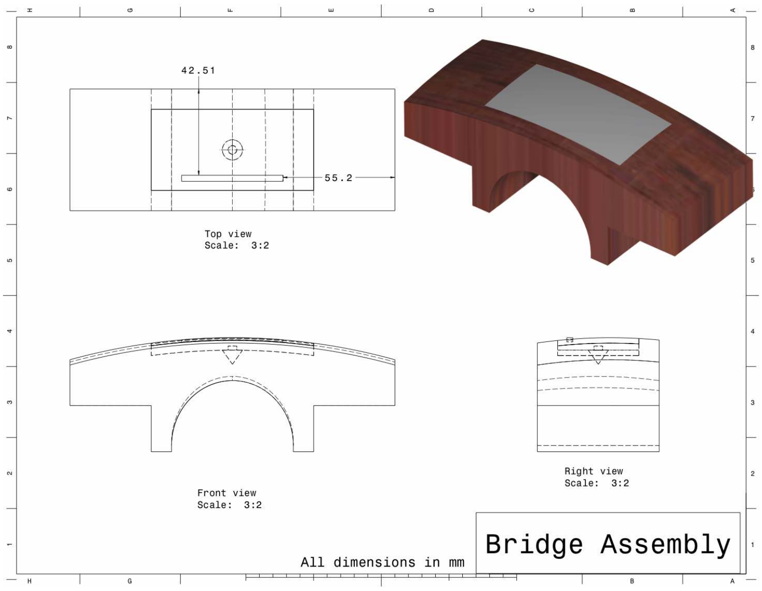

Figure 5. The metal plate (in grey colour) attached to the bridge using a spike.

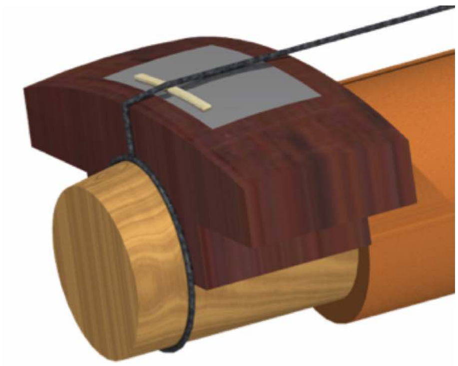

Figure 6. Partial assembly of *vīṇā* parts. The bridge is placed over the peg which is inserted into the fingerboard. The bamboo skin (in light brown) is placed below the string (in black) to maintain a grazing contact of the latter over the metal plate

in many modern Indian string instruments (*tānpurā*, *sitār*, *rudra vīṇā*, *Sarasvatī vīṇā*, etc.), where it is used to produce an overtone rich sound with sustained transfer of energy to higher modes of vibration [7, 8]. The metallic plate is however retained only in *Sarasvatī vīṇā*.

(e) **Wooden Spike**. A wooden spike is used to fix the convex metal plate onto the bridge (SR 6.35). On one side it fits into the conical pit located at the centre of the rectangular groove on the bridge and, on the other side, it has a cylindrical protrusion which holds the plate in the required position. The spike can be noticed, upon close observation, in Figure 5.

(f) **Bamboo skin**. A bamboo skin, 4 cm long and 0.3 cm wide (SR 6.49), is placed on the metal plate below the playing string at the point where they come in contact with each other (SR 6.50), see Figure 6. The purpose of the skin is to raise the string just enough to maintain a grazing contact with the plate (SR 6.50). The skin is supposed to enhance the quality of sound and deliver an overtone rich buzzing sound (SR 6.50) [9]. Presently

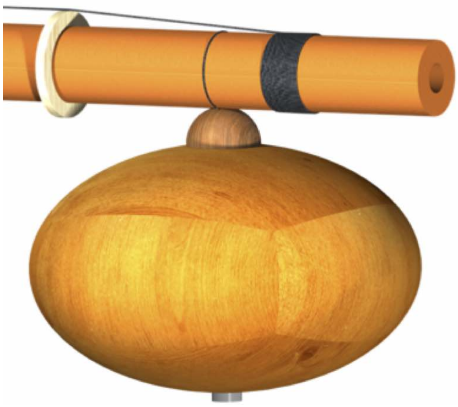

Figure 7. Partial assembly of the *vīṇā* from the resonator side. The top plate, in the form of a coconut shell (brown colour), is visible between the resonator and the fingerboard. The nut (light brown coloured ring) is a mobile sleeve which acts as one end of the vibrating string.

it is found most commonly in *tānpurā*, where it is otherwise made out of a cotton thread.

(g) **Resonator**. The resonator of *ekatantrī* is made out of a bottle gourd and is covered partially with a coconut shell cap (SR 6.42-44). The gourd should be matured, thoroughly ripe, dried, cleaned, and uniform in its circular shape (SR 6.42). It should have a circumference of 120 cm and height of around 24 cm (SR 6.42). On the naval side, a hole of 6 cm diameter is carved (SR 6.43). This hole is to be covered with a coconut shell before being fixed to the fingerboard. At the stem side, a small hole is to be provided to attach a bolt-like device. The basic design is illustrated in Figure 7.

(h) **Top plate**. A hemispherical cap, made out of a clean and polished coconut shell, is used to cover the 6 cm diameter hole on the resonator (SR 6.44). A small hole is to be drilled on top of the shell for fixing it to the fingerboard. The cap can be seen in Figure 7.

(i) **Cotton chord**. A strong triple stranded cotton thread is used to tie the resonator to the fingerboard (SR 6.39-41). The two ends of the cord are first threaded into the eye-like fingerboard holes (which form two ends of an arc like bore in the fingerboard, SR 6.39) to form a tight loop and thereafter inserted into the aligned holes of the gourd and coconut shell before being tied to a bolt-like wooden device at the other end of the resonator. The bolt is to be twisted till the gourd is firmly attached to the fingerboard (SR 6.45-46). This arrangement can be visualized in Figure 8.

(j) **Nut**. Nut is a mobile sleeve made of three-ply braided bamboo skin which is used to change the length of the vibrating string thereby affecting its pitch (SR 6.51). The thickness of the sleeve should be such that the string remains at the same height between the bridge and the nut, see Figures 7.

(l) **Playing string**. The playing string, made of strong, smooth, and solid animal gut, is tied on one end to a loop of a cotton thread, with a hanging noose for bringing minor variations in the string tension (SR 6.47-48). The other end is stretched over the bridge, pressing the bamboo skin and grazing the metal plate, before being firmly tied to the peg, see Figures 8 and 9.

(m) **Plectrum**. A small bamboo chip is used to press upon the playing string from the resonator side while plucking it with the right hand closer to the bridge (SR 6.58).

2.3. The assembled *vīṇā*

To summarize the above, we start by inserting a large wooden peg on one side of the hollowed wooden tube and then placing the bridge and the metal plate assembly over the peg. The metal plate should be firmly placed in the groove on top of the bridge and they together should be stable over the peg. At the other end, a gourd resonator is attached to the tube with the help of a coconut shell cap and a bolt-like arrangement. A stretched

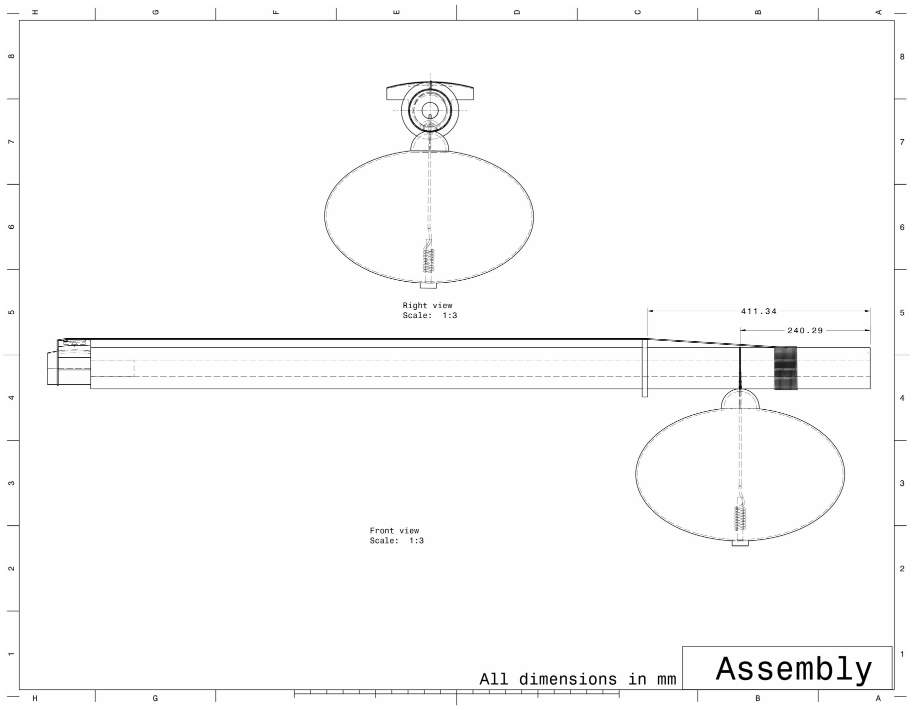

Figure 8. Design of the complete *ekatantrī vīṇā*.

Figure 9. The digital reconstruction of *ekatantrī vīṇā*.

playing string is then finally attached over the fingerboard in a way as pointed above. The final assembly is shown in Figures 8 and 9.

3 CONCLUSIONS

The purpose of this work has been to present a computer-aided reconstruction of an ancient Indian string instrument based on a 13th c. Sanskrit text. Detailed drawings were presented, the material used discussed, and complete assembly of various parts were given. It should be emphasized that this is first of its kind of study in the context of Indian musical instruments. This can possibly lead to a more systematic study of acoustics, mechanics, and materials in the context of ancient Indian science. It also provides a way towards actual reconstruction of ancient Indian musical instruments.

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