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On some Indian stringed instruments

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(Plate I)

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1. Introduction

A fascinating field for research offers itself in the scientific study of the numerous kinds of musical instruments to be found in India. Some of these instruments of indigenous origin are of undoubted antiquity and disclose a remarkable appreciation of acoustic principles. An investigation of their special features in comparison with those of instruments of other countries may be expected to yield results of great interest. An instance of the fruitfulness of the line of work here suggested is to be found in the present author's research on the Indian Musical Drums, which have been found to embody in a practical form the solution of the problem of loading a circular drumhead in such a manner as to make it give a harmonic succession of overtones in the same way as a stringed instrument.* In the present paper it is proposed to offer a preliminary note on the results of the author's study of some Indian stringed instruments.

*See *Nature* (*London*) 8 February 1920. A fuller account of the work on these musical drums is shortly to be published as a Bulletin of this Association.

2. The form of the bridge in the "Tanpura" and the "Veena"

The "Tanpura" and the "Veena" are two of the most highly valued indigenous stringed instruments intended to be excited by plucking. Plate I, figure 1 illustrates the form of the "Tanpura". This instrument has no frets and is intended

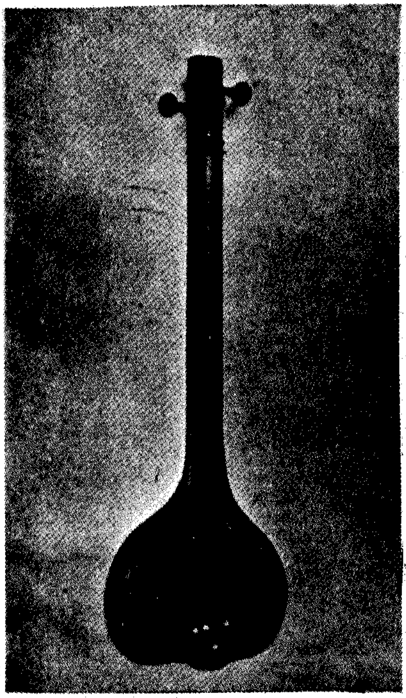

Figure 1. Tanpura.

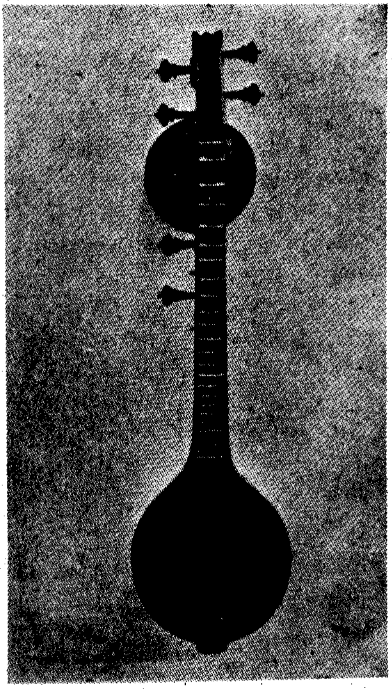

Figure 2. Veena.

Plate I

merely to be used as a drone in accompaniment with vocal or other music. It has four metal "strings" which are stretched over a large resonant body and can be accurately tuned up to the right pitch by a simple device for continuous adjustment of tension. The remarkable feature of the "Tanpura" to which I wish to draw attention is the special form of bridge fixed to the resonant body over which the strings pass. The strings do not come clear off the edge of a sharp bridge as in European stringed instruments, but pass over a curved wooden surface fixed to the body which forms the bridge. The exact length of the string which actually touches the upper surface of the bridge is adjusted by slipping in a woollen or silken thread of suitable thickness between each string and the bridge below it and adjusting its position by trial. Generally the thread is moved forwards or

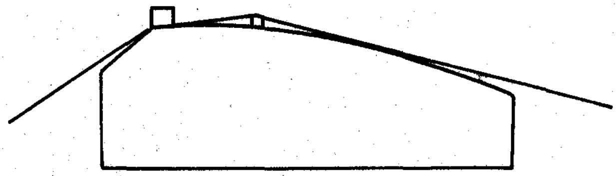

Figure 3. The bridge of the Tanpura.

backwards to such a position that the metal "string" just grazes the surface of the bridge. The description will be clearer on a reference to figure 3 above where the bridge and the string passing over it are indicated diagrammatically.

The "Veena" on the other hand is a fretted instrument intended for use in playing melodies (figure 2 in plate I). The form of the bridge adopted in it differs from that of the "Tanpura" in two respects. The upper curved surface of the bridge in the "Veena" is of metal, and the special mode of adjustment of contact by means of a thread used in the "Tanpura" is dispensed with, and the string merely comes off the curved upper surface of the bridge at a tangent, as indicated diagrammatically in figure 4. (No attempt is made in this figure to indicate the exact form of the lower part of the bridge).

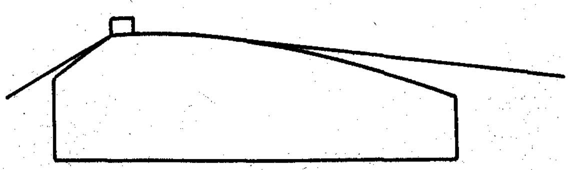

Figure 4. The bridge of the Veena.

The bridge of the "Veena" is also much higher above the body of the instrument than in the "Tanpura". Even when the strings are pressed down on the frets when the instrument is being played, the curvature of the upper surface of the bridge ensures the string always leaving the bridge at a tangent to it as shown.

3. The failure of the Young–Helmholtz law

The special form of bridge illustrated above has a very remarkable influence on the tone-quality. This can be most readily demonstrated in the "Tanpura". When the adjustment of contact of string and bridge is made carefully by trial, the instrument is highly sonorous, giving a tone of fine musical quality. If on the other hand the grazing contact of string and bridge is rendered inoperative (as for instance by inserting a small piece of metal between the string and the surface of the bridge) the tone becomes dull and insipid. A similar remark applies also to the case of the "Veena," though the difference is less striking in the latter case.

In attempting to find an explanation for the difference in tone-quality produced by the special form of bridge, the author made a surprising observation, namely, that in the tone of the "Tanpura" or the "Veena," overtones may be heard powerfully which according to known acoustical principles should have been entirely absent. According to the law enunciated by Young and Helmholtz, if the string is plucked at a point of aliquot division, the harmonics having a node at the point of excitation should be entirely absent. This law may be readily verified on an ordinary sonometer with the usual form of bridge. For this purpose, the position of the node should first be found exactly by trial by putting the finger in contact with the string and plucking elsewhere so as to elicit the overtones desired. Having found the position of the node, the string should be plucked exactly at that point and then again touched with the finger *at the same point.* On an ordinary sonometer, this results in the sound being immediately quenched inasmuch as the finger damps out all the partials except those having a node at the point touched, and the latter are not excited in the first instance in accordance with the Young–Helmholtz law. On trying the same experiment with the "Veena" or the "Tanpura", it will be found that the overtone having a node at the plucked point sings out powerfully. In fact the position of the plucked point hardly appears to make a difference in regard to the intensity of the overtones in the "Tanpura". This remarkable result is not due to any indefiniteness in the position of the node point, as the latter is found to be quite well defined as is shown by the fact that in order to demonstrate the effect successfully, the string must be plucked and then touched exactly at that right point, otherwise the sound is quenched. We are thus forced to the conclusion that the effect of the special form of bridge is completely to set aside the validity of the Young–Helmholtz law and actually to manufacture a powerful sequence of overtones including those which ought not to have been elicited according to that law.

4. Outline of a mechanical theory

Some photographs of the vibration-curves of a "Tanpura" string were made at the suggestion of the author by Mr Ahmed Shah Bukhari at the Government College, Lahore, last November. They showed that in consequence of the grazing contact at the bridge, the vibration of the string decreased in amplitude and altered its form at a much more rapid rate than when the grazing contact was rendered ineffective. A more complete investigation is obviously desirable. From first principles, however, it is obvious that in the 'Tanpura' the forces exerted by the vibrating string on the bridge must be very different from what they would be for a bridge of ordinary form. It seems probable that by far the greater portion of the communication of energy to the bridge occurs at or near the point of grazing contact. The forces exerted by the string on the bridge near this point are probably in the nature of impulses occurring once in each vibration of the string. This would explain the powerful retinue of overtones including even those absent initially in the vibration of the string. At a slightly later stage, the reaction of the bridge on the string would result in a modification of the vibration form of the latter and bring into existence partials absent initially in it. There would in fact be a continual transformation of the energy of vibration of the fundamental vibration into the overtones.

The foregoing explanation of the character of the tones of the "Tanpura" would not be fully applicable to the "Veena" as the forces exerted by the string on the bridge in this case would not be purely of an impulsive character. There is however a certain portion of the bridge over which the string comes into intermittent contact during the vibration, and it seems very probable that the theory for this case is intermediate in character between that for the 'Tanpura' and those for stringed instruments with bridges of the ordinary type. Further experimental work is needed in support of this view.

5. Summary

The present paper deals with the remarkable acoustic properties of the "Tanpura" and the "Veena" which are two of the most highly reputed among Indian stringed instruments. The form of the bridge used in these instruments is quite different from that usually found in European stringed instruments. In the 'Tanpura' the string passes over the wooden upper surface of the bridge which is curved to shape, and by insertion of a thread of wool or silk, a finely adjustable grazing contact of string and bridge is secured. In the 'Veena' the upper surface of the bridge is of curved metal and the string leaves it at a tangent. The tones of these instruments show a remarkable, powerful series of overtones which gives them a bright and pleasing quality. Experiment with these instruments shows that the validity of the Young–Helmholtz law according to which partials having a node at the plucked point should not be excited is completely set aside. A possible mechanical explanation of this result is suggested.