EXPERIMENT WITH A XYLOPHONE KEY

by

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The Xylophone, found in many tribes in South, Central, East and West Africa, is often a very rustic-looking instrument quite belying the craftsmanship which underlies its musical qualities. It consists essentially of a series of hardwood slats slung over a set of resonators, the whole being mounted in a wooden frame. Xylophones are also widespread on the other side of the Indian Ocean — in Cambodia and Thialand, Burma, Java and Bali, where they are often beautifully and elaborately made. In both cases, however, the actual tuning of the slats to produce the required notes is effected in the same way and falls into two distinct phases — rough tuning and fine tuning.

Rough tuning, as the name implies, aims merely at getting the pitch of the xylophone keys round the right note. This could be achieved just by selecting pieces of wood of varying length and thickness but if this were done, the low keys would be unduly long for convenience in performance. In actual practice, while the low keys are certainly longer and thinner than the higher ones, the major lowering of pitch is achieved by hollowing out the central section of their under side: the more you hollow out, the lower the pitch will be. Thus we have the first principle of tuning — to flatten the pitch, hollow out the centre. To sharpen the keys, one could of course shorten their length by chipping at the ends: but this would give an untidy finish to the instrument and is not done. The usual practice both in Africa and in Indonesia, for sharpening the pitch, is to shave off the under-side of the keys near their ends. In Africa, some tribes use a different method — they shave the *sides* of the keys near their ends so that the keys become more or less pointed.

Fine-tuning demands a very critical ear; it is done primarily as a stage in manufacture but also — in Indonesia — at the time of performance. It can take two forms. The first process — and this is the usual method in Africa — is to continue with the methods given above, scraping off the wood here and there with great care, either slightly flattening or slightly sharpening the keys and frequently testing them in relation to each other: Wachsmann has described this process in detail.[1] In Africa generally this is, we believe, the only fine-tuning which is done. In Indonesia however, after this stage is completed, additional accuracy of pitch is obtained by sticking beneath the keys, near their ends, little blobs of beeswax or a mixture of beeswax and a metallic substance, possibly galena. The latter being much heavier than pure beeswax will give a greater pitch variation in proportion to the size of the blob. Although this method of time-tuning is characteristic of Indonesia, we propose to include it in our experiments for it is an important aspect of what can be done to modify the pitch of a xylophone key.

This general process of tuning is well known to ethnomusicologists, but as far as we know, with the single exception quoted, no one has attempted to find out exactly what effects on pitch these processes can have. What difference do they make and how much is it? This essay describes a series of experiments which were carried out to find the answers to these questions.

Obviously an already existing xylophone is not suitable to experiment on, for in the first place its keys have already been hollowed and shaved when they were tuned, and in the second place one cannot further shave them without ruining the instrument. The first step, therefore, was to prepare a xylophone key of our own making on which to experiment.

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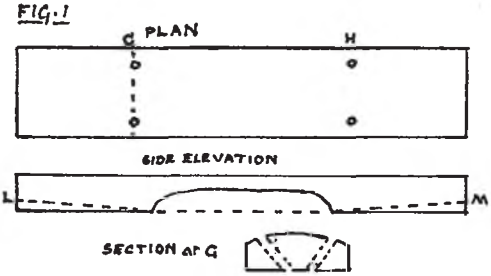
[1] K. P. Wachsmann: 'A Study of Norms in the Tribal Music of Uganda', *Ethnomusicology Newsletter* No. 11, Sept. 1957.

I have in my room a Cambodian xylophone whose keys are very regular in shape, of a hard red wood such as one meets with often in African instruments, and of a very usual size. I chose the sixth key from the bottom of my model. I also had a piece of hard red wood brought home from Africa, from which to make my key.

First of all I cut and shaped my key to the dimensions of the Cambodian key, except that I did not at this stage hollow it out underneath. It was a rectangle about 16½ inches long, 2″ wide and $\frac{11}{16}$ of an inch thick, but with the top curved over to the edges as shown in Fig. 1, 'Section at 9'. I drilled two holes to take the thong on which it is slung placing them at the points indicated at G and H and in the direction shown in the 'Section at G', again copying my model. It weighed 10 ounces. Then I hollowed it out to the dimensions of the hollowing on the Cambodian key (see the dotted line from J to K): it now weighed just under 9 ounces. So the hollowing removed approximately 1 ounce of wood. I could not weigh the Cambodian key for camparison because it was threaded with its other keys on two long cords. Noting, however, that the keys were obviously similar in cubic capacity, I weighed the whole string of keys and took the average: it turned out to be 8.9oz. per key. This gave me a fair assurance that the key was approximately the same weight as the Cambodian one. The dark outline in Fig. 1 shows the appearance of the key at this stage.

FIG: 1



The first experiment is to determine the effect on pitch of rough tuning, that is, the effect of hollowing the centre and of shaving the underside of the ends. After having made the key and before hollowing it as described above, I struck it and found its pitch on a Stroboconn. It sounded 311.5 vibrations per second. After hollowing, I again took the pitch, and now it had dropped to only 207.75 v.p.s. The difference between these two readings is 701 cents. So the effect of hollowing was to lower the pitch by almost exactly a fifth — which is a considerable drop, and gives some indication of the big latitude in tuning which is available to the craftsman.

I now shaved off the under side of each end as shown by the dotted lines at L and M (Fig. 1), taking off the same amount of wood as had been removed on the Cambodian key. This of course had the effect of sharpening the key: its pitch rose from the previous 207.75 v.p.s. to 212 v.p.s. So the shaving sharpened the pitch by 34 cents — which is about a third of a semitone. The amount of shaving had been slight — only $^3/_{32}$ inch at the extreme ends, so we can see how responsive the pitch of the key is to this process: it is clearly a very efficient way of sharpening the pitch. My experimental key was now in its shape and dimensions the same as the Cambodian model. But it was lower in pitch: while my key sounded 212 v.p.s. the pitch of the Cambodian one was 275 v.p.s. This has no importance for the experiments being carried out, and could be accounted for in two ways. I might have slightly overdone the hollowing and underdone the shaving, though as I aimed at accuracy I do not think my errors would have amounted to as much as 450 cents (2¼ tones in Equal Temperament). It is more likely that the wood I used was not quite so rigid in texture as that of the other key. However this may be, my key had now arrived at the end of the rough tuning stage and its pitch of 212 v.p.s. is the standard against which we measure the effects of fine-tuning now to be described.

The Horniman Museum in London has recently acquired from the owner and player a Siamese xylophone which still has nearly all the little blobs of fine-tuning wax attached to the under side of some of the keys about an inch and a half from their ends. This, while feeling like beeswax, is clearly not pure as it is too hard and has a grey metallic lustre. What it is mixed with we cannot say and as I did not wish to tamper with the blobs, I decided merely to estimate the weight of the blobs and to select two arbitrary weights for the purpose of experiment. This seemed reasonable as the blobs in any case were not of the same size and therefore not of the same weight. Accordingly I made two pairs of weights by embedding thin discs of lead in beeswax: one pair weighed 4 oz. each and the other pair ½ oz. each. I also decided to select two positions on the key at which to fix these blobs: the first position was to fix the centre of the blob 12 inches from the end of the key — which is about the average position for them. The second position was designed to produce the maximum flattening effect of the blobs and accordingly they were placed right at the ends of the key.

I also wanted to know what would happen to the pitch if one stuck only one blob on the key: would the key give out a single note at all, seeing that the two ends would now have different weights? I also wanted to know what difference from this latter pitch would be produced by using two blobs — one for each end of the key. Keys with either one blob or with two can be found in Indonesian instruments.

Starting with the heavier weights (½ oz. each), placed 1½ inches from the key-ends, I found that if two weights are used the pitch of the key is flattened by 94 cents (nearly a semitone in Equal Temperament): if only one weight is used, a clear single note does indeed emerge, but this note, compared with the standard 212 v.p.s., is only 48 cents flat. The inference is that one may, without spoiling the sound, use either a single blob at one end or a blob at both ends, the use of two blobs having amlost exactly double the flattening effect of a single one. This, though it seems obvious in terms of weight alone, is — when one thinks of the unequal balance produced by using only one blob — quite surprising.

We now repeat this experiment using this time the lighter weights, each of them being ¼ oz., and placing them as before, 1½ inches in from the ends of the key. The effect on the pitch of the key is similar but not so great. If two weights are used, the key is flattened by 57 cents: if we use only a single weight, it is flattened by 30 cents. Once again, the flattening effect of just one weight is almost precisely half that produced by using two weights.

The next experiment is aimed at determining the *maximum* flattening which can be produced by these various weights. This effect will arise if the weights are placed under the key as near to its extreme ends as possible. With the ½ oz. blobs, placing both of them at the ends flattened the key by 195 cents: this is nearly a whole tone in Equal Temperament and is just about twice the flattening we found when the weights were placed 1½ inches in from the ends. If only one ½ oz. blob is placed at one key-end, the key is flattened by 98 cents, that is, half the effect of using two blobs. Using the ¼ oz. blobs, if both are placed at the key-ends the key is flattened by 117 cents, while if only one blob is used, the flattening is 60 cents. It is worth mentioning that in none of these tests does the use of the weight make any perceptible difference to the quality of the note produced: the blobs merely flatten the pitch, the maximum effect of a drop of 195 cents being found when two ½ oz. blobs are placed at the ends of the key.

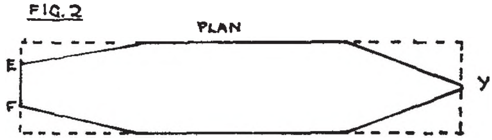
Let us rearrange the results of these experiments so as to show the progressive flattening effect of the various operations. In the Table below, we give both the interval drop in cents and also the pitch in vibrations per second at each stage.

	Weights		No. of wts.		V.p.s.	Cent Code no.	Interval in Cents
	½ oz.	¼ oz.	1	2			
Before hollowing	—	—	—	—	311·5	1048	
							701 cents flat
After ,,	—	—	—	—	207·75	347	
							34 cents sharp
Shaved ends	—	—	—	—	212	381	
No weight (see previous entry)			—	—	212	381	
							30 cents flat
1 wt. 1½″ from end	—	¼	1	—	208·25	351	
							18 ,, ,,
1 wt. ,, ,, ,,	½	—	1	—	206	333	
							9 ,, ,,
2 wts. ,, ,, ,,	—	¼	—	2	205	324	
							3 ,, ,,
1 wt. at end	—	¼	1	—	204·6	321	
							34 ,, ,,
2 wts. 1½″ from end	½	—	—	2	200·75	287	
							4 ,, ,,
1 wt. at end	½	—	1	—	200·25	283	
							19 ,, ,,
2 wts. at end	—	¼	—	2	198	264	
							78 ,, ,,
2 wts. at end	½	—	—	2	189·3	186	

Maximum flattening by weights 381-186-195 cents.

There remain two more experiments concerned with the method of tuning often to be found in Africa whereby the *sides* of the keys near their ends are tapered off to a lesser or greater extent. As this reduces the weight of wood near the ends the effect will be to raise the pitch of the key. We want to know how much this sharpening of pitch can be. To simplify and formalise the matter I decided to test the effect of side-shaving at two definite positions — first, when the end of the key is reduced to half its width, and second, when it is sharpened to a point. I therefore carried out two experiments, first with the key cut at both ends as at EF in Fig. 2: then again after I had cut both ends as at Y.

FIG. 2



With the half-taper at both ends, the pitch of the key was sharpened by 178 cents (not far short of a whole tone in Equal Temperament). When both ends were tapered to a point, the pitch had risen by no less than 468 cents, which is getting on for a perfect fourth. Tabulating these figures, we get:

	V.p.s.	Cent Code no.	Interval in Cents
No taper	212	381	
½ taper both ends	235	559	178 cents sharper
Full ,, ,,	278·6	849	290 ,, ,,

Total sharpening 949—381—469 cents

Reviewing the results of all these experiments our main impression is of the very considerable variations in pitch which can be achieved by the methods used by the xylophone craftsman. In a heptatonic instrument where the intervals between each key will mostly be somewhat less than 200 cents, the tuner can modify a key so much that he can flatten it till it is as low as the next key lower, or sharpen it till it reaches or exceeds the pitch of the next key higher — that is, if he is only using weights. In short he has at his disposal more than twice the tuning latitude necessary to adjust the key to the exact pitch he requires given that he has first cut it to approximately the right size.

The effect of hollowing the central under-side part of the key is so considerable that the craftsman can make an instrument of more than two octaves compass without the necessity of having very long slats for the low notes, which would be unsightly and indeed awkward to play. He can, on the contrary, by severe hollowing — which incidentally produces a louder sounding key — secure that there is only a slight change in length, say about 25%, from the highest to the lowest key.

It will be noted that the method sometimes used by Africans, of tapering the ends of the key at its sides gives an enormous possibility of sharpening the pitch: the key can be raised by nearly a fourth, and of course by any smaller amount below this figure.

With regard to the use of tuning wax, the two arbitrary weights we chose were designed to show both the *average* and also the maximum effect to tuning likely to be produced. We have never seen a blob which appeared to be heavier than half an ounce. On the other hand it is obvious that with smaller weights of wax the very finest variations in pitch could be easily achieved. This wax-blob method of fine tuning is, as we have said, characteristic of Indonesia and we cannot at the moment recall its use on African xylophones. Nevertheless it is not infrequently used by Africans in fine-tuning their *mbila* or *sansa* — the 'African hand-piano'. The principle is therefore known to Africans and the author would be interested to hear from any reader who has found wax blobs on an African xylophone.

The actual standards of tuning achieved by African craftsmen differ widely. This can be ascertained by inspecting the tuning of a number of xylophones all from the same tribe, comparing them among themselves, and comparing them with another batch all from a different one, and noting the degree of consistency of tuning achieved by each tribe. Hugh Tracey[2] has shown the considerable accuracy achieved by the Chopi tribe: *per contra* one could cite the Zande in the north-east Congo as a tribe which does not seem to pass beyond the stage of rough tuning. Taking the xylophone areas of Africa as a whole, however, it is often quite astonishing to note the precision with which the African xylophone makers exploit the tuning processes we have here described, and that without the convenience and subtlety of the wax-blob technique as used in parts of Indonesia.

2 H. T. Tracey: *Chopi Musicians*, Ox. Univ. Press, 1948, pp. 123 ff.