THE MANUFACTURE OF TUNED PERCUSSION INSTRUMENTS IN INDONESIA AND AFRICA- A SELECTIVE STUDY

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ABSTRACT OF THE DISSERTATION

The Manufacture of Tuned Percussion Instruments in Indonesia and Africa - a selective study

by

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This dissertation is divided into three parts. The first examines the manufacture of Javanese gamelan percussion instruments, the second examines the manufacture of xylophones in Central African Republic, Ghana and Zambia, and the third examines the acoustics of xylophones.

Part I

Gamelan is a generic term for a set of instruments consisting primarily of tuned gongs and metallophones. Two distinct forms of gamelan exist: those made of bronze which are forged, and those made of steel and/or brass which are usually cold-hammered. The manufacture of bronze gamelan is a highly specialised ancient tradition, whereas the making of steel/brass instruments is a more recent practice resulting from the availability of metal alloys in sheet form this century.

Central Java has been the centre of the bronze gamelan industry for centuries, supplying the royal courts, as well as producing gongs for export. The main source of published information on Javanese gong making is *De Gong-Fabricatie te Semarang* written in 1907 by Jacobson and van Hasselt. However, their study does not cover the tuning and voicing of gongs.

This dissertation documents the manufacturing techniques of bronze instruments with regard to the material, the workforce, workpractices and techniques and the tuning/voicing of gongs. The techniques of making steel/brass instruments are examined, which have so far remained undocumented.

Instrument makers subcontract frame building to specialist

woodworkers. This work, concentrating on carving, is examined. Folk instruments, made from locally available materials, are popular throughout Indonesia. The manufacture of the instruments from one such tradition, the bamboo *calung* ensemble from Central Java, is studied.

Part II

This part examines the role, significance and construction of a selected group of xylophones in Africa.

The LoDagaa and Sisaala peoples of northern Ghana use xylophones as their main means of musical expression. The xylophones are used for recreation, but more significantly, they provide the music for a number of cults and events, the most important of which is the funeral ceremony. Within recent years the Sisaala xylophone tradition has declined, whereas the LoDagaa tradition is still very strong: the reasons for this are discussed.

The Lozi and Nkoya peoples in western Zambia have two distinct xylophone traditions: royal court music, which is serious in nature with a rigid adherence to custom, and folk music which is used for entertainment and for cults. The court tradition and its instruments are examined and compared to the folk tradition.

At the end of the nineteenth century the xylophone traditions of the Azande and Nzakara peoples of eastern Central African Republic were flourishing. Today, the tradition has almost completely died out. Chapter XI documents what remains, and examines the reasons for its decline.

Part III

This part examines the acoustics of xylophones. An introduction mentions notable publications on the subject, and examines present acoustic theory of bars and air columns. Experimental work examines modes of vibrations of bars of uniform thickness but of different shapes, the effect of undercutting bars and the method for tuning second and third partials.

Published acoustic theory on bar idiophones deals only with western orchestral instruments. The rest of Part III examines the acoustics of African xylophones. Bars have been made by the author of forms representing the main xylophone types found in Africa. Sympathetically tuned resonators of various forms and materials have been made and tested with different bars. A study has also been made on the use of mirlitons and their effect on tone. The tone of these bars and resonators has been studied using digital analysis to obtain objective results.

CHAPTER I

INTRODUCTION

The first two parts of this study (Indonesia and Africa respectively) documents instrument making traditions and examines their social context. They are the product of a three-year research fellowship funded by the Leverhulme Trust. As a maker of tuned percussion I chose a wide area of study, reflecting the range of instruments I make. The third part examines the acoustics of xylophones.

The Indonesian study is based on Javanese gamelan, an orchestra composed primarily of tuned metallophones and gongs. My involvement with gamelan started as a result of a fascination with the bronze gongs and their construction. Previous to the research fellowship I had made a number of bronze metallophones, sand casting the bars. At that time, I was buying the bronze from the Whitechapel Bell Foundry (established in 1562) who have a specialist knowledge of bronze alloys, their workability and sonority. I knew that Javanese bronze gamelan were forged, but according to the bell foundry manager, it was not possible, in their experience to forge bronze without it cracking or suffering tin sweat. Two years later I found myself sitting in a Javanese gamelan forge being amazed at seeing a gong take shape. Chapter III explains in detail the processes of manufacturing bronze gamelan that I witnessed in Solo (or Surakarta), Central Java.

The cost of the raw materials, copper and tin, has always put bronze gamelan beyond the reach of all but the very wealthy in Javanese society. However, much cheaper gamelan instruments are now made from sheet steel (usually spent oil drums). These instruments have led to the wider use of gamelan in Java. Many schools and music centres in Britain have been able to buy iron gamelan. Chapter IV examines the manufacture of these instruments.

Apart from the more formal gamelan orchestras, there are also many folk ensembles in Java, using instruments made from locally available materials, such as bamboo. A study of making the bamboo *calung* ensemble from central Java is given in Chapter VII. In conclusion to Part I, Chapter VIII assesses the vitality of the gamelan industry in central Java.

The second part of the dissertation examines the xylophone making traditions in Central African Republic, Ghana and Zambia. These studies aim to document manufacturing techniques, the role of the xylophone, and its cultural importance. These chapters have their own introductions, giving brief historic and geographic backgrounds to the cultures examined.

Chapter IX examines the Sisaala and LoDagaba (a subgroup of the LoDagaa) xylophone traditions in north-west Ghana. In these two xylophone cultures the most important role of the instruments is to provide the music for the funeral ceremony. With the xylophones' inextricable link with death and the after-life, and the pagan structure of LoDagaba and Sisaala society, much mysticism surrounds the instruments' manufacture; this is documented. The Sisaala tradition is in serious decline, whereas the LoDagaba tradition is flourishing: the reasons for this are examined in Chapter IX

The royal xylophone ensembles of the Lozi and Nkoya peoples in western Zambia are examined in Chapter X. These ensembles are a prominent and important feature of the royal establishments: four performances are given every day in the Lozi capital, and the xylophone must play at every public appearance of the king. The role and significance of the royal instruments are examined, and compared to the folk xylophone tradition. In keeping with tradition, the present Lozi king takes part in the making of the royal instruments, and this role is examined in Chapter X.

The two most useful sources of information I found on xylophone construction were Hugh Tracey's study of the Chopi xylophone tradition in Mozambique[1] and Olga Boone's analytical notes on the collection of xylophones in the Musée de l'Afrique Centrale.[2] During 1987 I made a study of that museum's collection, and was captured by the finely made Azande xylophones (*manza*) from north-east Zaire. These xylophones featured prominently in Azande culture, being used exclusively by court musicians, chiefs and kings. Unfortunately, the tradition is in serious decline. The xylophone traditions of the Azande and Nzakara peoples are examined in Chapter XI.

Chapter XII, is a conclusion of Part II, comparing the traditions, and discussing their vitality.

The acoustics of bar idiophones are examined in Part III, Chapter XIII. The first part of this chapter, Acoustic Principles of the Xylophone, gives a brief account of the publication of advances in the field, and a study of vibration in bars, air colums and spheres, and the effect of beater hardness.

The second part of Chapter XIII, Experimental Work, includes a series of tests on xylophones bars and resonators made by the author. This work examines modes of vibrations of bars of uniform thickness but of different shapes, the effect of undercutting bars and the method for tuning second and third partials, tone characteristics of African-type xylophone bars coupled with resonators of different types, and the effect of mirltons on tone, paying regard to membrane material and size.

PART I

CHAPTER II

JAVANESE GAMELAN

Gamelan is a generic term for a set of instruments consisting primarily of tuned gongs and metallophones. Ensembles may consist of thirty or more instruments, as in the Central Javanese Court gamelan, or as few as four or five in village ensembles. Indonesia's geographical position, lying on major trade routes for at least two thousand years, has resulted in its history and culture being heavily influenced by mainland S.E.Asia and India. Successive waves of migration have brought Hindu-Buddhist, Islamic and, to some extent, Western culture to Indonesia.

Today three distinct forms of gamelan exist: Central Javanese, Sundanese (West Java), and Balinese. For all these traditions, Central Java emerged as the centre of instrument making, supplying the others with the most difficult instruments to make: the large gongs.

THE TUNING

Javanese gamelan uses two tuning systems : slendro and pelog. Slendro consists of five pitches, generally conforming to a roughly equitonal pentatonic scale. The pitches are numbered 1, 2, 3, 5, and 6, where 1 is the lowest. The pelog system divides the octave into seven un-equal intervals. From these seven pitches (1, 2, 3, 4, 5, 6, 7) just five notes are used to build up different pentatonic scales. In the *tumbuk nem* gamelan, pitches slendro 6 and pelog 6 are the same, facilitating change from the pelog to the slendro system (and vice-versa) in the same piece. In the *tumbuk lima* (five) gamelan, pitch 5 is the same.

There is no absolute standard of pitch for gamelan scales; each individual gamelan has its own characteristic sound or 'voice'. However, many school gamelan are tuned to the standard used on the national radio station.

THE INSTRUMENTS

The layout of the instruments (*ricikan*) generally follows the pattern of the large hanging gongs, kempul and kenong positioned in the back row, with the sarons and slenthem in the centre row, and the bonang, gender, gambang, suling and rebab in the front row. The metal percussion instruments in gamelan are divided into two types, *wilah* (or *bilah*) and *pencon*. *Wilah* refers to the bar or plate instruments which include the saron and gender instruments, and *pencon* refers to the gong-pot instruments. There are two types of *ricikan pencon*, distinguished by the method of support; *gandhul* (hanging) and *pangkon* (cradled). *Pencon gandhul* include gong, gong suwukan and kempul. *Pencon pangkon* include bonang, kenong, and kempyang and kethuk.

Gong type instruments

These instruments all have onomatopoeic names, the final syllable imitating the sound:

gong
kempul
kenong
kethuk
kempyang
bonang

Gong ageng

The vertically hanging gongs positioned at the back define the metrical structure and form of the music. The largest of these, the gong ageng, is used to signal the end of the largest musical cycle. Gong ageng are tuned to produce two slightly different pitches that 'beat' to produce the characteristic slow throbbing, known as *ombak*. The Javanese gong almost always has *ombak*. Some large royal ensembles have two gong ageng, in which case one is tuned to pitch 6 and the other to pitch 5. When there is only one gong ageng it is almost always tuned to pitch 5. Although the gong ageng has a definable pitch, it plays in both the pelog and the slendro tuning system, so it is the tone of the instrument which is more important.

The medium size hanging gong is called gong suwukan. It is tuned between one and two octaves higher than the gong ageng, and so has a very definite pitch. If there is only one gong suwukan it is tuned to pitch 2. Large ensembles may have two gong suwukan; in slendro they are tuned to pitches 1 and 2, and in pelog to pitches 7 and 2. All gongs are played with large, soft padded beaters to develop the deep, mellow tone.

Kempul

Kempul are very similar in shape to the gongs, but since they are tuned to produce a single note, with no *ombak*, the Javanese word 'gong' is not associated with them. They are hung vertically, alongside the gong ageng and gong suwukan. Kempul are used to subdivide the melodic flow of the *balungan* (fixed melody, literally skeleton) into musical phrases. They are played at the points of secondary importance of the *balungan*, whereas kenong are played at the points of primary importance.

A complete gamelan set usually has eight kempul. Slendro kempul are 3, 5, 6, 1 and pelog kempul are 3, 5, 6, 7, 1. In the *tumbuk nem* (6) gamelan, kempul 6 slendro is interchangeable with kempul 6 pelog, and kempul 5 slendro can be used as kempul 4 pelog. In the *tumbuk lima* (5) gamelan kempul 5 slendro is interchangeable with kempul 5 pelog, and kempul 6 slendro can be used as kempul 7 pelog. In a less complete gamelan set, kempul may be tuned to slendro 5, 6, 1 and pelog 5, 6, 7.

Kempul are played with beaters similar to those used for the gong ageng and gong suwukan, but slightly smaller and less softly padded. During fast moving kempul parts, damping is used in between each successive note.

Kenong

Kenong are large, horizontally suspended gong pots. Played with cord-wound sticks, they produce a ringing 'nong' sound. A complete gamelan set has as many as ten or eleven kenong. Slendro kenong are 2, 3, 5, 6, 1 and pelog kenong are 2, 3, (4), 5, 6, 7, 1. A less complete set may have slendro kenong 5, 6, 1 and pelog kenong 5, 6, 7. The same system of interchanging between pelog and slendro is used as with the kempul. The kenong are also in the back row of instruments reflecting their metrical function.

Kethuk and Kempyang

These two small, horizontally mounted gong pots are usually placed in the back row, between the gong stand and the kenong. Their function is also metrical, the kethuk often interlocking with the balungan on the off beat.

Bonang

There are two types of bonang: bonang barung and bonang penerus, the latter being tuned an octave higher, so that the two overlap each other by one octave and together encompass three octaves. In addition to these bonang, some very large gamelan from Yogyakarta have a bonang penembung, which is tuned one octave below the barung. Bonang have two rows of gong pots, supported horizontally on string over a rectangular wooden frame. Slendro bonang have twelve gong pots, while pelog bonang have fourteen. The pots are arranged as follows : (from the player's viewpoint)

slendro 6 5 3 2 1' 2'   pelog 4 6 5 3 2 ,1 7
1 ,2 ,3 ,5 ,6 ,1   ,7 1 ,2 ,3 ,5 ,6 ,4

Bonang are played with cord wound sticks. These instruments elaborate the balungan, and lead the gamelan in the loud style. As such they are placed at one side at the front of the gamelan.

Bar type instruments

These metallophones fall into two categories; those with thick heavy bars, played with wooden or horn mallets, and those with thin bars played with soft padded beaters. In addition to these there is a xylophone, gambang.

Saron

There are three types of saron : saron demung, saron barang (normally just called saron), and saron penerus or more commonly known as peking. Together they span three octaves, the demung being the lowest and the peking the highest. The layout of the bars on the saron from the players viewpoint are:

slendro 6 1 2 3 5 6' 1'   pelog 1 2 3 4 5 6 7

All these instruments have very heavy bars, supported over a shallow trough resonator frame. The demung and saron are played with wooden mallets, while the peking is played with a horn mallet. Often grouped with the saron family is the slenthem. Together, all these metallophones are known as *balungan* instruments, and play the fixed melody or *balungan* (except for the peking which plays at two, four, or eight times the tempo of the saron beat). The slenthem differs from the saron family by having thin bars suspended over tube resonators, the instrument being played with one padded beater. It has the lowest pitch of the *balungan* instruments, being set one octave below the demung. This group of instruments stretches across the middle area of the gamelan.

The *balungan* instruments are played with one beater, held in the right hand. Due to the long decay of these instruments it is necessary to damp each key at the same time as the next key is struck. This damping is done with the forefinger and thumb of the left hand.

Gender

The gender barung and gender penerus belong to the soft style group of instruments and are placed at the front of the gamelan opposite the bonang. Both instruments have fourteen thin metal bars suspended over tube resonators. The gender penerus is tuned an octave higher than the barung. A full gamelan has one slendro gender barung, one slendro gender penerus, two pelog gender barung, and two pelog gender penerus. The tunings of slendro gender barung and pelog gender barung are given below:

slendro gender	,,6 ,1 ,2 ,3 ,5 ,6 1 2 3 5 6 1' 2' 3'
pelog bem gender	,,6 ,1 ,2 ,3 ,5 ,6 1 2 3 5 6 1' 2' 3'
pelog barang gender	,,6 ,7 ,2 ,3 ,5 ,6 7 2 3 5 6 7' 2' 3'

The gender is one of the most technically difficult instruments to play, requiring a high degree of musicianship. Two padded disc beaters are used, one in each hand. Damping of notes is done with both hands using either the heel of the hand or the thumb. The gender barung is accepted as a particularly important instrument in the ensemble; without it, a gamelan is said to lack sonority.

Gambang

The gambang is the only xylophone used in the gamelan. It is a member of the soft-style, embellishing on the *balungan*. The gambang has as many as twenty-one wooden bars, giving four octaves, the largest range in the ensemble. The bars are supported either on coiled string covered in material or twisted string alone, resting over a trough resonator. The gambang is played using two padded disc beaters, with long flexible horn handles, making possible the very fast (but soft) playing style. The gambang plays mostly in parallel octaves, though at times other intervals are used.

Kendhang

The kendhang is a double-headed, barrel-shaped drum with one head smaller than the other. The two heads (normally of cow hide) are laced together using raw hide or raffia, and are tensioned by moving hoops through which the lacing passes. Most kendhang are mounted on a horizontal stand, and played with the hands. There are many types of kendhang in Java, especially if one looks at folk instruments, but the four most common types are listed below:

a) kendhang gendhing (or kendhang ageng) is the largest drum and is played in peaceful passages of music,

b) kendhang ketipung is the smallest drum and is played with the kendhang gendhing,

c) kendhang *wayangan* is a medium sized drum used to accompany the *wayang* show,

d) kendhang ciblon is a small to medium sized drum used to accompany dance. It is also used in concert music.

The kendhang player is placed in the middle of the ensemble, and is the rhythmic leader. The kendhang guides the players through tempo changes and the various transitions in a piece.

Rebab

The rebab is a two-stringed bowed fiddle, and is the melodic leader of the soft style. It has a heart-shaped body made of light timber, over which a very thin skin (rabbit) or cow's bladder is stretched. A long wooden 'spike' passes through the body which supports the brass strings at the top. The strings pass over a bridge resting on the thin membrane covering the body. A shorter 'spike' at the bottom of the body supports the instrument on the ground.

The playing technique of the rebab is particularly difficult to master, requiring years of training to produce a clear sound with correct intonation.

Celempung and siter

The celempung is a plucked zither set on four legs, the front two being shorter so the instrument is angled towards the player. Thirteen pairs of strings are stretched between the tuning pegs at the top of the instrument and hitchpins at the bottom. The strings pass over an angled metal bridge.

The siter is similar to the celempung but has simple folding legs usually made of sheet metal. It is also much smaller and less grand. Both zithers are plucked with the thumbs, using the fingers to damp the strings.

Suling

The suling is an external-duct flute made of bamboo. The slendro suling has four finger holes, while the pelog suling has five. The suling encompasses a range of almost three octaves, although the lowest octave is very rarely played.

Kemanak

The kemanak is a banana shaped bell, made of bronze and played with a cord wound stick. The kemanak has a slit running along its length, with a handle at one end. It is played by holding the instrument in the left hand, striking the bell part using the right hand, and then rapidly closing the slit with the left thumb so the bell rings for a short time and is then damped. This technique makes a 'whooping' sound.

Kemanak are always played in pairs, the two instruments playing an interlocking pattern. There are two kemanak for slendro and two for pelog. Kemanak are used to accompany the *bedhaya* (sacred dance) and form part of the *santiswaran* ensemble consisting of kemanak, kendhang, terbang (tambourine), and chorus. Kemanak are quite rare, usually only found in the royal courts.

Kecer

Kecer is a pair of cymbals, with one permanently attached to a wooden frame. The other cymbal is held in the hand and strikes the stationary one. Kecer are used to accompany *wayang* (puppet) performances.

Keprak

The keprak is a wooden slit drum used to accompany dance. Occasionally, as in Solo, metal plates (kepyak) are hung from the keprak. In this case the plates and keprak are played with a wooden mallet.

Kepyak

Kepyak consists of two or three square metal plates held loosely together with cord and hung over the side of the wooden puppet box. Kepyak are played during *wayang* performances by the puppeteer (*dhalang*) by either kicking them with his toes or with a small wooden mallet (*cempala*) held between his toes. They are used to emphasise tension and drama during the play

CHAPTER III

THE MANUFACTURE OF JAVANESE BRONZE GAMELAN BY BAPAK TENTREM, SOLO, CENTRAL JAVA

SOURCES OF INFORMATION AND THEIR IMPACT ON GONG MANUFACTURE

In recent years, reflecting the explosion of interest in both Europe and America, many books have been published on gamelan, most concentrating on theory, instrumentation, and history. The eminent musicologist Jaap Kunst spent many years studying gamelan in Java, and produced what is still considered the most comprehensive and authoritative study of Javanese music.[1]

Publications dealing specifically with the manufacture of Javanese musical instruments are more scarce. For over seventy years the main source of published information on Javanese gong making was *De Gong-Fabricatie te Semarang*.[2] This still remains the definitive study of gong making published in Europe, but during the 1980s a number of studies were written in Java.

The most notable of these was commissioned by the Javanese Department of Education and Culture: Drs. Soeroso, *Pembuatan Gong Besar Oleh Empu Resowiguno,* 1986. This study concentrates solely on the manufacture of gong ageng made in Wirun, Surakarta, by the gamelan maker, Bapak (Pak) Resowiguno.[3]

The School of Performing Arts (Akademi Seni Karawitan Indonesia, ASKI) in Surakarta published a study by Rustopo, *Pengetahuan Membuat Gamelan* in 1981. This study, also based on the maker Resowiguno, deals with the manufacture of all the bronze gamelan instruments, but is less detailed than the study by Soeroso.

Jacobson and van Hasselt's study was based on the work of gong smiths in Semarang, which was the main centre for gong making until the middle of this century. Semarang has been an important trading port for centuries, and since much of the gong smiths' work was traditionally exported (mainly to Chinese traders in Singapore), it is understandable that this northern port should have been the centre of gong making in

Java. During the 1930s and 1940s the demand for the great gong ageng declined severely, to the extent that Kunst, in a discussion on the manufacture of gong ageng in the second edition of Music in Java, 1949, wrote:

> It is indeed a great pity that this industry, which, although carried on in an incomparably primitive manner, achieves the highest results in its own fields, is now on the verge of ruin. The demand for good instruments is getting steadily smaller. The principal - ie. the Semarang - gongsmithies, for example, which in 1907, still numbered seven, and at present only two, hardly, if at all, train any pupils now, so that it is probable that this beautiful craft, so full of ancient tradition, will die with the present generation, unless, in some way or other, a helping hand is offered in the nick of time.[4]

As an addendum to this passage, bound as an extra page at the end of Volume 1, Kunst continues:

> The sad news has reached me - too late for its inclusion in the main text - that there is not now a single gongsmithy left in Semarang. As a result, owners of gamelans in both Java and Bali, knowing the replacement of their gongs to have become impossible, are giving greater care than ever to their maintenance. This information was given me orally by His Excellency Anak Agung, Prime Minister of the Republic of East Indonesia. Thus, an unrivalled craft was lost before our very eyes in a single generation. For shame![5]

The composer and ethnomusicologist Mantle Hood read this sad news as a student in 1950, and upon his arrival in Java in 1957 set out to discover whether this information from Anak Agung was in fact true. In *The Ethnomusicologist*, Hood writes:

> For the first month I received conflicting answers. Finally, in an audience with the sultan of Djogjakarta (Yogyakarta) I had confirmation that the last family of gong makers capable of fabricating the gong ageng had disappeared from Semarang some time during World War II. He informed me that small gongs, up to 75cm. in diameter, were still manufactured; but the art of making the large ones had vanished.[6]

After this confirmation, Mantle Hood endeavoured to find men who had assisted in the making of a large gong, as well as smiths currently making gongs of 75cm. It was his intention that if these men could be brought together on a special project, it may well be possible, with practice, to again forge the gong ageng. Mantle Hood voiced this idea to representatives from various government ministries, all of whom agreed that the loss of the art of forging gong ageng was tragic, but none could give any assurance that something would be done to address the problem. Mantle Hood was frustrated by the apparent unwillingness of any gongsmiths to commit themselves to the project, and also by the negative response of dignitaries (who might help fund the project) to the feasibility of the plan. Mantle Hood became aware that the almost universal condemnation of the project was due to something other than objective feasibility:

> I was troubled by one subtle reservation in my otherwise resolute determination to launch a gong project. It had to do with the peculiar aura of mystery and the mystical that had always surrounded the manufacture of gong ageng. Traditionally, the smith who made the large gong was in effect entrusted with a dangerous responsibility. He was a man of great spiritual development; and he fasted for three days before beginning his sacred task.[7]

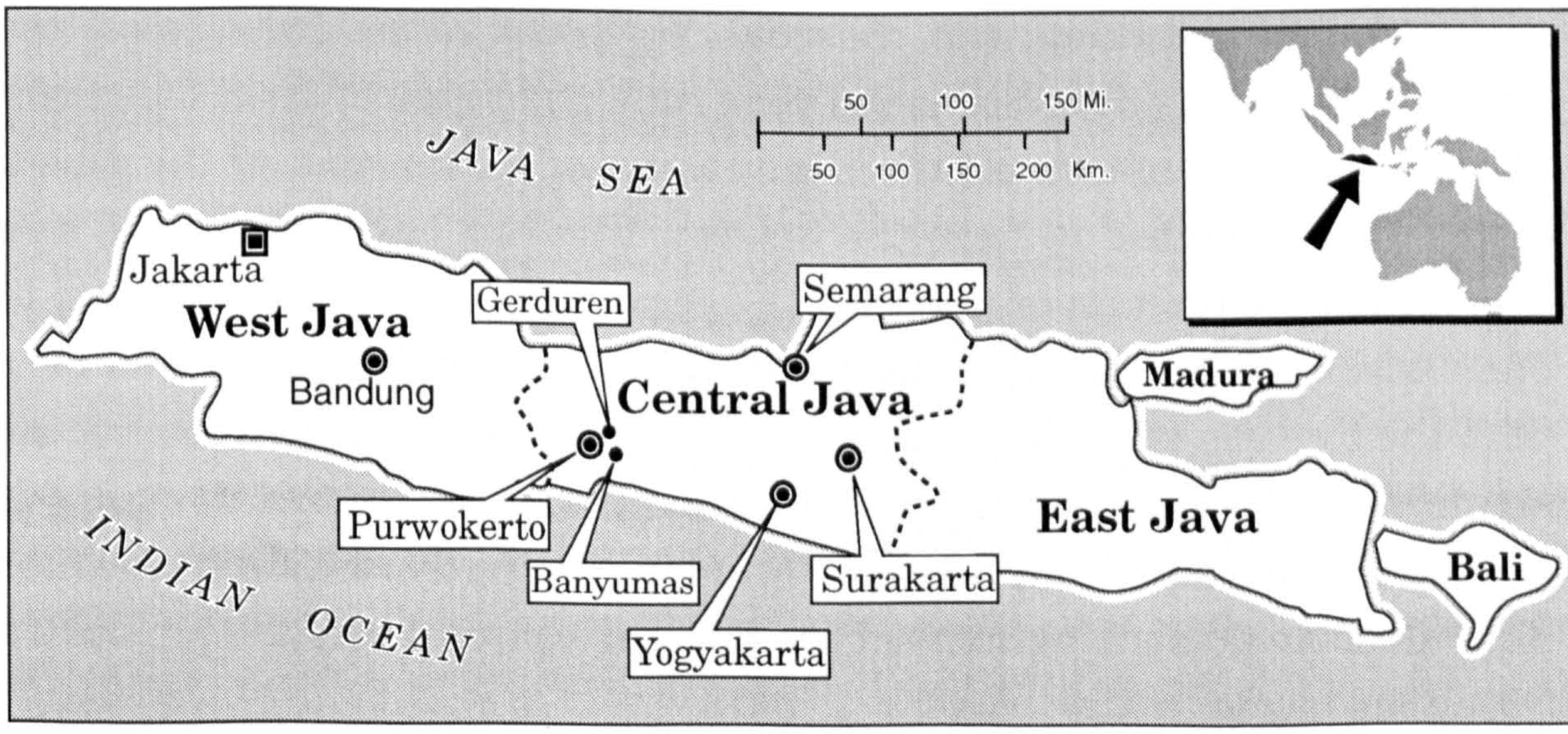
A year later, 1958, the Asia Foundation provided the money to fund the project, and so the search to find a willing and competent gongsmith continued. On the day of Mantle Hood's departure from Central Java, the news of a gongsmith working in a small village near Solo came to light.[8] The gongsmith was willing to take part in the project, and so, over the following year gongs were forged until the magic 90cm diameter had been reached. Mantle Hood did not return to Solo until 1967, where he found that the foundry had been idle for eight months, and the workers had returned to work the rice fields. This was due to the difficult economic years during the violent suppression of the communist uprising, and the ensuing witch-hunt. However, the country gradually regained political stability, and the economic climate improved, resulting (among other things) in the renewed demand for gong ageng.

So it can be seen that during the 1950s Solo took on the role of the centre of gong ageng making in Java. In addition to the successful foundry run by Bapak Resowiguno , a gamelan factory was set up in Solo in the 1960s. Although urged to join the 'industry' in Solo, Bapak Resowiguno preferred to remain independent.

It is difficult to assess the state of the gamelan industry in Solo at the beginning of this century; I have been unable to find any information claiming that large gongs were made in Solo during this period. According to the information given to Jacobson and van Hasselt, the gong smiths working in Solo were less skilled:

> According to the present gongsmith's knowledge of his colleagues in Solo, Banjarnegara and elsewhere, where *wilah* (bars) and bonang are made, the art of preparing *gangsa* (bronze) is no longer known, and old broken instruments are instead melted down.[9]

I am unable to refute this, but believe it to be unlikely since these Semarang smiths made other dubious claims as to the inadequacies of Solonese smiths (see note 22). The works written by the Javanese authors mentioned earlier are both based on studies at Wirun with Pak Resowiguno. It was suggested to me by Aloysius Suwardi, a lecturer at ASKI, that I should conduct my study with Pak Tentrem[10] who runs a bronze gamelan foundry in the south of Solo, and who currently supplies ASKI .[11] Al. Suwardi introduced me to Pak Tentrem, who offered me the chance of studying with him, and spending as much time as I wanted in the foundry. During my field studies in Java, March to June 1989, and November to December 1990, I was able to see the manufacture of almost every bronze gamelan instrument at Pak Tentrem's foundry. Unfortunately I was unable to witness the making of a gong ageng since no orders for the large gong were taken during my stay, and my own budget did not make possible the commissioning of such an instrument. Pak Tentrem was always very welcoming, freely explaining work practices, techniques, and terminology. I spent most time with the gongsmiths in the foundry, who were also very friendly and helpful, explaining everything clearly. I am indebted to everyone at Pak Tentrem's foundry for making the present study possible.



Map 1 Java

The workplace is described, and the specialist jobs allotted to members of the workforce explained. A stage by stage detailed account is then given of the processes involved in the making of a gong suwukan. The other instruments made in the forge (kenong, bonang, metallophones, and kemanak) are described later.

THE FORGE

The workshop where all the bronze instruments of the gamelan are forged is known as *besalen*. The *besalen* was traditionally built using a timber frame and tiled roof. Non-structural walls made of woven, split bamboo were used to provide some cover and protection from the elements and, more importantly, to keep the workshop dark so that the temperature of the workpiece can be judged more accurately by its colour. Pak Tentrem has, however, a modern brick workshop with steel roofing beams and a corrugated roof. This was built in 1990 to replace the old forge which burnt down in 1989. The high roof is in two halves, with a gap between the upper and lower-parts to enable the smoke, sparks, and ash to escape. The top-part of the roof overhangs the lower-part in the style of the traditional *pendopo*.[12] The inside of the old forge had to be sprayed every half hour with water to prevent the wooden roofing beams burning, such is the intense heat produced by three working hearths. Figure 1 shows the layout of Pak Tentrem's smithy.

The hearth (*prapen*), which is used both to melt the raw material and heat the workpiece during forging, is a shallow pit dug into the floor of the workshop and filled with charcoal. When not in use (when cold) the hearth is known as *dongo*. A metal pipe runs underground from the centre of the hearth to another pit three metres away. At this end of the pipe a cloth-bag is attached to form the bellows. The bag has a slit in one side over which the forearm of the bellows operator rests. The slit is allowed to open when the bag is pulled up to fill it with air and then covered over with the forearm when both arms are used to compress it thus forcing the air through the pipe into the hearth. A surprising amount of dexterity is needed to operate these bellows (*lamus*) efficiently; I found it rather difficult to avoid sucking some of the burning charcoal into the pipe when filling the bag with air!

There are three hearths in Pak Tentrem's workshop, one being considerably larger than the others which is used for making the large, heavy instruments such as kempul or gongs. The large instruments are moved about within the hearth by two, long wooden-handled pokers, called *penyukat*. The *penyukat* are operated from another pit three metres from the hearth. The worker sits on a board placed across the pit with the *penyukat* lying almost horizontal on a long metal tool rest *(angell)*.

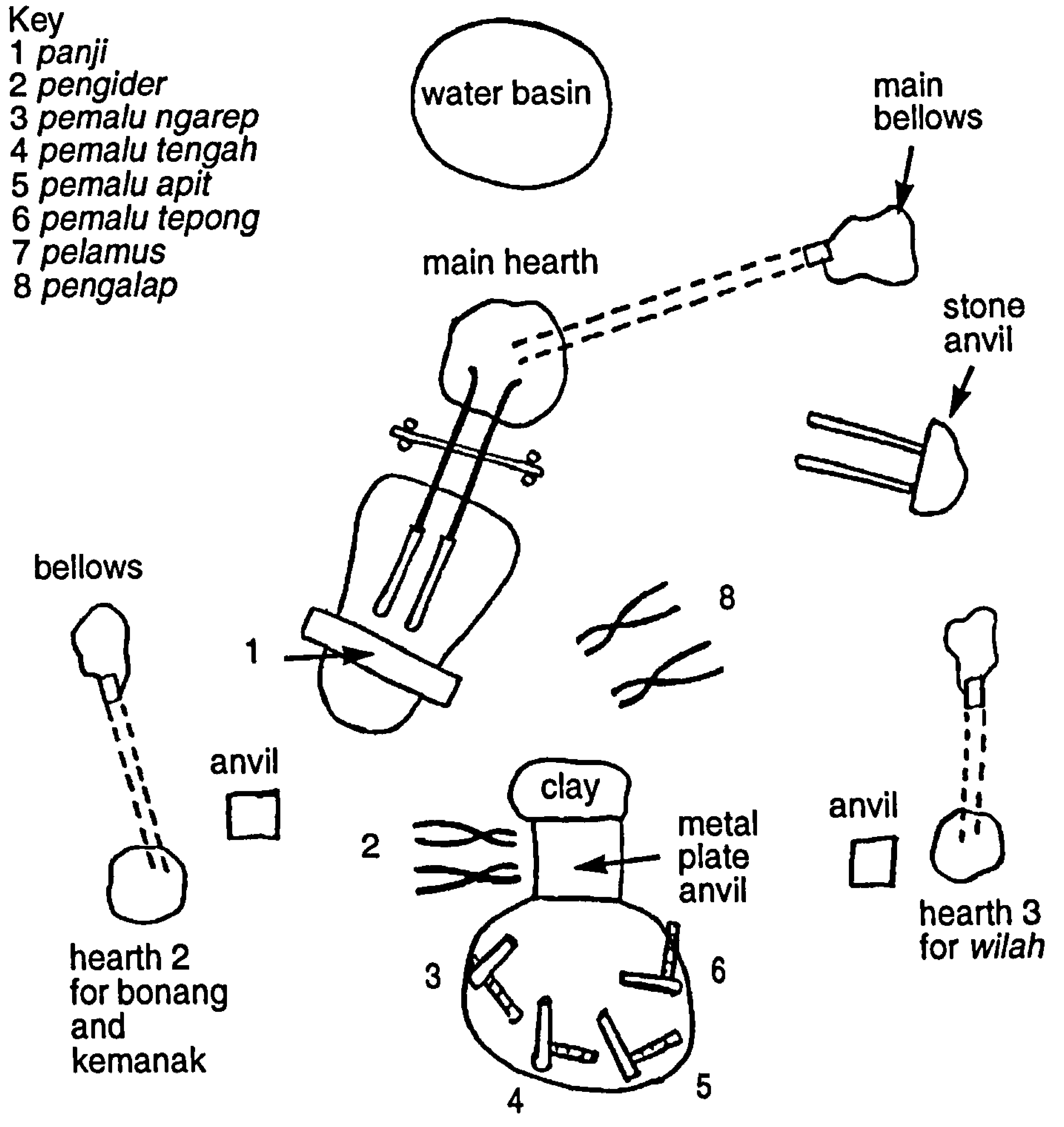


Fig. 1 Floor plan of the smithy.

There are two main anvils used in the forging of gongs: the *ladok tandes* is an iron plate set into the ground whilst the *ladok mendan* is a stone anvil which is also laid into the ground. The two other hearths also have anvils located near them, where smaller instruments such as bonang and the bronze keys of the metallophones are made.

A large concrete water basin (*planden*) is situated behind the main hearth. After forging, the instrument is plunged into this to cool it.

THE WORKFORCE

Gongsmiths have held a position of respect within Javanese society for many centuries. The art of forging gong ageng, above all other instruments, was traditionally regarded as a mystical and dangerous task, as Jaap Kunst noted:

> Just as was the case in mediaeval Europe, the Javanese smiths are not mere craftsmen like the others: an atmosphere of mystery surrounds their labours - more especially of the gamelan smiths - and their activities can flourish only under the special patronage of the higher powers. More than all other mortals they are exposed, during their work, to the cunning artifices of evil spirits.
>
> In order to ward off any disasters the gamelan smiths, therefore, adopt other names during their labour than those they bear in daily life. These names they borrow from various personages from the 'Panji-stories'. In regard to this, Rassers arrived at some remarkable conclusions. He discovered, in fact, that the identification of the prince or tribal hero (for that is what Panji, after all, appears to be) with the smith has been carried to such an extent that the two are, at times, almost indistinguishable. The art of gong-forging is thereby elevated to a sacred act, heavily charged with magic, on the part of the king-priest.[13]

I was unaware of this practice amongst the gongsmiths at Pak Tentrem's foundry. Pak Tentrem informed me that ceremonies are more commonly performed when making gong ageng, since this is the most sacred task.

Javanese gongs are recognised throughout south-east Asia as being the culmination of the highest level of bronze forging techniques developed over the last millennium. Chinese gongs which were probably introduced to Java around 1000 years ago[14] have been developed by the Javanese into a gong with a central knob or boss which facilitates complete control over considerations such as pitch, timbre, and the beating of two notes to produce the characteristic sound of the Javanese gong (*ombak*). Arab and Chinese traders continued a lucrative business up until the beginning of this century exporting gongs throughout south-east Asia. Against this background it is easy to understand why gongsmiths hold a position of importance and respect in Javanese society.

Pak Tentrem employs three teams of workers, each one specialising in making instruments of a particular type:

1) large instruments (such as gong, gong suwukan, kempul and

kenong) made in the principle forge.

2) bar instruments (such as gender and saron) made in one of the two smaller forges.

3) bonang and kemanak made in the other smaller forge.

Gamelan-smiths spend many years learning their trade. All smiths start their apprenticeship in their youth, usually by the age of fifteen. They start as helpers and move onto jobs such as carrying the workpiece from the forge to the anvil, and operating the bellows. During their work as helpers in the forge, the apprentices observe the processes and techniques of forging. After a period of about two years the apprentices join a team as a junior smith.

The team making gong, gong suwukan, kempul, and kenong consists of six true smiths, each with a different level of knowledge, experience and skill. One more smith is needed when making the very large gong ageng. In addition to the smiths, the team also has a bellows operator and a worker whose job is to carry the workpiece to the anvil from the forge. The team is based on a strict hierarchy, headed by the *panji* or master smith:

1) *panji*,
2) *pengider*,
3) *pemalu ngarep* (*pemalu*=hammerer),[15]
4) *pemalu tengah*,
5) *pemalu apit*,
6) *pemalu tepong*,
7) *pelamus* (bellows operator),
8) *pengalap*.

Panji

The *panji* directs all the important aspects of instrument manufacture. It is a heavy task since he alone is responsible for the quality and successful completion of instruments (the smiths are paid piecemeal and get nothing for failures). Ultimately it is the skill of the *panji* that decides the quality of the instruments and the ensuing prosperity of the forge. The *panji* assays the quality of the bronze alloy to be used. During the forging the *panji* uses the *penyukat* to move the workpiece within the hearth determining which areas of it are to be heated and to what temperature. He gives directions to the bellows operator (*pelamus*) during the reheating of the workpiece in between the hammering.

The *panji* must also be capable of tuning and voicing gong and kempul which is regarded as the most difficult task in the making process. There are currently three *panji* working at Pak Tentrem's smithy; one working with each of the three workgangs mentioned above. Pak Tentrem, himself also a *panji*, does most of the voicing and tuning of gongs and kempul. This skill is regarded as a gift that only very few people have and cannot be wholly taught, but rather is built upon the individual's innate ability and understanding by practice. Furthermore, as will be explained later, although general principles can be laid down for voicing and tuning, a certain amount of the ability is said to rely on 'feeling' (see Voicing, page 45 and Tuning, page 48.

In the following description of the *pengider*'s job there may appear to be little distinction between his role and the role of the *panji*. The main difference is the level of knowledge and experience. If there is no *pengider* in the workshop the *panji* will also perform his duties.

Pengider

The *pengider* controls the reheating of the workpiece in the forge if the *panji* is occupied with some other task. The *pengider*'s main job is to turn the workpiece (*lakaran*) on the anvil whilst it is being pounded by the four hammerers (*pemalu*). He uses two small clasping tongs (*supit cocor*) to grasp and turn the *lakaran* in between the blows of the hammers. This job involves giving orders to the *pemalu* where the *lakaran* must be hit, with how much force, and when to start and stop each individual round of pounding.

The *pengider* may also help the processes of melting (*mbesot*), casting the *lakaran*, and the quenching of the gong in water at the end of forging (*ngelem*).

Pemalu

Up to four *pemalu* may work in the making of kempul, kenong, and gong at any one time. The first of these is the *palu ngarep* (literally first hammer). He is the most experienced and skilled smith besides the *pengider* and *panji*. The need for accuracy of the hammer blows must be stressed since if a heavy blow falls on an already thin part of the workpiece it may well tear it. Consequently great concentration must be maintained at all times during the forging.

Pengalap and pelamus

The other workers in the smithy are not true gongsmiths, but they may be apprentices. The *pengalap*[16] has the task of carrying the workpiece to and from the hearth and the anvil, between forging and reheating. He uses tongs known as *supit klowong* for this purpose. The worker who operates the bellows is known as *pelamus*.[17] Other helpers or apprentices have the tasks of collecting charcoal, water etc. and protecting the *pemalu* from the intense heat from the workpiece with a screen (*aling-aling*), and other general duties.

Each workgang will usually work as an integral group, each man having a specific task. In 1907 Jacobson and van Hasselt noted that "if one member of the group is absent due to sickness, and so forth, usually the entire group stops work".[18] This is not the case with Pak Tentrem's workforce. Although each man has a specific job, workers will sometimes take it in turn to do the more exhausting jobs like wielding the 15kg hammers during forging.

THE MANUFACTURE OF KEMPUL AND GONGS

There are four distinct processes of manufacture:

1) Casting.
2) Forging.
3) Cold shaping with hammers (includes initial tuning and voicing).
4) Finishing (filing, turning, polishing and final tuning and voicing).

The casting

The casting of the plate (*lakaran*) that will be forged into the gong is usually done in the afternoon, at the end of the days' work, so that it is ready the following morning. Since the correct method of casting is important the *panji* oversees the procedure. The bronze alloy is called *gangsa* - this term is formed from GA and SA of *temba*ga (copper) and *reja*sa (tin). The best alloy for making gamelan is ten parts copper to three parts tin, or, expressed as a percentage, 77% copper and 23% tin. This alloy has been developed through the centuries to produce a bronze with the optimum characteristics for sonority, workability, longevity, and appearance. It is no surprise, therefore, that we find exactly the same alloy used in the manufacture of large church bells in Europe. The Whitechapel Bell Foundry, London has been making bells at the present site since 1572, and currently uses a 77% copper to 23% tin mix.

The exact formula of the alloy used in gamelan used to be a closely guarded secret kept by the *pande* (owner, master smith) of each foundry. Small quantities of precious metals such as silver and even gold used to be added with the intention of increasing the workability and sonority of the bronze, with a certain amount of credence paid to the spiritual purity of the ensuing instrument. Today such refinements are lost to the economic pressures of running a foundry on a competitive basis.

It is important that the tin and copper used is of a known high purity, since metallurgic tests are not possible in the gamelan foundry. Some foundries melt down old broken instruments (*kreweng*) to make new ones, but this is not good practice if the foundry owner is unaware of the origins of the *kreweng*; on the other hand if the *kreweng* originated from his own foundry there is no question of impurity.

The very high cost of tin and copper bought at world market prices has undoubtedly led to the lack of demand within Indonesia for bronze gamelan, especially the large gongs. Indeed, the art of forging gongs of over one metre diameter was almost lost, and it is only recently that such sizeable instruments are being made again.[19] The new demand has been helped by the growing interest in gamelan internationally. Pak Tentrem made a gong of 105cm diameter in 1990 for a Japanese order, this being the largest instrument that he has made to date. He intends to make a gong of 110cm diameter that will fall just ten centimetres short of the largest gong in Solo made more than three hundred years ago. This instrument is in the royal collection at the Mangkunegaran Palace, Solo.

The process of melting the metals is known as *mbesot*. This is done in a large crucible (*kowi*) made at the foundry by a few of the craftsmen trained in this work. The crucibles are sculpted from a mixture of burnt, crushed charcoal *(abu)*, clay (*lempung*), and rice husks (*padi*). The crucible is then put out into the sun to dry for three days. It can then be fired in the hearth without risk of cracking.

The crucible is placed in the charcoal in the forge and heated using the *lamus* (see fig.2) Some charcoal is placed in the crucible in order to heat it more evenly.

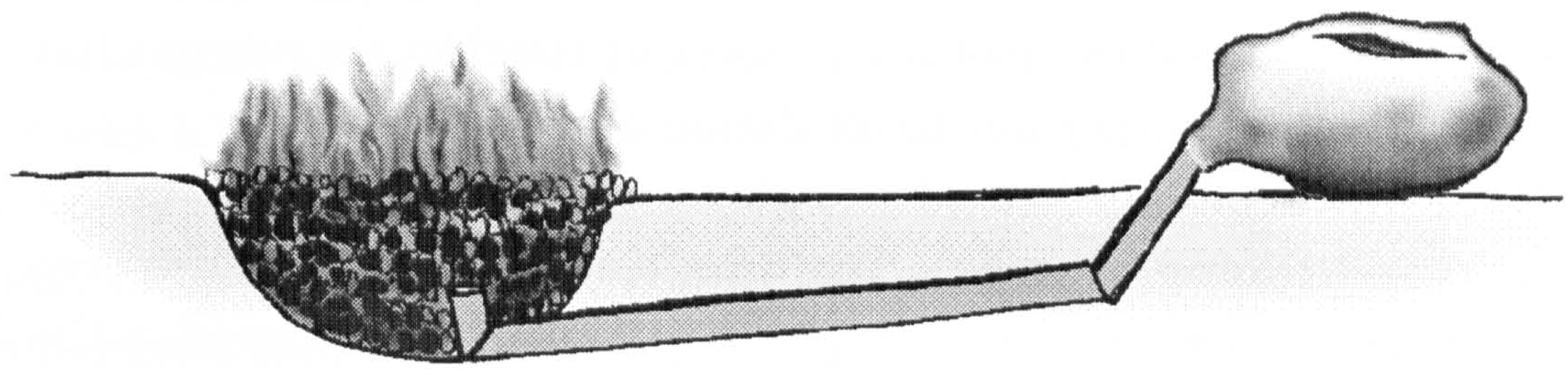


Fig. 2 Operation of the bellows (*lamus*).

After this initial heating the crucible is covered with charcoal and an overhead bellows (*congklok*) is used (see fig. 3).

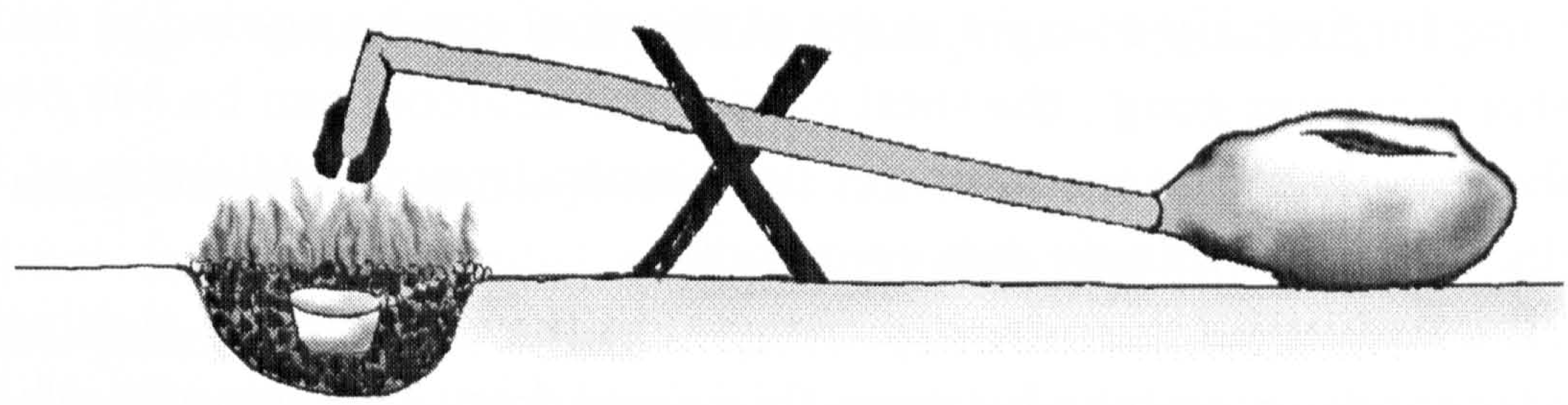


Fig. 3 Operation of *congklok*.

The *congklok* operates on a similar principle to the *lamus*. Formerly the *congklok* was made from a bamboo pipe,[20] but nowadays is made of a two or three metre long metal pipe of about ten centimetres diameter. At one end the bag is attached and at the other end an extension of the pipe is welded on through ninety degrees. A nozzle is sculpted around the blowing-end of the pipe to reduce the diameter to 25mm, thus increasing the blowing force. Like the crucible, this nozzle is made from a mixture of clay, crushed charcoal and rice husks. This mixture must be replaced every day since it is subject to the intense heat of the forge and tends to contract and crack. Should some of the mixture fall into the crucible it would spoil the metal since the clay will not burn off like the charcoal. It is possible to see the result of this in instruments made with less care than Pak Tentrem uses - some bars of the saron or especially those of the gender tend to buzz, and upon inspection of the under-side of the bar pockets of grit (from the mixture) may be noticed. The *congklok* is supported on a stand called *cekeh*.

The metal required to make the particular size of gong is weighed. A loss of metal during the melting process of roughly six percent has to be accounted for, this being due to oxidation and slag.

Once the crucible is heated to a glowing red, the copper is put in along with some burning charcoal. The whole crucible is then covered with charcoal and heated with the *congklok*. All the charcoal used in the forge is made exclusively from *kayu jati* (teak - *tectona grandis*). Teak charcoal is used since it produces an even heat. Although charcoal made from a more dense timber would burn hotter and longer, and be much cheaper, the heat produced would be too intense and would fluctuate too much. This intense heat could produce tin sweat (due its low melting point, the tin can ooze out of the alloy in a similar way to sweating cheese) and the uneven heating could cause the gong to crack or the metal to oxidise during forging. Up to eight sacks of charcoal can be needed to make a one metre diameter gong ; the total cost of the charcoal can be 300,000 rupiah (£90). The forge owner must get permission from the Ministry of Forestry to buy this increasingly rare commodity.

Depending on the quantity of metal in the crucible the melting process of the copper may take between thirty and forty-five minutes. The mound of red hot charcoal covering the crucible is removed with the wooden handled iron rods (*penyukat*). The state of the copper is inspected by moving the *penyukat* around inside the crucible - if the mixture still feels heavy it is not yet ready. Any slag from the copper is removed and the tin is added. The tin is added last since it melts at 232 degrees centigrade whereas copper melts at 1083 degrees centigrade. Charcoal is then piled over the crucible again and heated with the *congklok* to mix the metals.

Whilst the smelting is taking place the moulds (*penyingen*) are inspected for cracks and if any exist these are filled with soot from the roof. The mould which will be used to make the bronze casting or plate (*lakaran*) from which the gong is to be forged is placed on the edge of the hearth. The mould is heated by filling it with burning charcoal; this helps retard the cooling of the molten metal once poured.

The alloy is analysed by making two test-castings known as *njujut*. The tools required for this are a small crucible the size of a cup (*kowi cowek*) and a mould the size of a brick with two round, shallow depressions in the top of it known as *penyingen njujutan* (see fig 4). The mound of burning charcoal is once more removed from the top of the crucible and the slag drawn off. The small *kowi cowek* is dipped into the crucible and some of the molten alloy scooped out. The *panji* then pours this into the *penyingen njujut* which has previously been coated with bees wax (*malam*). The wax ignites, and rice husks are thrown over the molten alloy in order to retard cooling. Of these test castings, one will be used for a hot test (*jujutan*) and the other for a cold test (*gecakan*).

Fig. 4 Moulds for test castings (*penyingen njujutan*).

The small cast disc for the *jujutan* is knocked out of the mould whilst still red hot. It is then pounded with an iron club hammer (*geblog*) onto a thick steel plate to produce a thin tongue, which is then hammered over to form a tight curve. If this tongue of metal breaks or cracks, there is insufficient tin in the alloy. The other disc is taken out of the mould and moved about on the smithy floor in a pile of damp charcoal dust. It must not be quenched in water as this would not make the bronze brittle. It is then broken by pounding with a hammer so that the structure of the bronze may be assayed. Great experience is required to judge the quality of the bronze, so it is the *panji* who carries out this test. Once they have judged the broken pieces of bronze, they are passed around the forge for the other workers and apprentices to study. If the break is smooth and shiny, the bronze contains too much tin. This can be corrected by adding copper or simply heating the alloy longer so that more tin is burnt off in the form of oxides. The term for adding more copper is *nyolok*. If, on the other hand, the break is rough and a little dull, too much copper has been added. The only way to correct this is to add more tin; this process is known as *nyangoni*.

If both of these tests are satisfactory the bronze may be poured into the mould to produce the *lakaran*. This mould is called *penyingen bunderan* (see fig. 5). Before the casting takes place wax is melted onto the surface of the hot mould which has been made level on the smithy floor.

Fig. 5 Mould for *lakaran* (*penyingen bunderan*).

The mound of burning charcoal covering the crucible is removed. The crucible is taken out of the hearth, the slag drawn off, and then the metal poured by the *panji*. During pouring the face of the *panji* is protected from the intense heat of the molten bronze by a screen made of split bamboo lattice work, known as *aling-aling*. Rice husks are thrown on the molten metal which ignite and retard cooling (see fig. 6). A fragile crust of slag is allowed to form which, is then drawn off with an iron rod and the surface is again covered with rice husks. The *lakaran* is allowed to cool in the mould for twenty minutes and then removed and set aside for the following morning. The mould is placed at the edge of the hearth to prevent rapid cooling which might cause it to crack.

Fig. 6 Throwing rice husks on the molten bronze to retard cooling.

The forging

There are eight distinct processes in the forging of gong and kempul. They are:

a) *ngucik* - making the *lambe,*
b) *njereng* - making the *uceng,*
c) *njebler* - making the *jleberan,*
d) *ndekung* - making the *bahu,*
e) *mencu* - making the *pencu,*
f) *membuat widengan* - making the *widengan,*
g) *mapak* - smoothing the *rai,*
h) *menda* - smoothing the *bahu,*
i) *membuat pasu* - forming the *pasu.*

The various parts of gong and kempul are named in figure 7

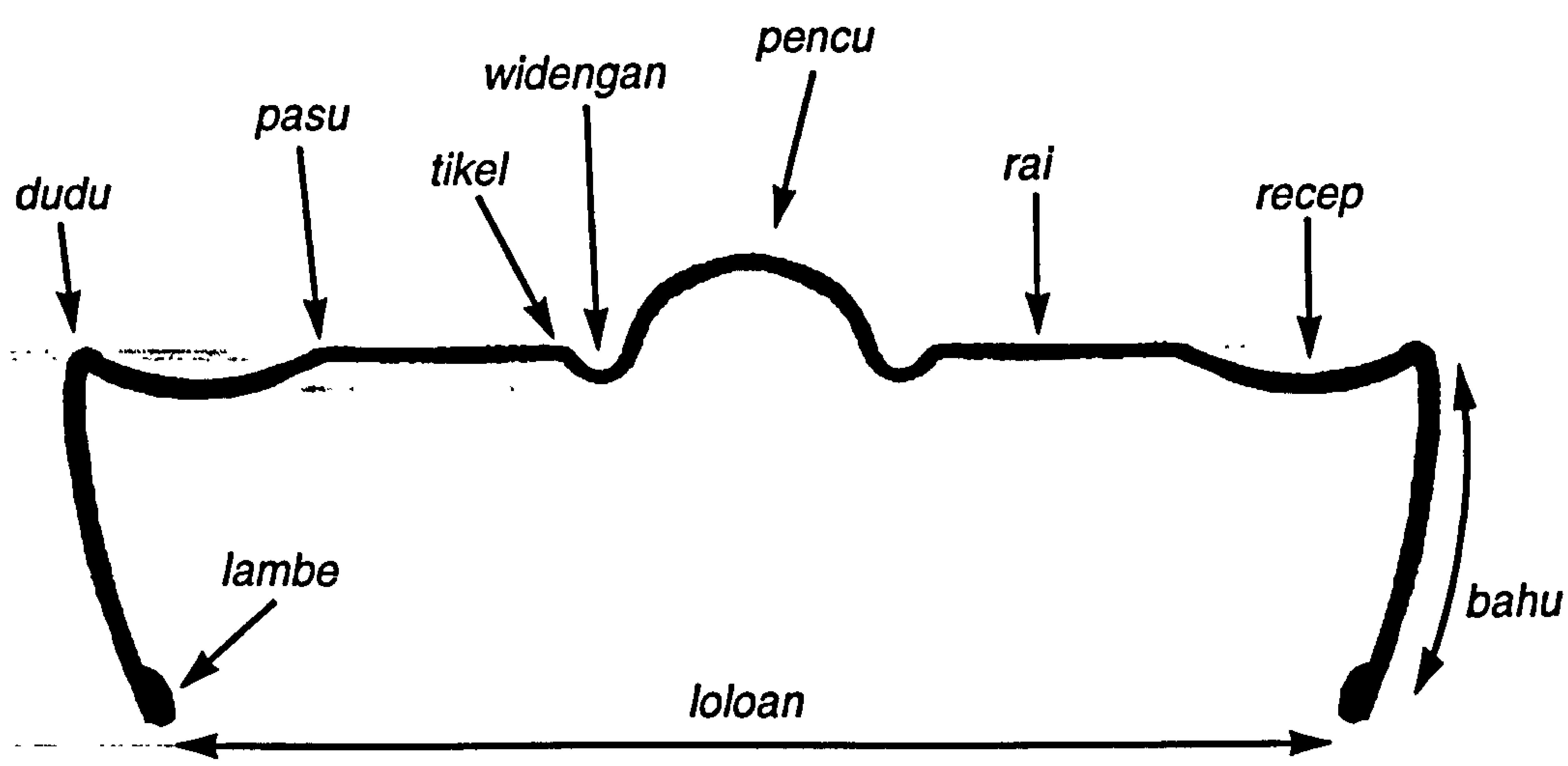


Fig. 7 Showing various parts of gong.

The days work starts with the heating of the *lakaran* made the day before. The *lakaran* for an 80cm diameter gong at this stage has a diameter of about 35cm, and thickness of 2.5cm. The *lakaran* is not perfectly round since no retaining hoop is used during casting.[21] The *lakaran* is heated to a glowing red colour, taken from the hearth and placed upright on its edge on the large flat iron anvil (*ladok tandes*) by the *pengalap.* A large mattock (*jugil*) is used to trim uneven edges to make the plate round.

The forging may now begin. There are five distinct types of iron hammers used during forging, each with a specific function. There are also four wooden hammers, most of these having the same name as their iron counterpart. The surface area of the striking part of the wooden hammers is very large, and they are used to smooth out any irregularities made by the metal tools. The hammers are listed below, starting with the one most frequently used known as *palu besi* (iron hammer). This is the only hammer that does not have a specific name, since it is used for many operations.

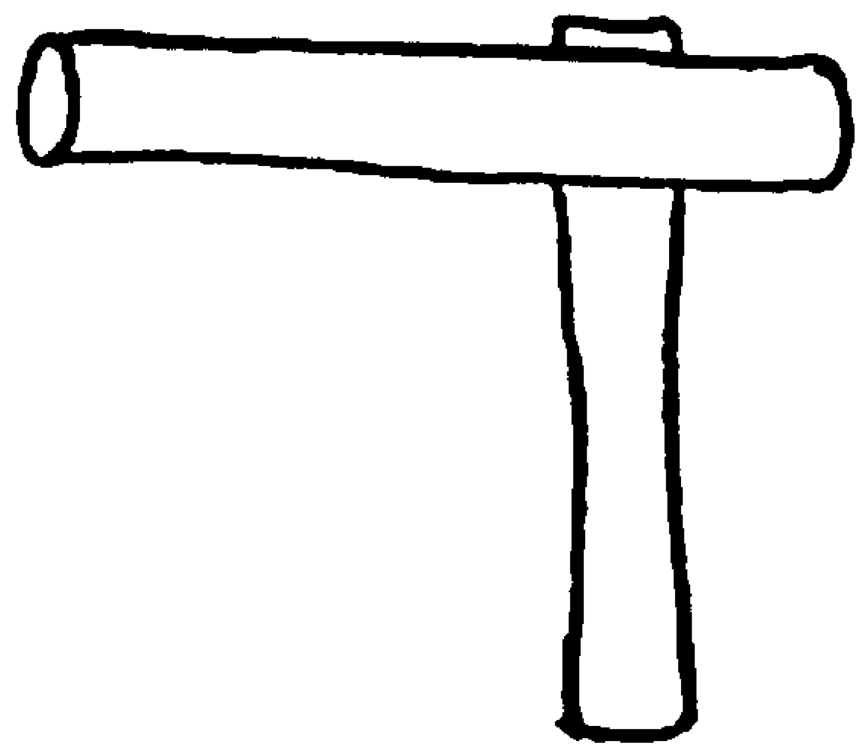


Fig. 8 *Palu besi* - These large hammers weigh between 10 and 15 kilograms and are used by the four *pemalu* during the stages of heavy forging.

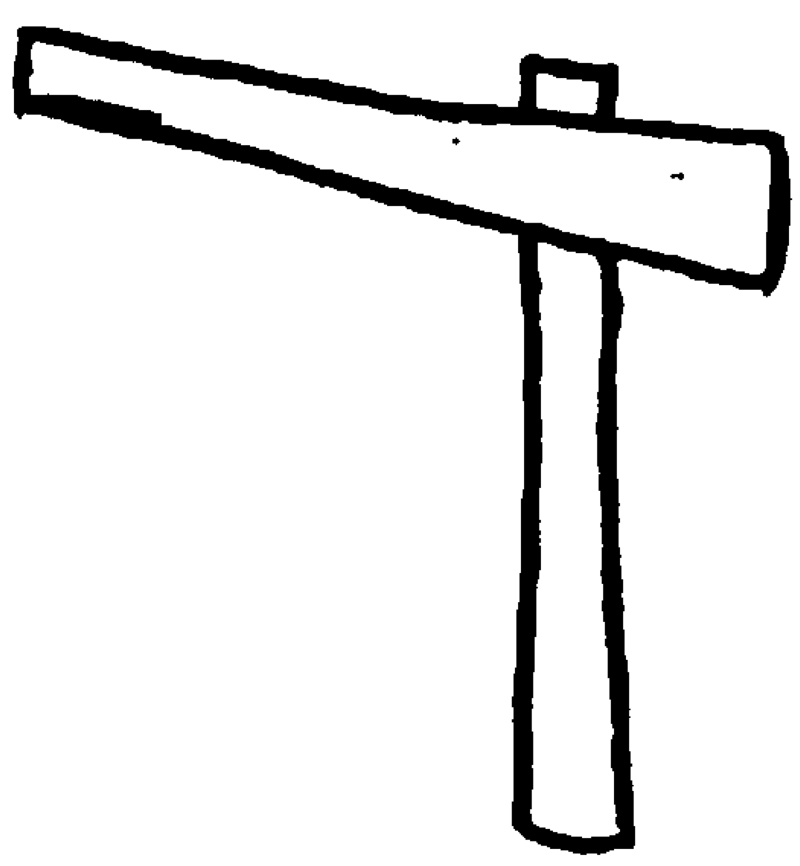


Fig. 9 *Palu ucikan* - There are two sizes of this hammer. The striking point of the larger one is quite small and is used to make the *lambe*. The smaller one (not pictured here) is the same shape and size as a builder's club hammer and is used in the forging of bar-type instruments.

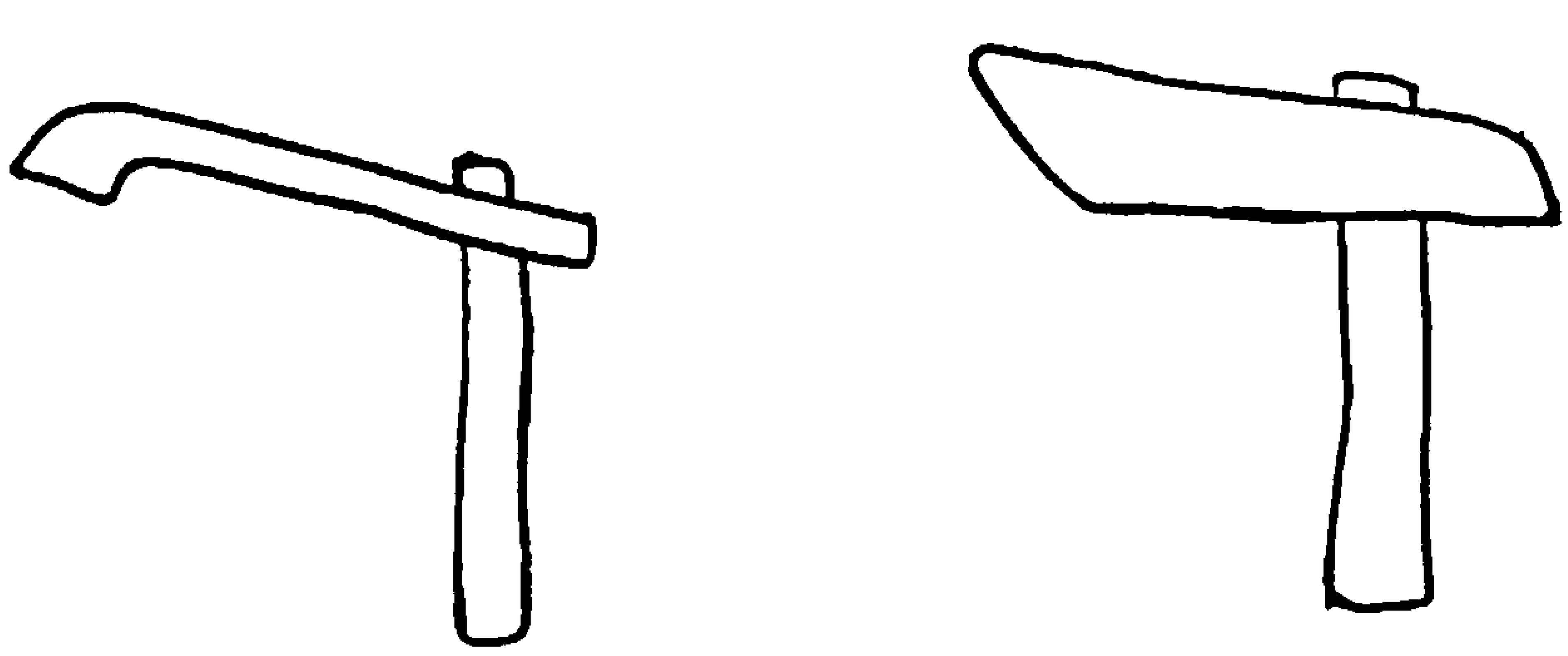


Fig. 10 *Palu mendan* metal version on left, wooden on right.

There are both metal and wooden versions of this tool. They are used to make the *bahu* (side-wall). The head of the metal version is not set square on to the handle but at an angle so that it may be used to hammer the bahu in a vertical plane, against the side of a large stone anvil set into the ground. The head of the wooden version is set squarely onto the handle but the striking end is cut off at an angle so that it can be used like the metal version.

Fig. 11 *Palu alang*, metal version on left, wooden on right.

The *palu alang* is used for making the *pasu* (the ring separating the *rai* from the *recep*). Its head is also set at an angle, like the *palu mendan* for ease of use.

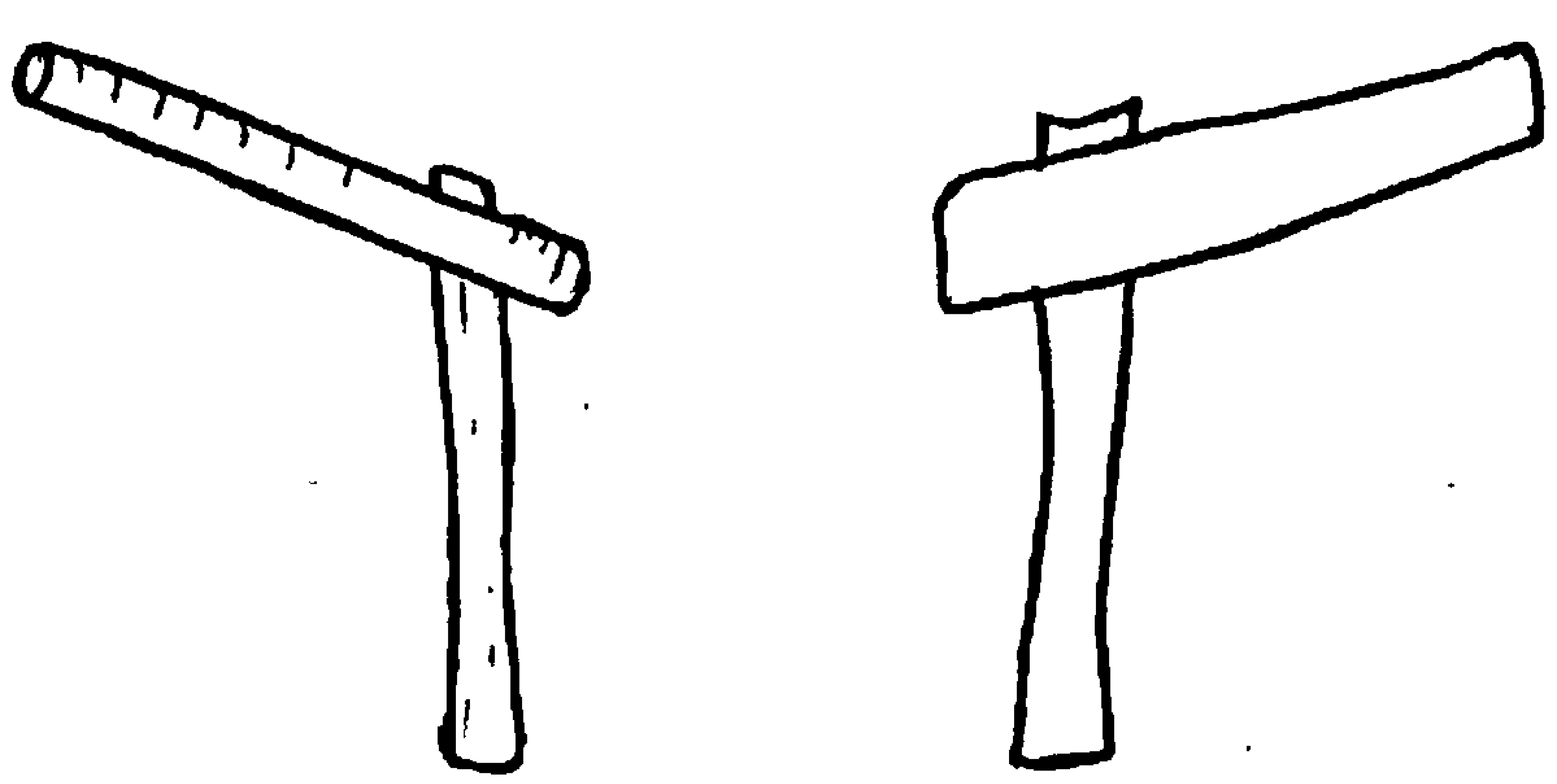


Fig. 12 *Palu penunjut*, metal version on left, wooden on right. The *palu penunjut* is used for making the *pencu* (boss).

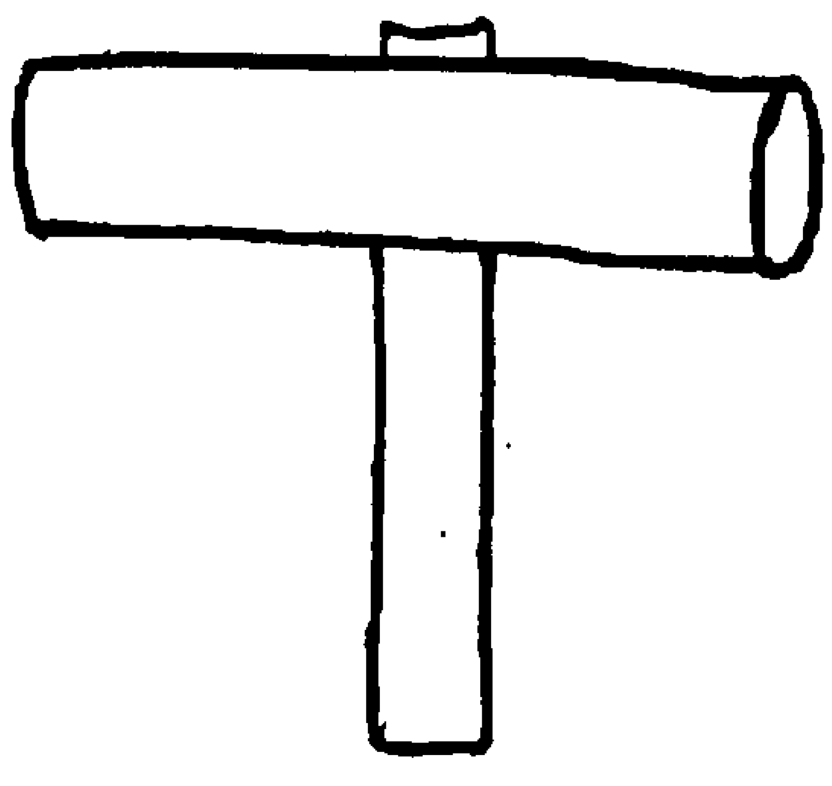


Fig. 13 *Palu laga*.

The *palu laga* is the largest of the wooden hammers. With the large diameter of the striking end it is used to even out any troughs and high points in the *rai* and *recep* made by the forging with the *palu besi*.

Ngucik - making the lambe

The *lambe* is the thick rim at the base of the *bahu*. The *lambe* is structurally very important; without it the gong would not retain its shape and the thin wall of the *bahu* would probably crack. It is also important during the actual forging since this rim allows the gong to be picked up securely with tongs.

The *lakaran* is heated in the hearth to red hot. The besalen is intentionally kept quite dark, with only two or three small windows at the top of the workshop, allowing very little light in. It is thus easier to assay by colouration the temperature to which the workpiece is heated. Metal which would appear red in low light conditions would appear grey in natural sunlight. Hence flash photography in the smithy makes the workpiece grey when it was actually red hot when the photograph was taken. The temperature to which the workpiece is heated before each bout of forging is quite critical. If it is too hot, the tin will start to sweat, altering the composition of the alloy.

The *lakaran* is taken from the hearth by the *pengalap* and placed on its edge on the *ladok tandes*. It is held upright with a pair of tongs (*supit cocor*) by the *pengider* whilst the *palu ngarep* pounds the edge of the *lakaran* with the smaller of the two *palu ucikan*. During this pounding the *pengider* rotates the *lakaran* with the *supit cocor* so that the whole circumference is hit in this way. The *lakaran* may only be pounded for twenty-five seconds or so before it must be returned to the fire to be reheated.

The red hot *lakaran* is now placed flat on the *ladok tandes* and hammered about three centimetres from its edge with the special *palu ucikan,* whilst being turned in between each blow by the *pengider*. The angle at which the hammer head is set into the handle has the effect not only of compressing but also of pulling or spreading the metal towards the edge thus making the *lambe* thicker. This operation is repeated a number of times until the *lambe* is of equal thickness around the circumference.

During the *lambe* making process a layer of moist clay [22] is laid on the *ladok tandes* so as to support the *lakaran* at the desired angle. This clay is kept moist and thus malleable by splashing with water between each round of pounding. The part of the *lakaran* that is being pounded is always directly in contact with the large, flat iron anvil (*ladok tandes*). The clay support is known as *ganjel.*

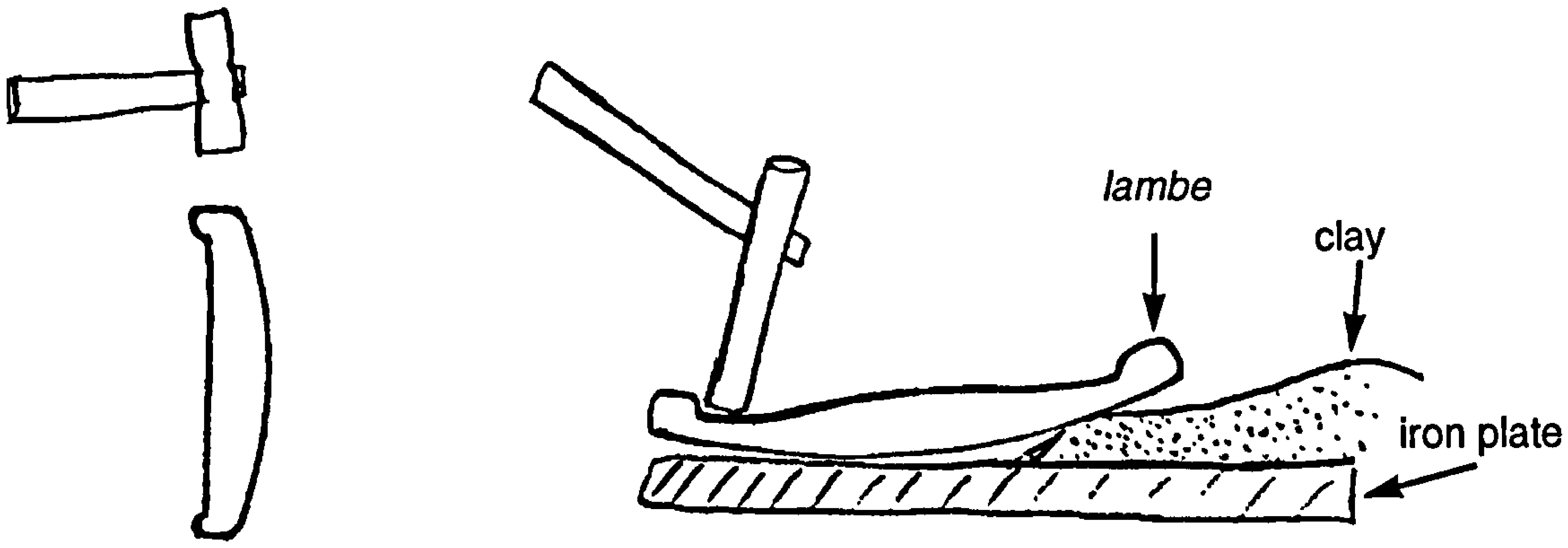


Fig. 14 showing the two stages of making the *lambe.*

Njereng - making the uceng

The *uceng* is the central part of the *lakaran* which is left at almost the original thickness of the cast plate. The *uceng* is an area of about ten centimetres diameter, which will later be forged into the boss (*pencu*).

The glowing *lakaran* is taken out of the fire and placed on the *ladok tandes*. The *palu ngarep* and *palu tengah* now start pounding the *lakaran* about ten centimetres from its centre with the large *palu besi.* The two smiths alternate hammering in quick succession, whilst the *pengider,* who holds the *lakaran* flat on the anvil with his tongs, turns the workpiece in between each blow in a clockwise direction. It is turned just a little so that the hammer blows, which fall on the same place on the anvil, just overlap each other on the *lakaran.* Because the *lakaran* is at this stage quite thick, it retains heat better and can thus be forged for about thirty seconds before it has to be returned to the *prapen* to be reheated. This process of forging and reheating is repeated perhaps six or seven times until the area surrounding the *uceng* is made to the required uniform thickness.

Njleber - making the jleberan

Making the *jleberan* can be seen as a continuation of forming the *uceng,* where the forging extends to the *lambe.* The *jleberan* is the form that the *lakaran* assumes after its diameter has been increased by the forging. During the *njleber* process all four smiths may pound at the same time (see fig. 15). The *palu ngarep,* who starts the pounding, stands next to the *pengider.* The other smiths, namely the *palu tengah,* the *palu apit,* and the *palu tepong* stand in order to the *palu ngarep's* right. All the smiths apart from the *palu tepong* wield their hammers right-handed. The fourth smith must wield his hammer left-handed because all the hammer blows must hit the same spot on the anvil; if he was using his tool right-handed he would have to stand further away from the *lakaran,* and stretch to hit the exact point.

Fig. 15 The four smiths pounding the workpiece.

Upon the command of the *pengider* the *palu ngarep* strikes the *lakaran* with his *palu besi* and is followed in order by the other smiths so that the *palu ngarep* follows the *palu tepong* to start the next round of pounding. The metal can be hammered for about twenty-five seconds before it must be reheated, and within that time about thirty-five hammer blows are made. During the pounding the *pengider* turns the *lakaran* after each blow of a hammer. At the end of each round the *lakaran* is marked with chalk before returning to the fire so that the smiths know from where to start again. The smiths work gradually towards the *lambe* so that a spiral of hammer blows emerges (see fig. 16).

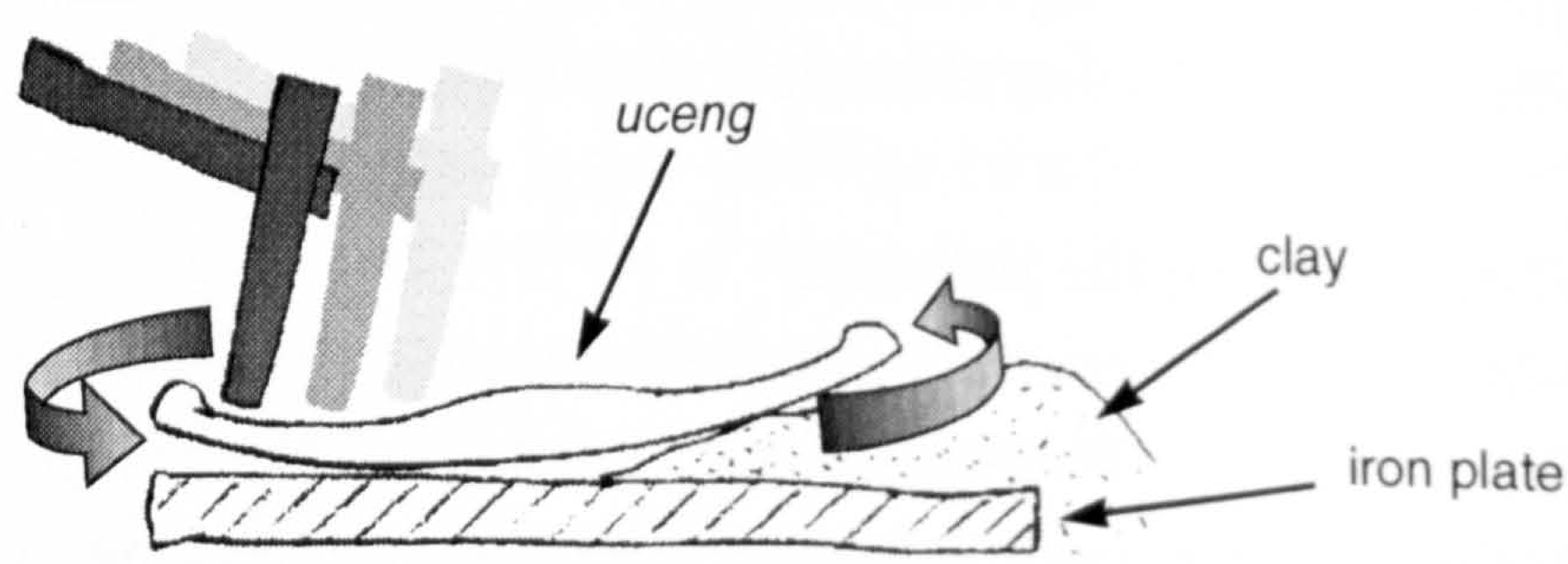


Fig. 16 Making the *jleberan.*

Once the edge of the *lakaran* has been reached, the *palu ucikan* is again used to maintain the *lambe*. After this the large wooden *laga* hammer is used to smooth out any irregularities in the thickness of the metal caused by the use of the *palu besi*. Attention is paid to the shape of the *lakaran* for roundness. This checking is done only by eye, yet remarkable accuracy is gained through years of experience. The area needing attention is marked with chalk, returned to the fire and then corrected by pounding with the smaller *palu ucikan,* which has a large head to avoid denting and making thin spots. The whole process is then started again, working from the centre using the four *palu besi*. This work is continued until the *jleberan* is at the required diameter; this may take four or five complete rounds for a small gong, and many more for a large gong ageng.

As in making the *uceng,* half the plate is slightly raised by placing a layer of clay beneath it. More and more clay is added as the plate becomes larger and more dish-like. As the *lakaran* gradually becomes thinner the blows of the *palu besi* must be lighter. It should also be noted that as the metal becomes thinner its capacity to retain the heat diminishes, so the rounds of forging are successively shorter.

Ndekung - making the bahu

The *bahu* is the side wall of the gong, and the process of making it is called *ndekung*. The *jleberan* is now quite dish-shaped, and the outer-part of the *jleberan* (the area that will form the *bahu*) must be turned up to stand perpendicular to the central, flat portion of the *jleberan.*

A large mound of clay is placed on the *ladok tandes* (fig. 17) which will support the *jleberan* at roughly forty-five degrees to the *ladok tandes*. The red hot *jleberan* is placed on the *ladok tandes* and pounded with the large wooden *laga* about two-thirds from the centre of the workpiece. One of the helpers prevents the mound of clay moving by placing his foot against it. At the beginning of this process the *pengider* turns the *jleberan* through thirty degrees between each blow of the *laga*. This initial forging has the effect of creasing the side wall. Once the whole disc has been pounded in this way the *pengider* turns the workpiece through smaller rotations so that the creases are evened out

The workpiece is now bowl-shaped, the *bahu* being about twenty centimetres high; the term used by the gong smiths for the workpiece is now changed to *klontong*. The clay is removed from the *ladok tandes* and the red hot *klontong* is placed flat on the anvil for the next stage of forging. One of the smiths now uses the *palu ucikan* to pound at the internal corner of the *klontong*. This is done to increase the diameter of the flat part of the workpiece (see fig. 18). The head of the hammer is off-set in such a way as to pull the *bahu* back and down, thus reducing the height of the *bahu*. This process is continued by just one of the smiths until the height of the *bahu* is reduced to five centimetres or so.

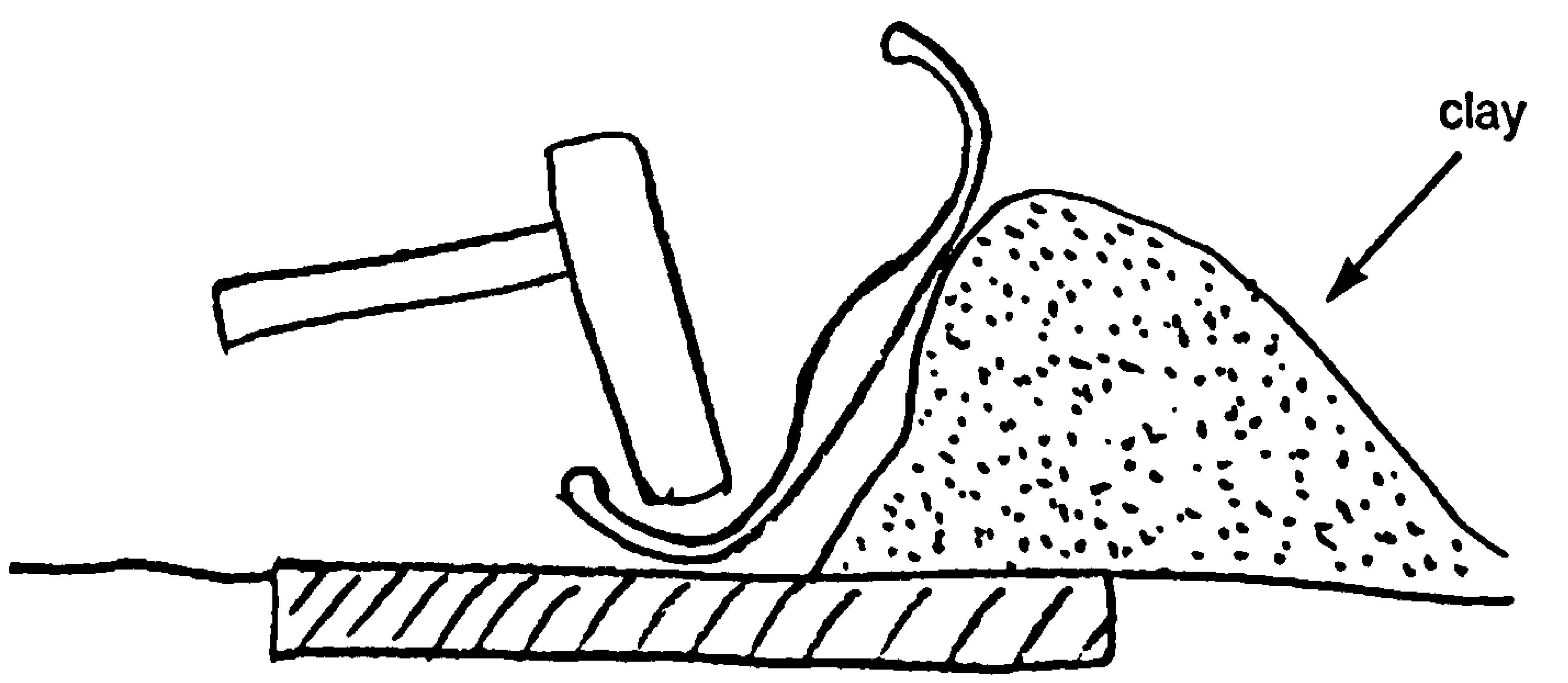


Fig. 17 Forming the *bahu*.

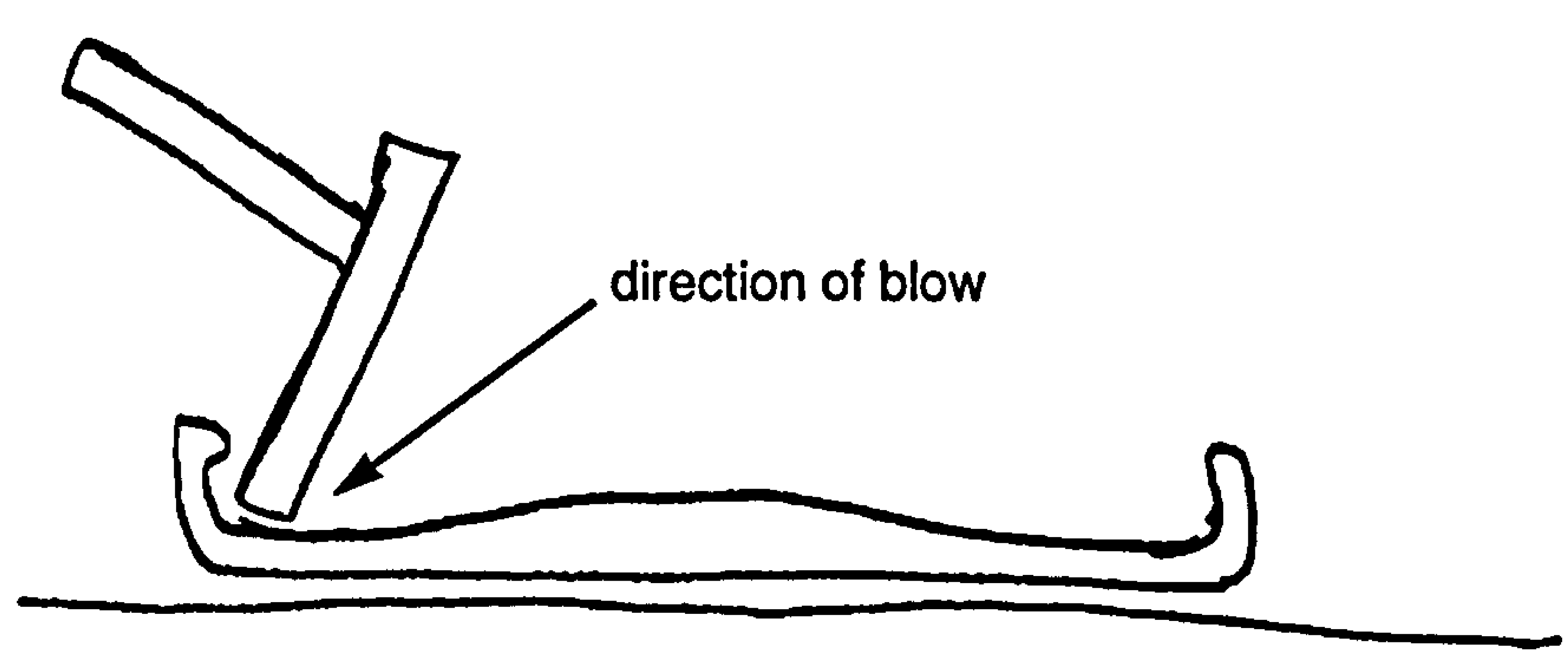


Fig. 18 Process to reduce the height of the *bahu*.

The *bahu* is checked for uniformity in height and thickness. The *bahu* is quite creased, as a result of forging. This is evened out by hammering the *bahu* against the stone anvil (*ladok mendan*) with the *palu mendan* (see fig.19). The workpiece is supported on two lengths of bamboo. A section of fresh (wet) split banana trunk is placed on the bamboo so that the gong rests directly on the soft, fibrous material. This allows the gong to be turned easily by the *pengider* or *panji* during forging. After each bout of pounding the banana trunk support must be renewed since it is dried out very quickly by the red hot gong.

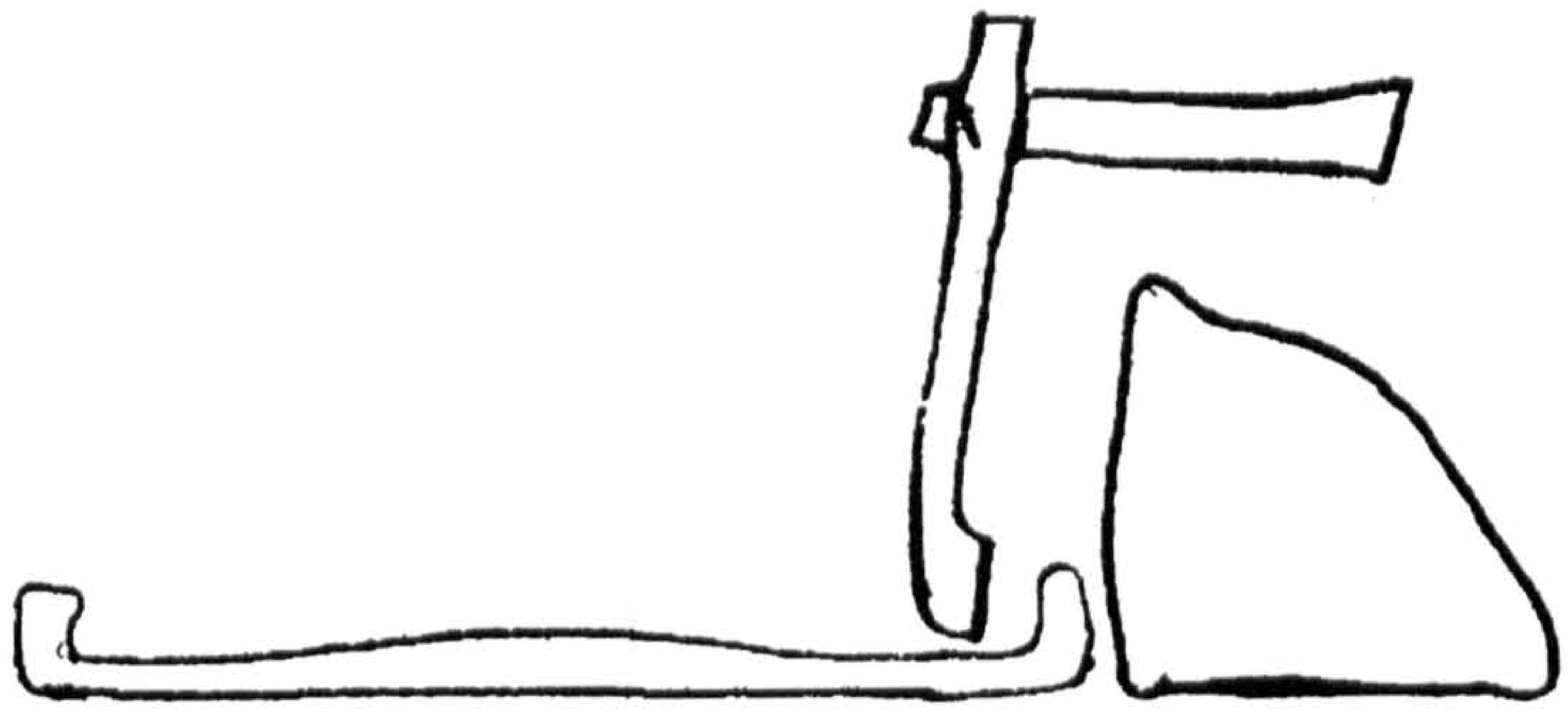


Fig. 19 Working *bahu* on the *ladok mendan.*

Once the circumference of the *bahu* has been hammered smooth, the workpiece is reheated and returned to the *ladok tandes*. It is laid flat on the anvil and the *lambe* is hit so as to make the height of the *bahu* uniform (see fig. 20).

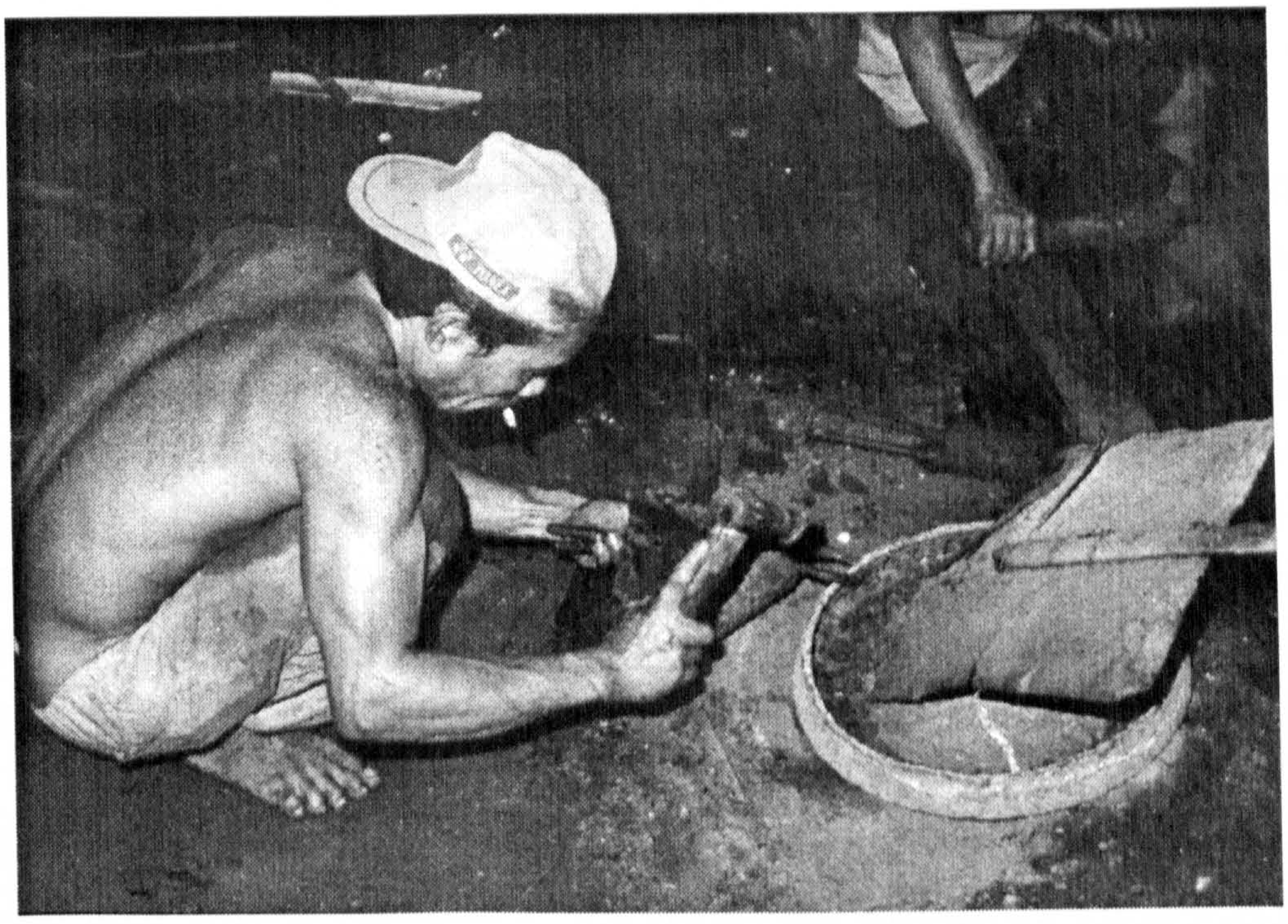


Fig. 20.

The process of expanding the gong is started again. It shall be seen that once the *bahu* has been made higher it is again made smaller thus increasing the diameter of the whole workpiece; these processes are continued until the gong has the correct diameter and the *bahu* is the correct height.

Fig. 21.. Fig. 22.

The forging is started again, using the large iron hammers (see fig. 21). On a medium-sized gong or large kempul three smiths work at the pounding, in the manner described for the *jleberan*. A layer of clay is placed on the *ladok tandes* to support the workpiece at an angle. The interlocking pounding is started this time at the centre and follows the spiral pattern to the edge (fig. 21). From starting at the centre to reaching the side wall, the gong will have to be reheated about six or seven times. Once the sidewall of the gong has been reached it is necessary to even out the sidewall by hammering with both the wooden and iron versions of the *palu mendan* (see fig. 22). The sidewall of the gong is kept at the correct angle to the stone anvil by supporting the gong on two lengths of bamboo (fig. 22). Figure 23 shows the forms the workpiece passes through during this process. This process makes the *bahu* higher, but if the diameter of the gong is not yet large enough the height of the *bahu* must again be reduced by using the *palu ucikan* in the manner previously described (see fig. 18). These two processes have to be repeated about eight times for a small gong, and many more for a large gong ageng. As the gong reaches its required size the diameter is checked with a large pair of measuring dividers known as *jongko*. The *jongko* are also used to make sure the gong is perfectly round. Areas to be hammered are marked with chalk before returning the workpiece to the forge.

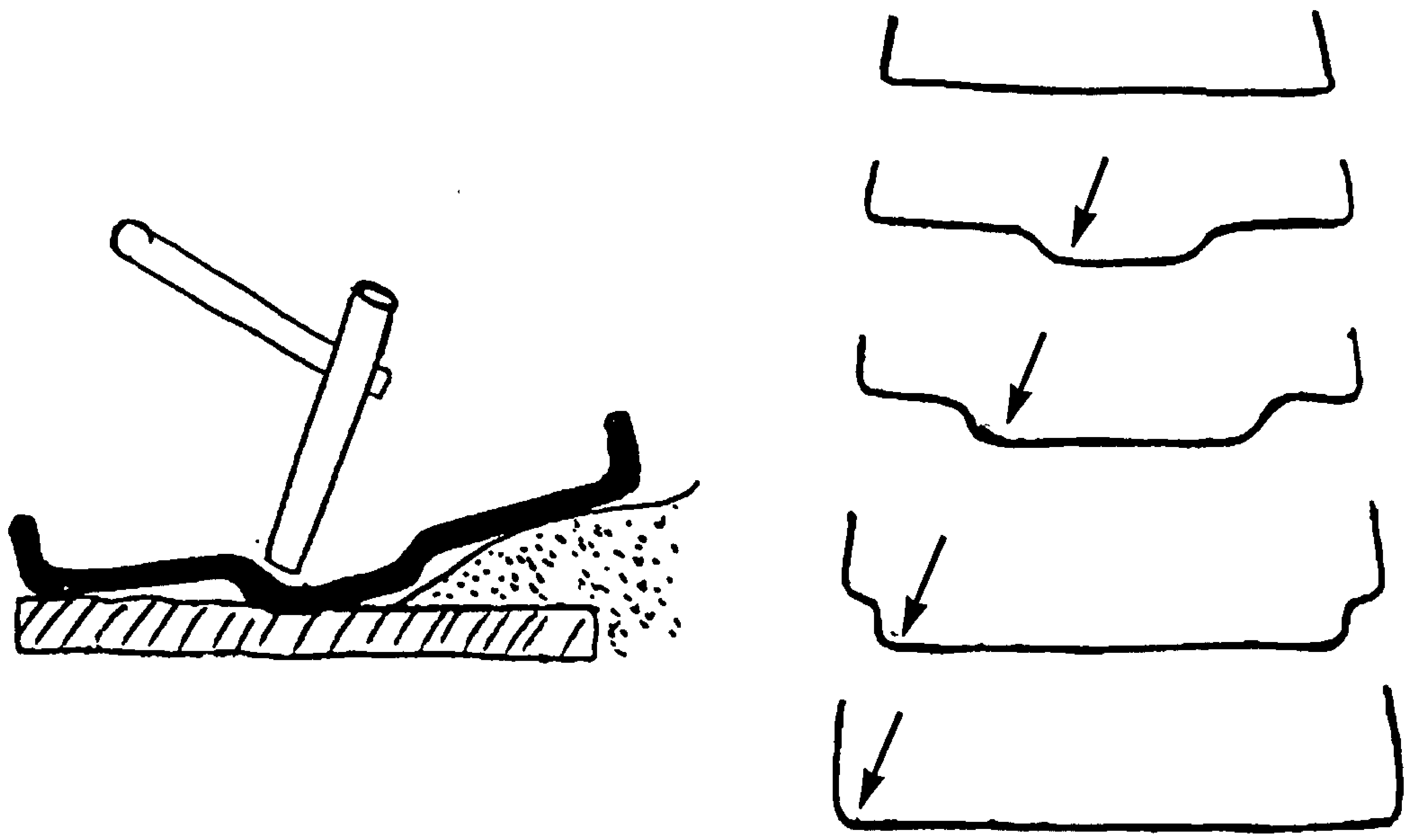


Fig. 23.

Mencu - making the pencu

Once the gong has reached the required size the boss (*pencu*) is hammered out. This process is referred to by the smiths as *mencu.* Jacobson states that the boss "which the Javanese layman calls *pencu,* is known to the gongmaker as *endas* (head)".[23] The *ladok tandes* is prepared by making the clay floor level with the sunken iron plate (see fig. 24). A hole is then made in the clay on one side of the plate for the boss. Sections of banana trunk are laid on the plate and on the clay floor; the gong lies directly on these when it is turned and pounded.

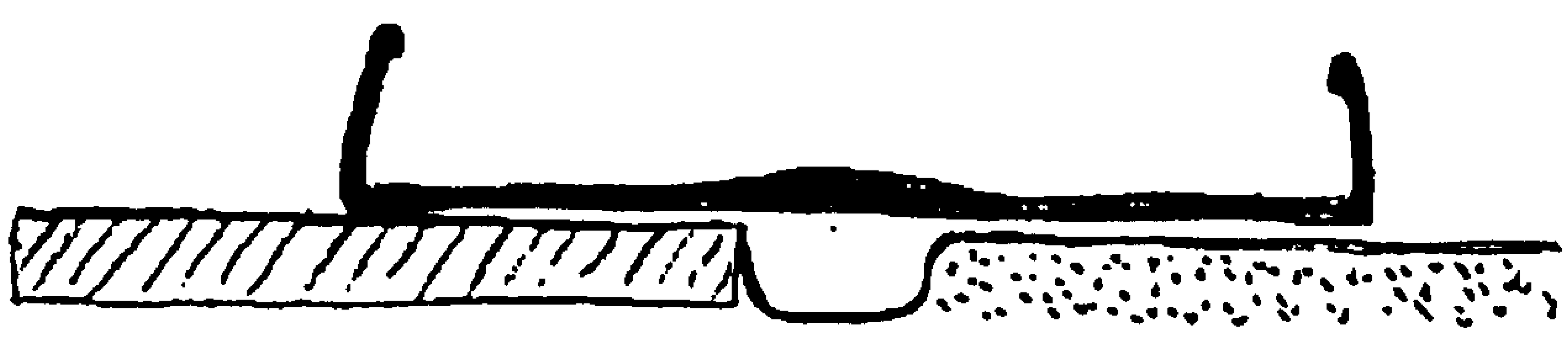


Fig. 24 *Ladok tandes.*

The glowing gong is placed on the *ladok tandes* with its centre directly over the hole in the ground. One smith now pounds the centre of the gong with the *palu penunjut,* a metal hammer specially made for this purpose (fig 25). While the smith stands, legs apart, directly over the workpiece, commands are given to him by the *panji* on the strength of the pounding and when to start and stop. Exactness is required here, so the interior of the gong is illuminated with a length of burning wire which is dipped in paraffin. This torch is known as *colok.* The face of the smith who bends directly over the glowing workpiece is protected from the intense heat by a large fan known as *aling-aling.* The *colok* and *aling-aling* are held by one of the helpers.

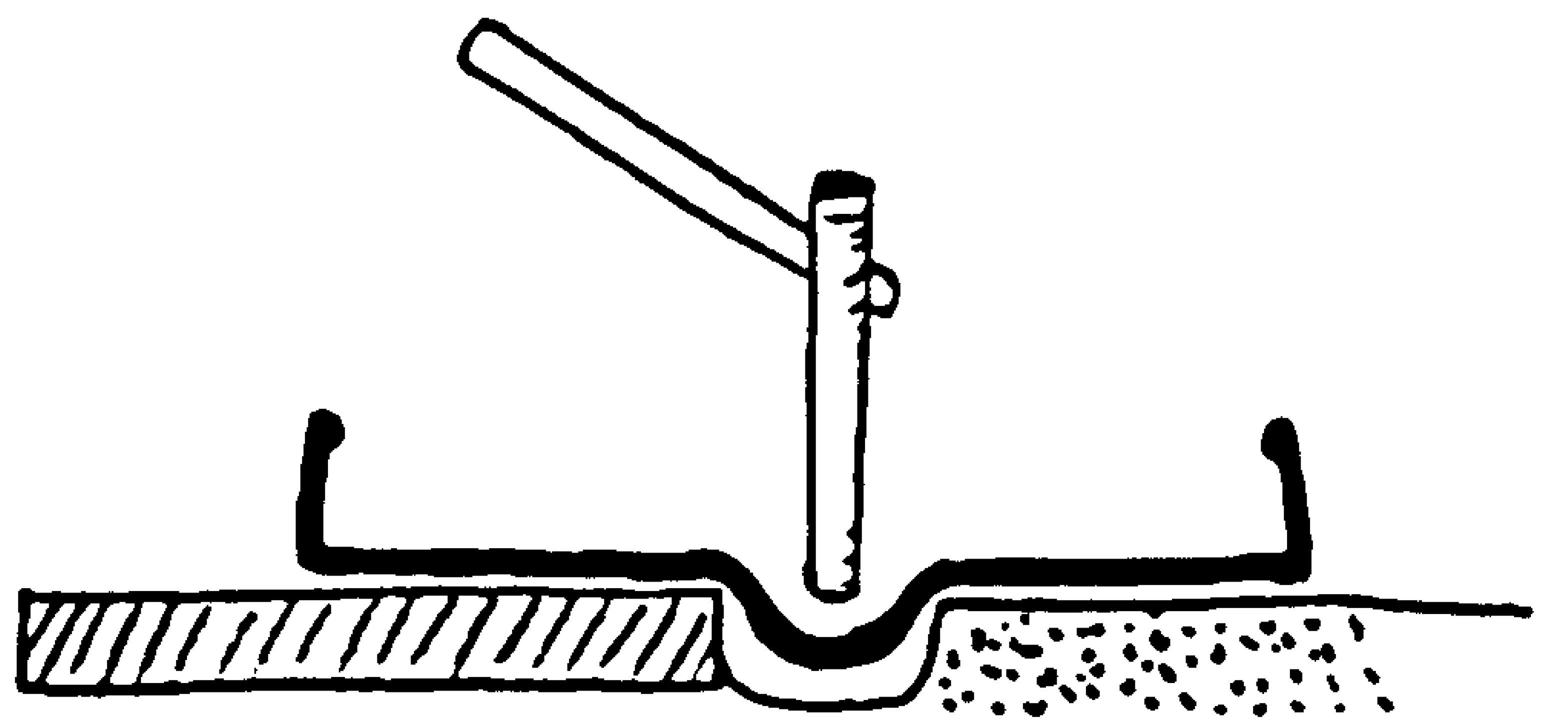


Fig. 25 Hammering the boss out squarely.

Once the boss has been partly pounded out at its centre, the hammer blows are placed so as to strike the base of the boss where it meets the *rai* (*pok pencu*), against the edge of the iron plate (see fig. 26). This process is called *kamilan.* All this time the gong is turned by the *pengider* between blows of the *palu penunjut.* This is done to make the foot of the boss smooth, round and symmetrical, against which the rest of the partly shaped boss may be judged.

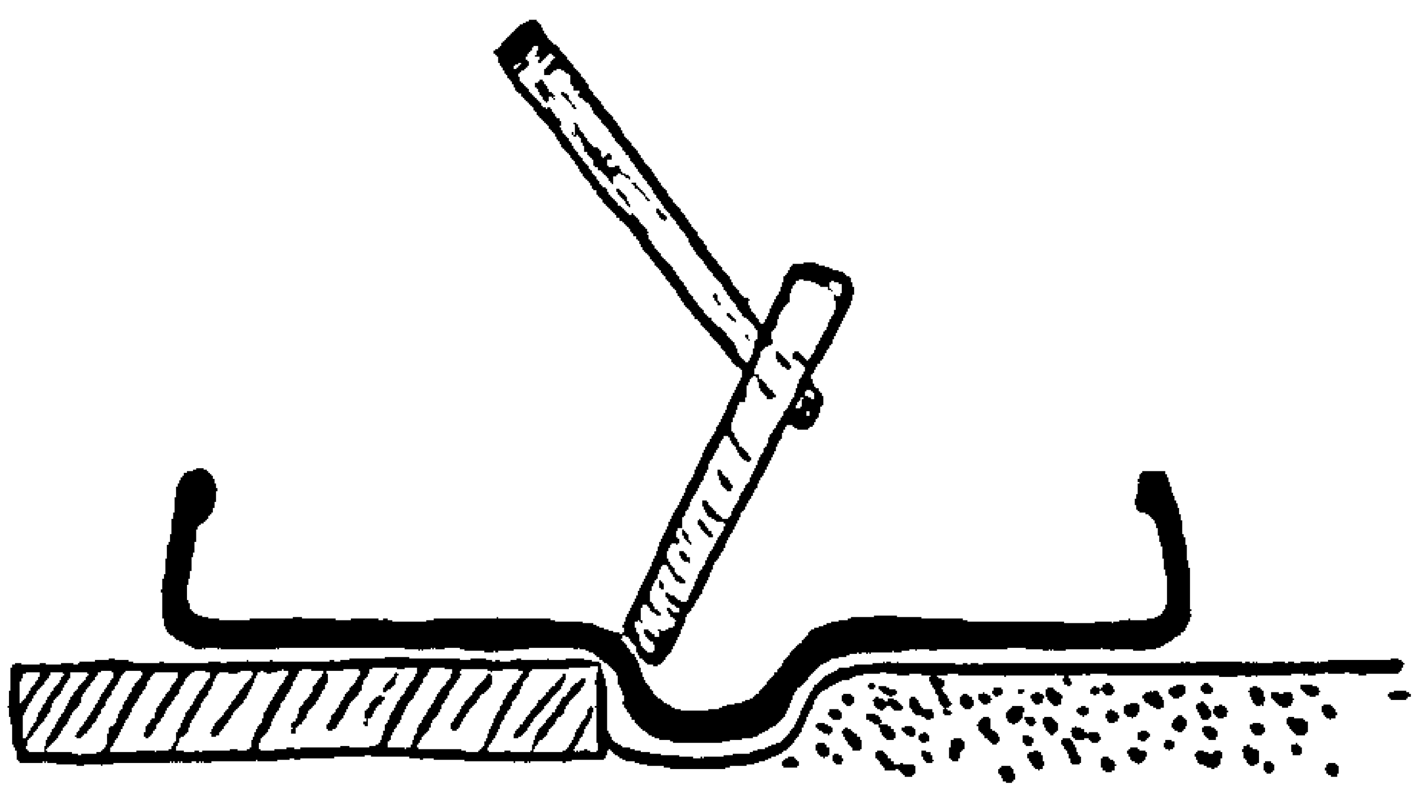


Fig. 26 Shaping the boss.

During this critical stage the gong is only pounded for very short periods, whereupon it must be turned over and inspected. Chalk is used to mark areas where more hammering is required, and the gong is reheated. With the pounding and turning of the gong, the hole in the clay assumes the shape of the boss so that the boss is actually being hammered against the clay. The final shaping of the boss is done with the wooden *palu penunjut* which will smooth out any irregularities in the *pencu*.

Membuat widengan - making the widengan

The *widengan* is a groove at the base of the *pencu,* the outer ridge of which is called *tikel*. The *widengan* is made on all but the largest of gongs and is said to produce a fuller tone. There appears to be some confusion regarding its origins and significance: Pak Tentrem told me it was introduced by a Solonese gongsmith, Kjai Guno Pawiro, and the tradition continued as a hallmark of "instruments of quality from Solo". It is true that Solo is one of the few places where such instruments exist but not the only place where where they are made; Jacobson[24] notes the use of the term *'widengan'* for the groove and instruments employing it "are in demand principally in Solo". He also writes "according to the gongmakers, this feature was adopted during the Majapahit empire from gongs made in Siam".

The *widengan* is made by placing a bent piece of wire on the edge of the *ladok tandes,* placing the red hot instrument on the anvil so that the wire is in contact with the foot of the *pencu* and then pounding this area with a large wooden hammer (see fig. 27).

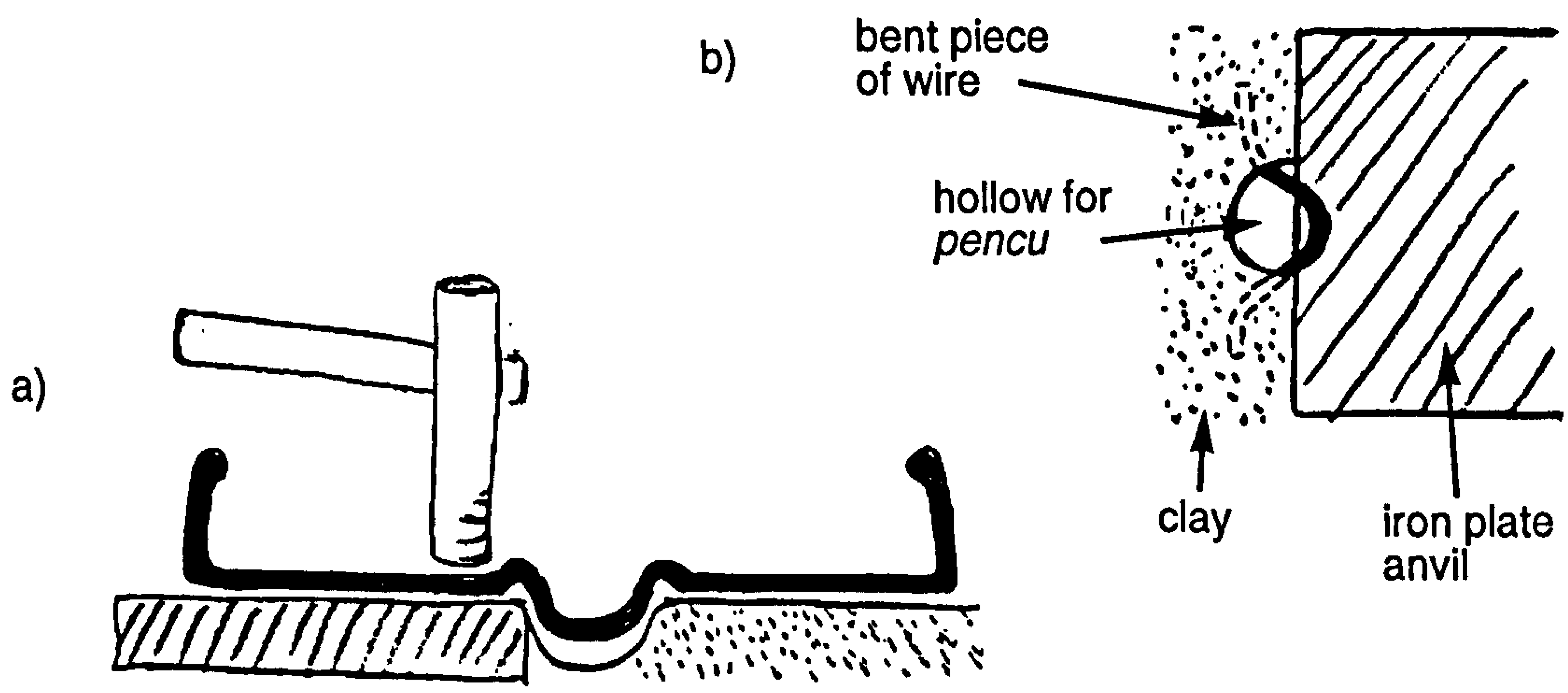


Fig. 27 Making the *widengan*, a) elevation, and b) plan of anvil.

Mapak - smoothing the rai

Mapak is the process of smoothing out and correcting any irregularities in the thickness of the *rai*. The instrument is placed upside down with the *rai* resting on the *ladok tandes*. The *rai* is pounded from the inside using the large-headed wooden *laga*. This stage is very important since it is the *rai* that is the main 'voice' of the gong and consequently the forging is either carried out by, or supervised by, the *panji*. A high degree of concentration and skill is needed to avoid piercing the thin *rai*; any mistake at this stage could easily cause irreparable damage. The longer the time spent hammering during *mapak* to ensure uniform thickness, the better the voice of the gong will be.

Once the whole of the *rai* has been treated in this way, the internal corner of the *dudu* is also shaped with the rounded tip of the wooden *palu mendan*. This is to ensure that the *dudu* has the same shape about its whole circumference.

Menda

Menda is essentially the same process as *mapak*, but is carried out on the *bahu*. The gong must be supported so that the *bahu* rests against the *ladok mendan*. This is achieved by supporting the gong on the *rai* on two pieces of bamboo (see fig. 28). The bamboo can be pivoted at the base of the *ladok mendan*, enabling the helper who is holding the other ends of the bamboo to change the angle at which the gong is supported. The curved *bahu* can thus be kept in contact with the stone anvil at any point of its curvature by raising or lowering the height of the bamboo. Segments from the trunk of the banana tree are placed in between the bamboo and the gong so that the instrument may easily be turned, without damage, during the forging. The forging is done with the wooden *palu mendan*, the head of which is cut at roughly forty-five degrees to the handle.

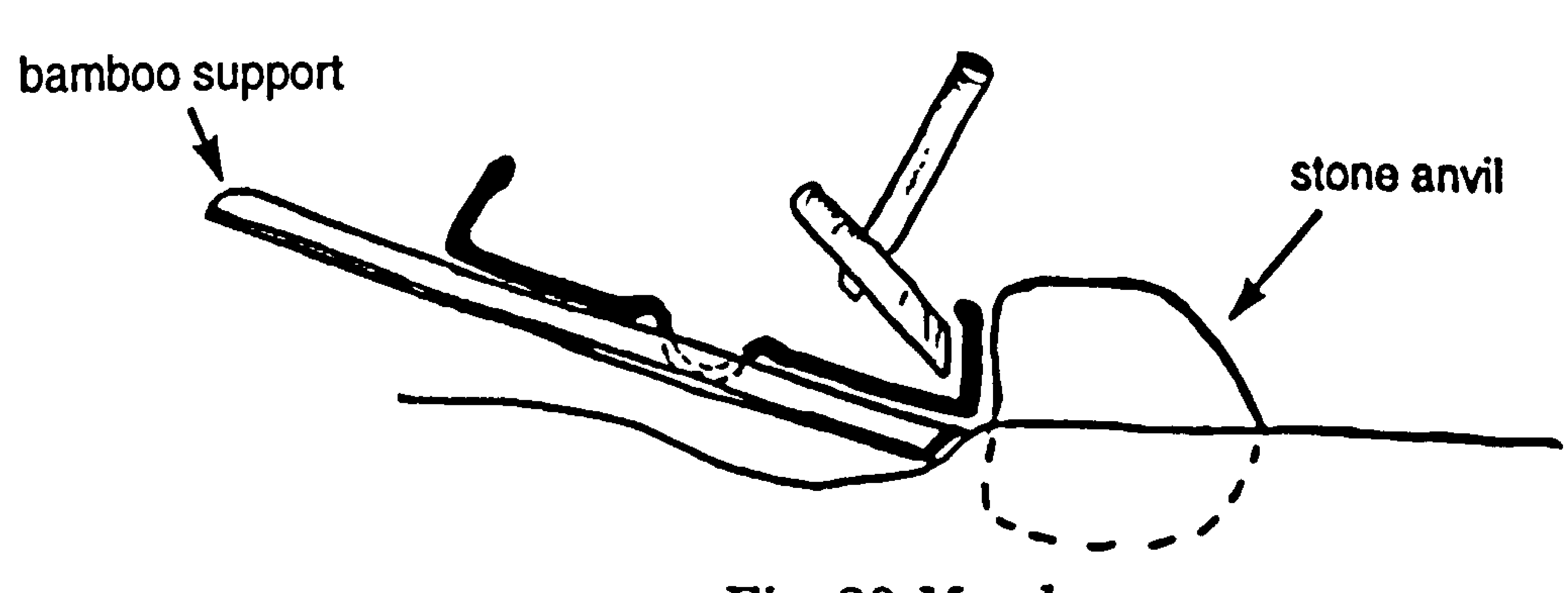


Fig. 28 *Menda*.

Membuat pasu - making the pasu

The *pasu* is the circle which separates the *rai* from the *recep.* The *pasu* is formed by pounding from the inside of the gong, whilst it rests on the *ladok tandes* (see fig. 29). A thin layer of clay is placed on the flat iron plate so that the gong is not in contact with the iron. The part of the gong that is not supported on the anvil rests on strips of banana trunk.

Through experience the *panji* knows the correct position of the *pasu,* although he may also check this by reference to an existing instrument. The *pasu* is marked with chalk on the inside of the instrument before being reheated. At first the wooden *palu alang* is used to define the circle where the *rai* and *recep* meet, and once the gong has been turned over to inspect the *pasu* the metal version of this pointed hammer is used. Having completed the *pasu,* the gong is inspected for any damage done to the boss and other areas which are corrected at this point.

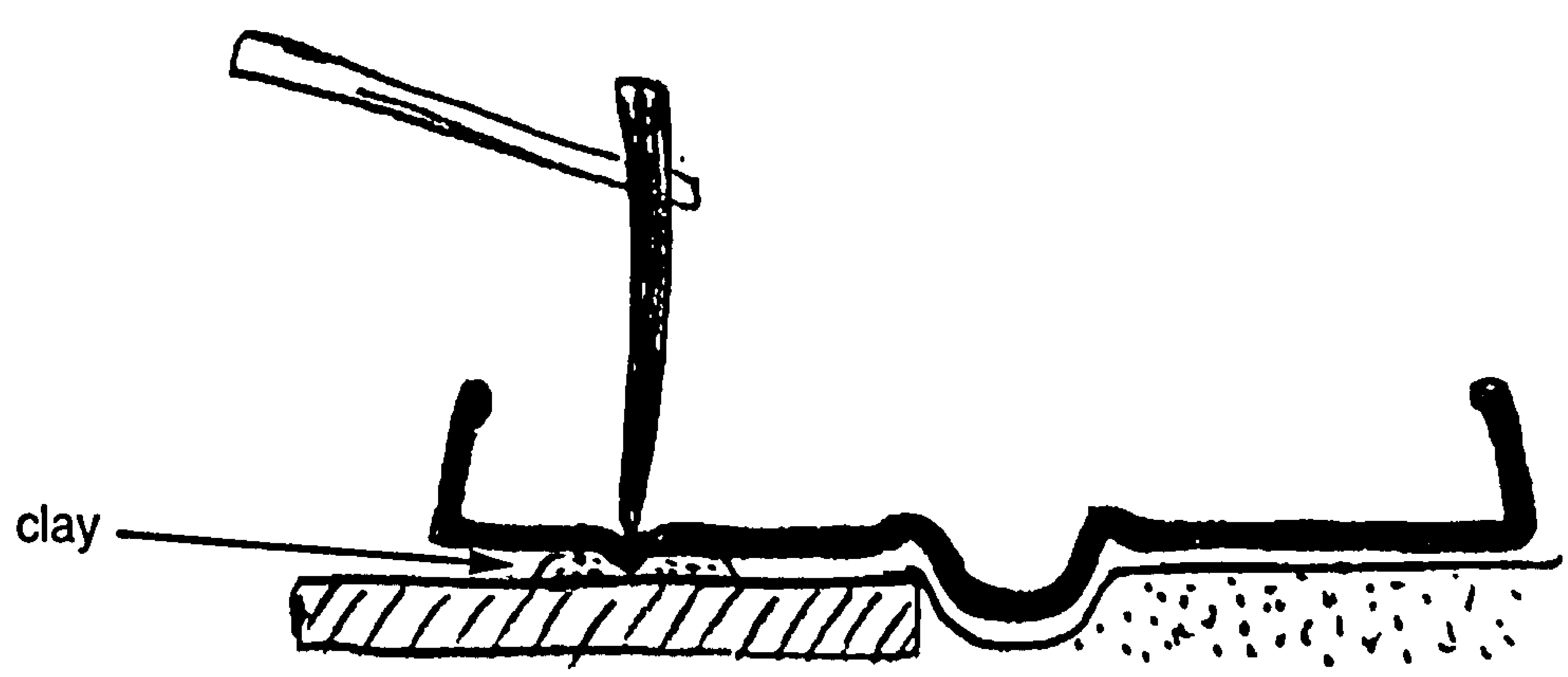


Fig. 29 Making the *pasu.*

Ngelem

The gong must now be heated to red hot and then quenched in water, a process known as *ngelem.* Great care must be taken to ensure that all of the gong is heated to the same temperature. This is done by keeping the gong moving within the forge so that one area is not over heated. The instrument is then taken out of the fire and an iron hoop (*klowong*) of the required diameter is placed over the side wall of the gong very close to the *lambe.* If the side wall is slightly out of round, a hammer is used to gently correct it so that it assumes the shape of the *klowong.* The gong is picked up by two or three men using their *sapit klowong* and carried to the pool of water (*planden*). It is then plunged into the water and two other men, using lengths of bamboo, push it under so as to immerse it completely.

This rapid cooling, or tempering, hardens the metal and also makes it elastic, enabling it to be hammered when cold without risk of breaking. The *klowong* prevents the gong from distorting out of shape while it rapidly cools. The hot processes of making the gong are now finished unless there is a hole or crack in the skin of the instrument.

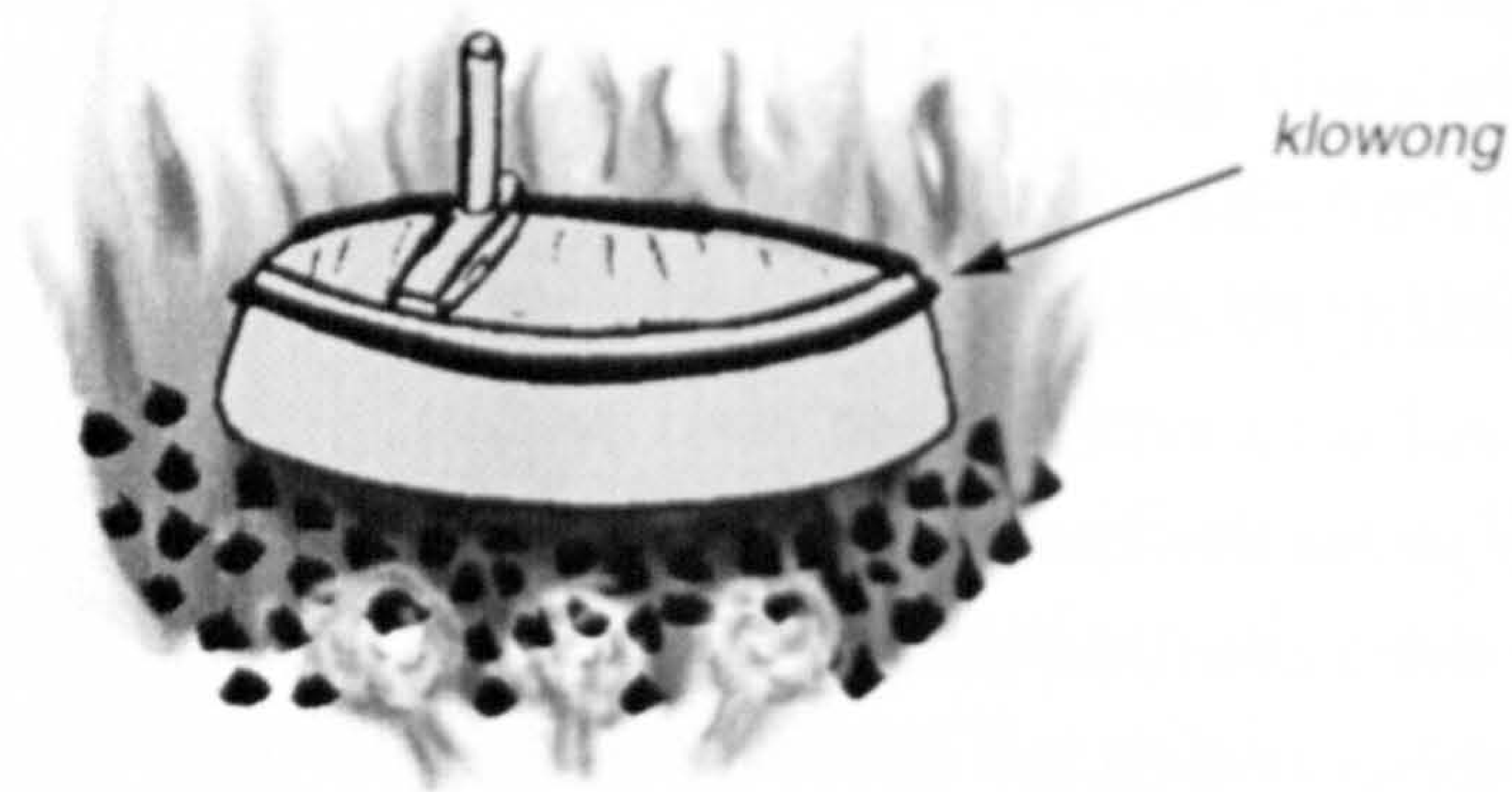


Fig. 30 *Ngelem* process using *klowong* hoop.

Di nyingeni

Small holes or cracks may appear in the gong during the latter stages of forging. These usually occur around the *dudu* and on the upper-part of the *bahu,* where it is thinner. Holes in these areas can be repaired satisfactorily using a lost wax casting process, known as *di nyingeni.* Holes and cracks in the *rai* and *recep* are much more difficult to repair because these are the main sound producing parts of the gong and the levels of vibration tend to loosen the cast plug. It is rare for holes to occur in the *rai*, *recep*, and *pencu*. During all the time I spent at Pak Tentrem's forge this never occurred, but I am told that should a hole develop in one of these areas the gong is abandoned and melted down.

The area to be repaired is first cleaned with a file to expose the yellow bronze beneath the black surface resulting from forging. Beeswax (*lilin* or *malam*) is melted onto the area surrounding the hole using the heated end of a small *penyukat* known as *lakarwo* (refer to fig. 31). The wax is built up on both the outer and inner walls of the gong so that the hole is completely filled. Two small rolls of wax are made, one to form the entrance channel and the other the exit. These are stuck onto the wax plug, one either side of the hole, the uppermost one being the entrance channel.

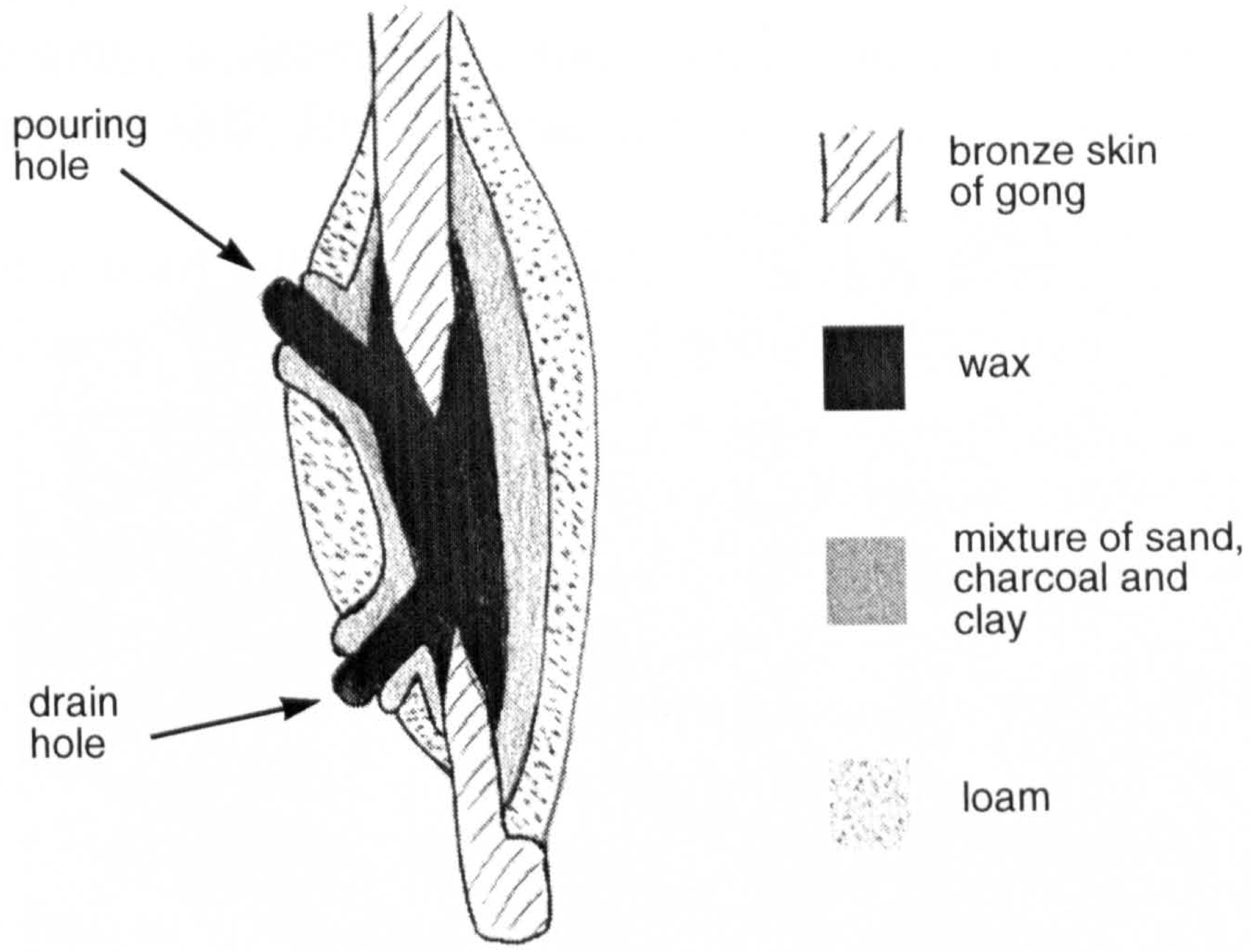


Fig. 31 Showing method of lost wax casting, in this case, on the *bahu*.

An equal mixture of sand, clay and crushed charcoal is made up and is then sieved to produce a fine black powder. Water is added to create a soggy paste, which is carefully placed over the wax plug and also built up around the entrance and exit channels. The paste forms the wall of a cavity to be filled with molten metal. A kind of loam (a mixture of sand and clay used by traditional Javanese bricklayers) is then placed over the paste and built up in thickness so as to add strength to the mould. The gong is placed near the fire so that the gentle heat melts the wax gradually, thus forming a cavity. Rapid heating at this stage would result in the layers of clay, charcoal and sand cracking. This process takes up to twenty minutes, after which the instrument is placed directly on the fire and heated using the bellows. During this whole process other workers have been preparing bronze alloy to pour in and fill the cavity. The tests for the bronze alloy described earlier are used so as to ensure that the bronze plug is of the same quality as the rest of the instrument. Some makers cut corners during this process by omitting the test, but this is not the case with Pak Tentrem.

The area of the instrument to be repaired is heated to red hot and then the molten bronze is poured from the smallest crucible used for the test (*kowi cowek*). The liquid mass is poured into the funnel-shaped entrance channel, until an excess drains through the exit channel. All the air is expelled and the hole completely filled with metal. A lump of wet clay attached to a stick is placed over the exit channel. This stopper is known as *sumpet*.

The cast bronze is allowed to cool and then the hard sand and clay mould is removed with a hammer and subsequently by scraping. The overflow plugs are sawn off and then the whole instrument is reheated to red hot and the *ngelem* process repeated.

Although this process of repairing is not ideal, a perfectly adequate result may be obtained as long as a) the area of repair is heated sufficiently prior to pouring so that the metals can truly fuse, and b) that the test of the bronze alloy is carried out. The utmost care must be taken during the making of the mould to prevent it breaking apart during the pouring. If this method is not adhered to, the plug may in time come loose and vibrate.

Cold hammering

After the gong has been tempered by immersing it in the *planden* the instrument's surface is black, rough, and not completely level. The roughness is due to the pounding during forging producing many visible hammer marks. Some distortion of the instrument's shape takes place as a result of the tempering process. Before the tuning may begin it is necessary to attend to these two problems, firstly dealing with the gong's shape, a process known as *metak*.

At this stage the *recep* is almost flat (level with the *rai*) and the shaping of it to produce its characteristic curvature is done during the *metak* process. *Metak* involves applying considerable pressure via a stout piece of wood to the gong, and then hammering the area surrounding the piece of wood. The pressure is applied by a long beam of timber pivoted at one end. At the other end up to four workers sit on the beam to provide the downward force (refer to figs. 32 and 33). There are three stages of the *metak* process; firstly levelling the *rai*, secondly shaping the *recep* and finally smoothing the *dudu*. These are described in order.

To flatten the *rai* the gong is laid upside down on a square steel plate anvil known as *ladok*. The *ladok* has a hole in its centre to accommodate the *pencu* so that the *rai* may lie flat. The member between the beam (*entol*) and the gong is known as *umbul*. Various sizes of *umbul* are used for different parts of the gong. *Kayu besi* (iron wood) is used for making the *umbul* which must be capable of withstanding immense force (the same timber is used in pile drivers).

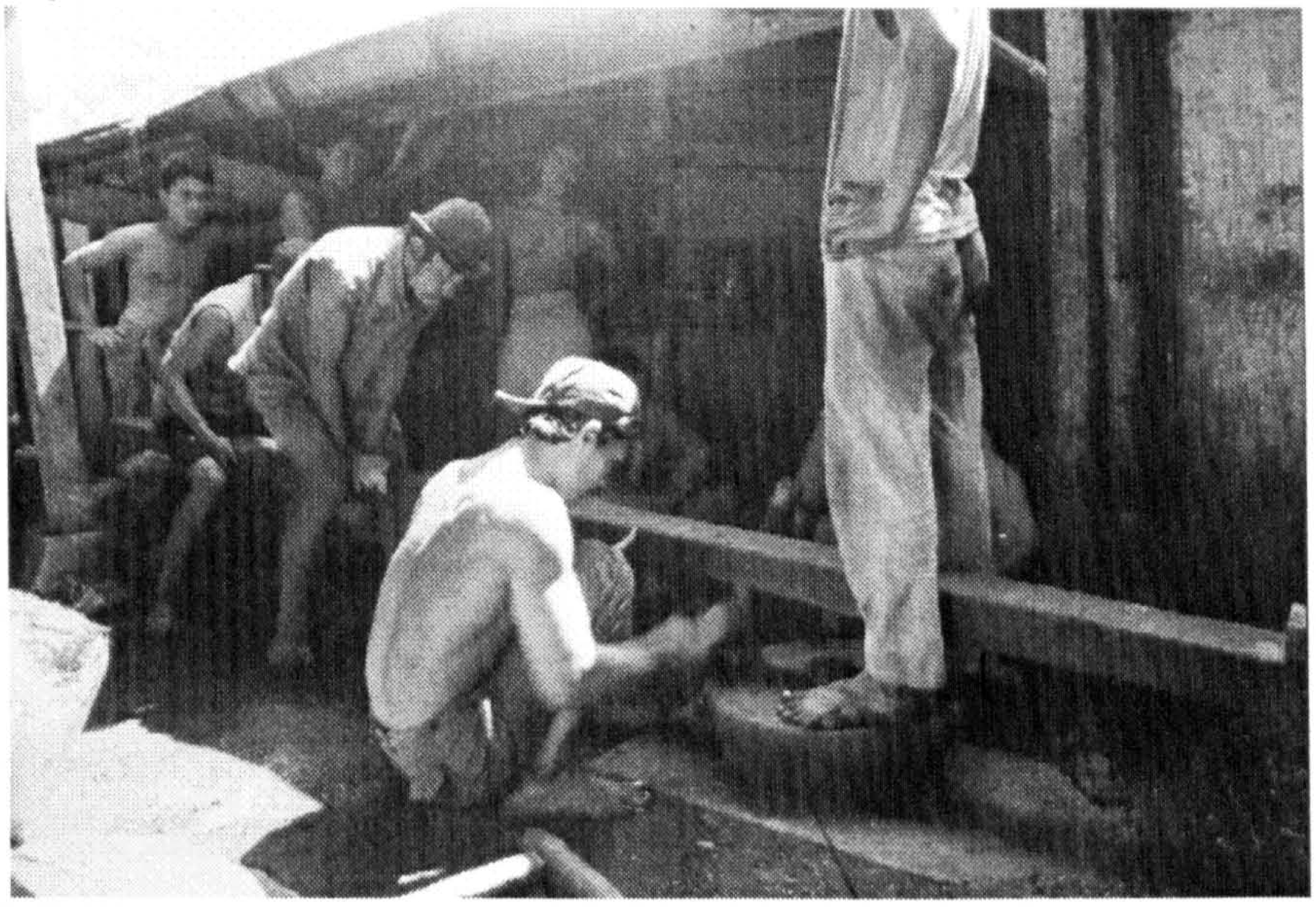


Fig. 32 *Metak* process.

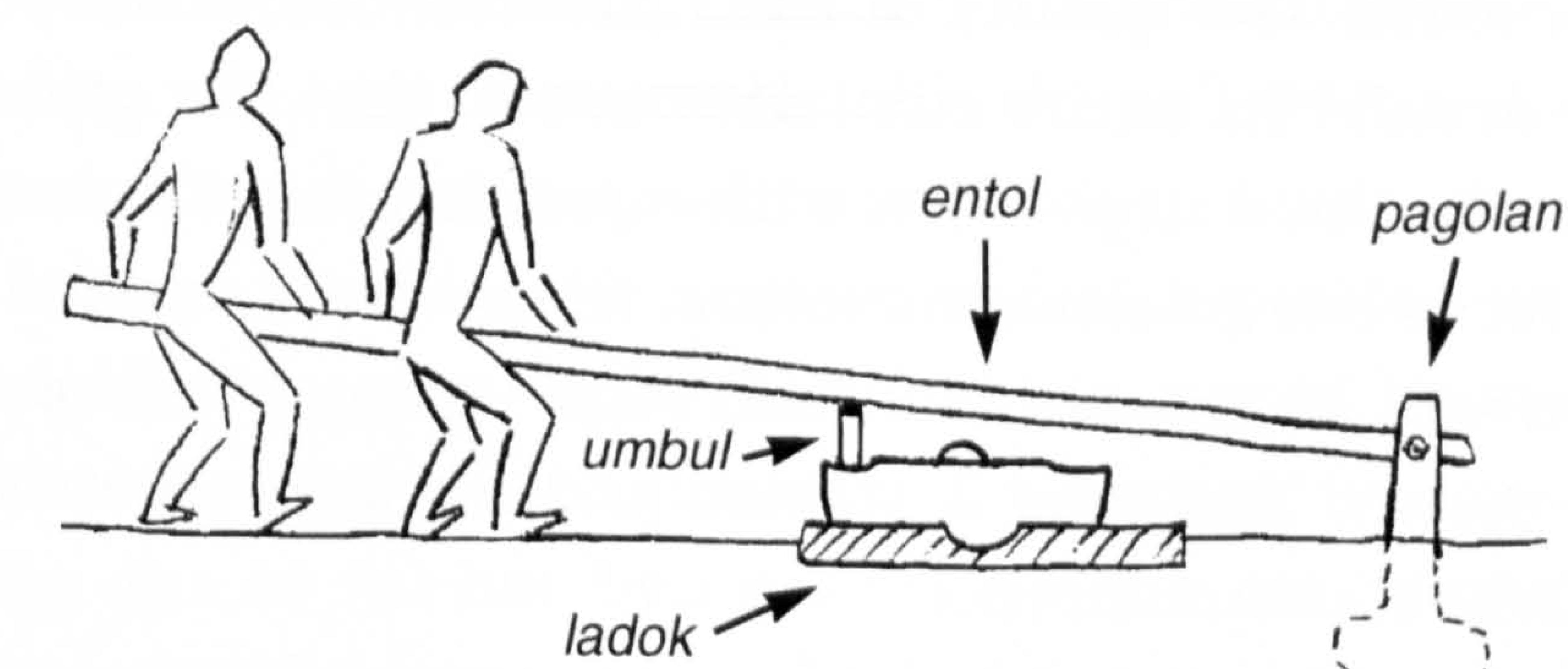


Fig. 33 *Metak* process.

Pak Tentrem supervises the entire *metak* process which, at worst, can easily result in breaking the gong, if the instrument is not examined thoroughly with an expert eye before and during the work.

The gong is laid on the *ladok* with the *umbul* in position and then two smiths strike either side of the *umbul* in rapid succession using small iron hammers (refer to fig. 34 - levelling the *rai*). After pounding in one position the gong is examined and then turned; or the *umbul* is moved to a different position so that another part of the *rai* can be treated in the same manner until the whole of the *rai* has been hammered flat.

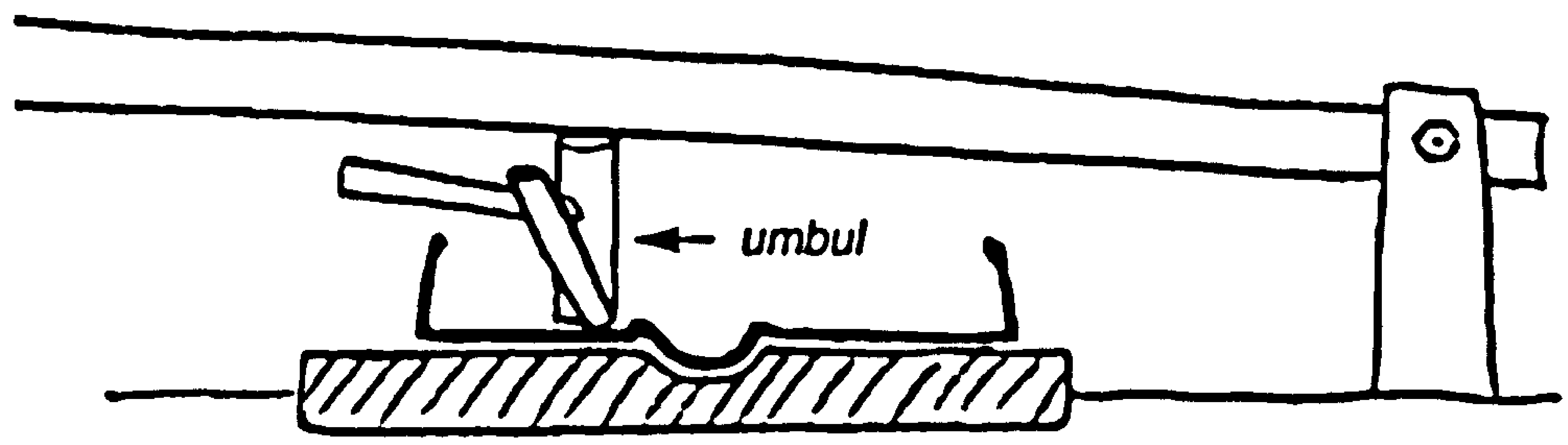


Fig. 34 Levelling the *rai.*

For the next stage of *metak*, that of making the *recep*, the gong is turned so that the boss is uppermost. A shorter *umbul* is placed between the beam and the *recep*. A helper stands on the gong to stop it moving. Once the pressure is applied the same method of hammering is used as for flattening the *rai* (refer to fig. 35). Making the *recep*, known as *membuat kirih*, is a very skilled art, since the shape and size of the curvature dictates the sound and quality of the instrument. The *recep* must be the same shape around its entire circumference so that the central plate (the *rai* and *pencu*) is held in position with equal tension. For example, if one area of the *recep* has a deeper curvature, the pressure exerted on the *rai* at this position will be greater, and with such unequal tensions the *rai* will not vibrate evenly. The gong is rotated and the same process carried out around the whole circumference.

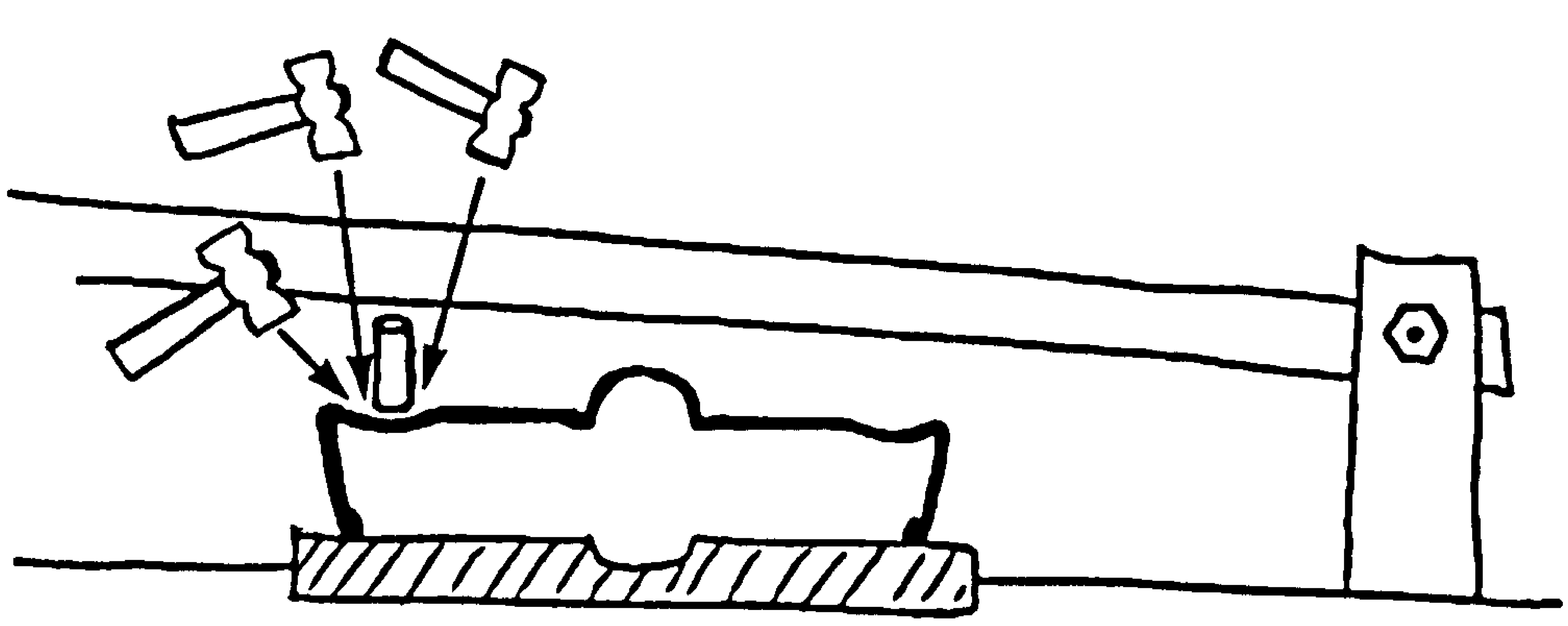


Fig. 35 Making the *recep.*

For the final stage of *metak* the gong is turned over again so that the inner rim of the *dudu* can be shaped. A long hammer with a rounded striking end is used to smooth the curve (refer to fig. 36).

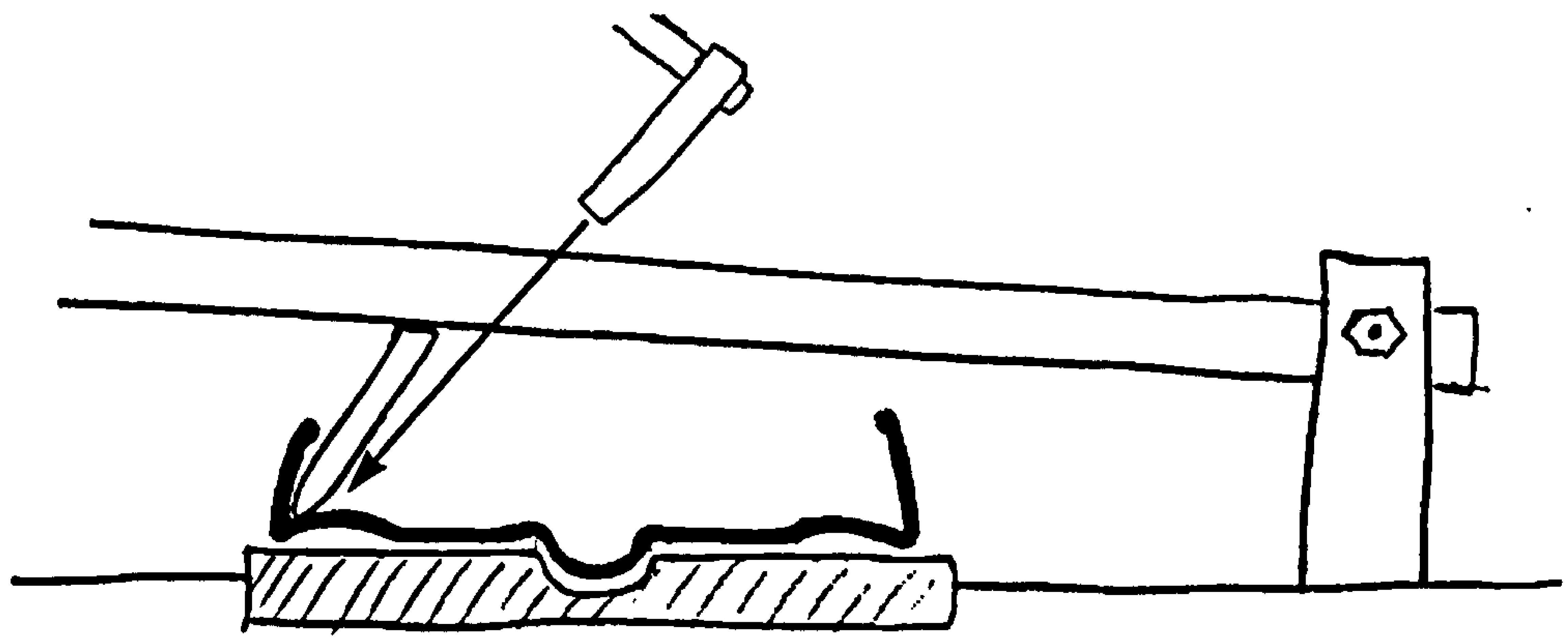


Fig. 36 Shaping the *dudu*.

Voicing

After the cold shaping processes of *metak*, the sound of the gong is assayed. The instrument is hung from a beam using a hook-shaped piece of wood (see fig. 48), and then struck with the soft beater. At this stage it is very unlikely that the instrument will produce a smooth, ringing tone. The sound is more likely to be a series of fast repeating pulses of short duration (deg-deg-deg-deg-deg). This sound is caused by uneven stresses and tension in the gong which prevents it vibrating freely; these stresses are normally due to *rai* not being level, or the *rai* having thick spots (areas). Voicing is the process by which the gong is made to produce a ringing tone. Javanese gongsmiths use the term *kempel* for this sound. It is only possible to tune the gong to a specific pitch after it has been voiced.

The voicing and tuning of gongs is the most difficult aspect of gong making, and consequently this work is done by the master smith, Pak Tentrem. Voicing is done by hammering various parts of the gong (normally the *rai*). The difficulty is knowing where to hammer, and by how much. This is found out by sticking clay onto the gong, experimenting with varying amounts on different areas, until the voice 'sings' out. Once the tuner is satisfied with the sound achieved, he will begin the process of losing (*membuang*) or throwing the clay (*menghilangkan lempung*).

Pak Tentrem will usually start by adding clay to the inside of the *pencu*. If this action results in an audible tone, more clay will be added until the optimum voice is reached. From experience Pak Tentrem knows roughly how much hammering is necessary to 'lose' any amount of clay. For losing clay from inside the *pencu* there are two methods of hammering:

1) *Kentheng* - the gong is hammered from inside at a part of the *rai* near the *pasu*. A thick part of the *rai* is chosen (refer to fig. 37).

2) *Endak* - the gong is hammered from outside at a part of the *rai* close to the *pencu*. A thin part of the *rai* is chosen (refer to fig. 38).

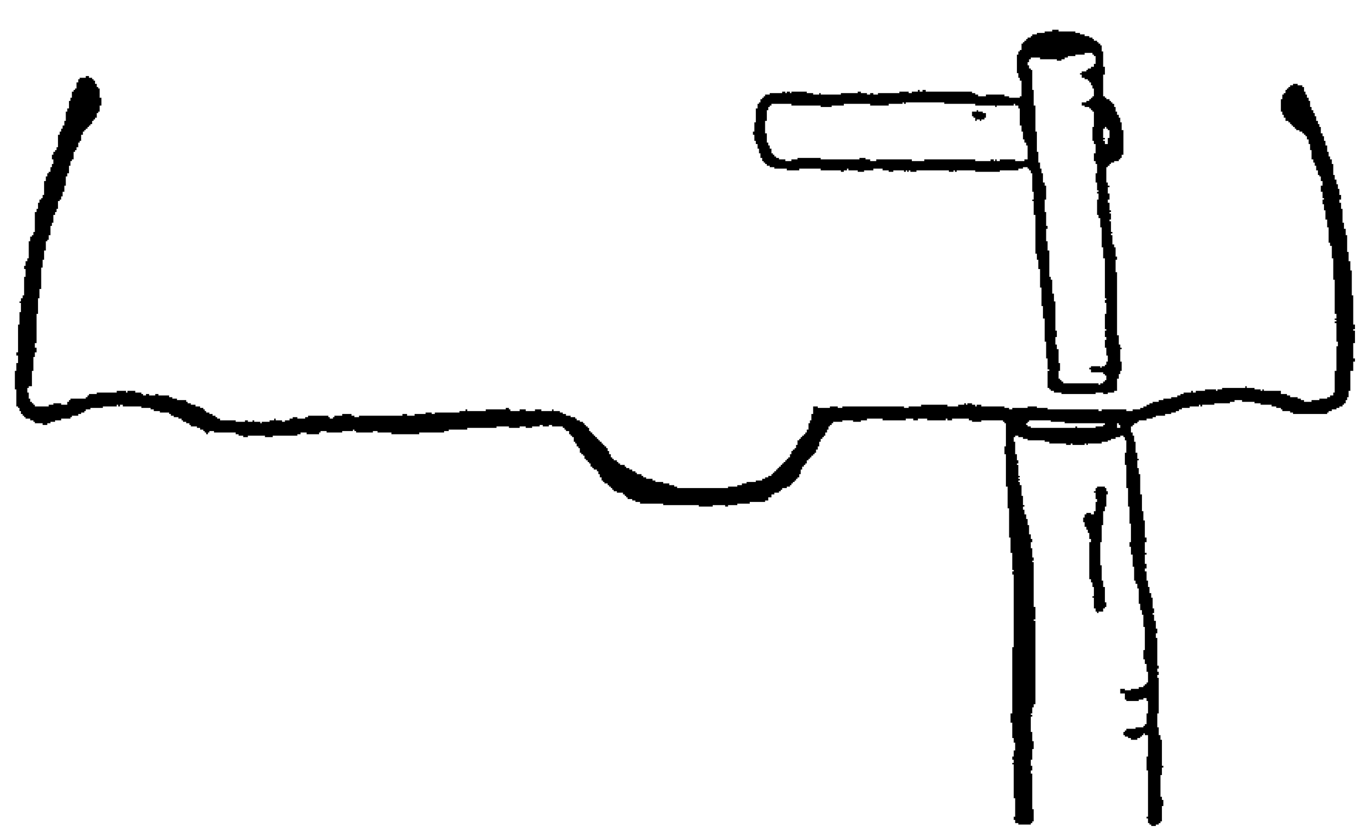


Fig. 37 *Kentheng.*

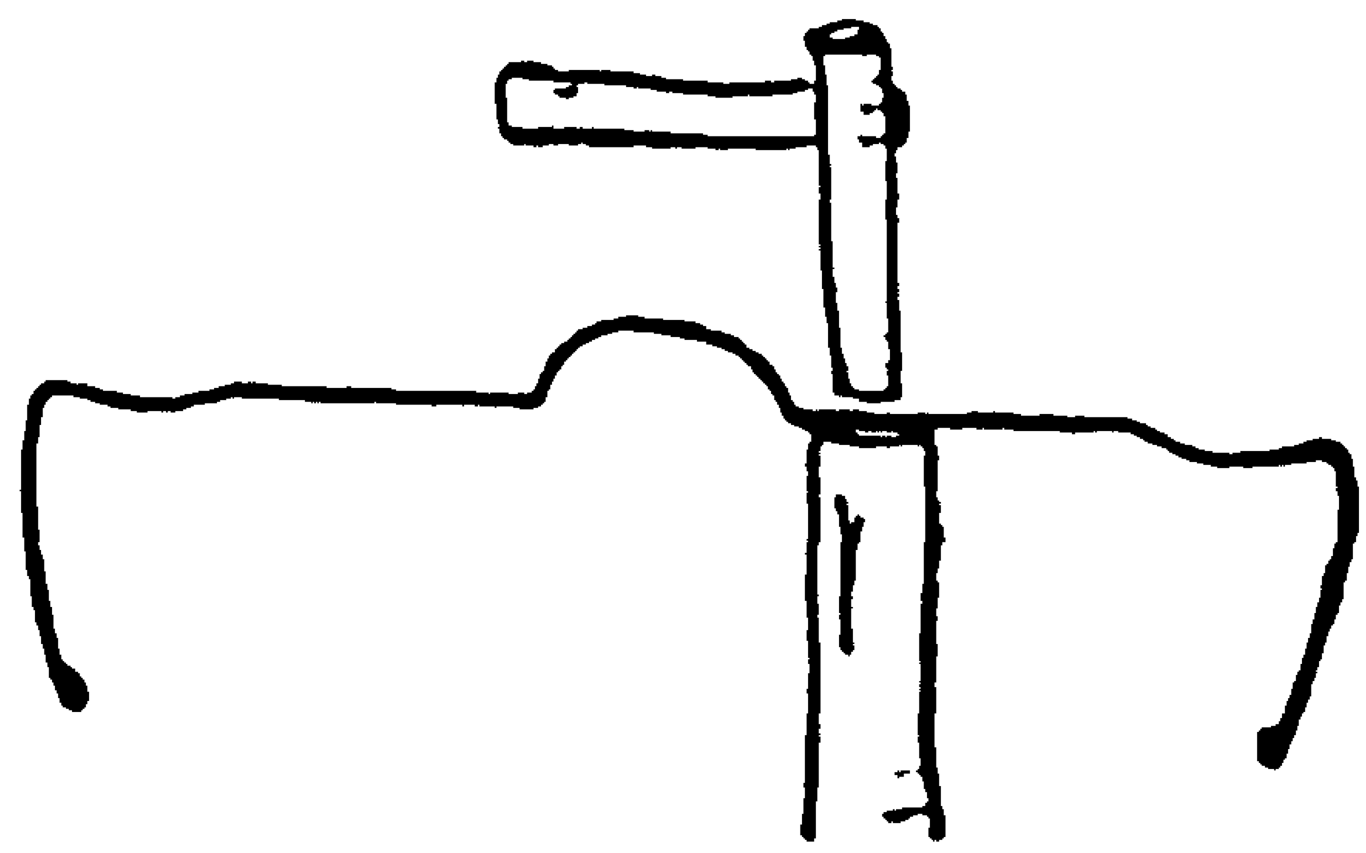


Fig. 38 *Endak.*

It should be noted that it is important to know which parts of the *rai* are still thick, and which are thin. Therefore, before any hammering is started, a considerable amount of time is spent checking this by placing the palm of one hand inside the instrument on the *rai*, and then, with the other hand, tapping with the finger nails from the outside, at the same position. By this method the differences in thickness can be both heard and felt: a thick area will ring, and feel hard (hurting the nails), and a thin part will sound dull, and feel soft. The thickness of areas is marked out with chalk.

The gong is placed on the wooden stake (*pagol*) as shown in the diagrams. Before any hammering is started, it is necessary to make sure that the gong is sitting square on the stake, and that the stake is directly underneath where the hammer will strike. If this positioning is not carried out accurately, there is a risk that the instrument could crack. The hammering is always done with great care, little by little, checking the sound of the gong after every couple of blows, and temporarily adding clay to ensure the hammering has not gone too far (if it had, the addition of a small amount of clay would deteriorate the sound).

During the initial experimentation, if placing a small amount of clay inside the *pencu* makes the sound worse, this indicates that the clay needs to be placed on the outer surface of the *rai* close to the *pasu*. The term often used for this is l*empung bagian muka*, literally meaning 'clay part face'.The tuner will look for places on the *rai* which, when the clay is positioned, give the best possible voice. It is usually necessary to find two or more such places. Two methods are used to lose clay from the *rai*:

1) *Impes* - the gong is hammered from the outside, on the *rai* close to the *pasu*. A thin area is chosen (refer to fig. 39).

2) *Juluk* - the gong is hammered from inside, on the *rai* close to the *pencu*. A thin area is chosen (refer to fig. 40).

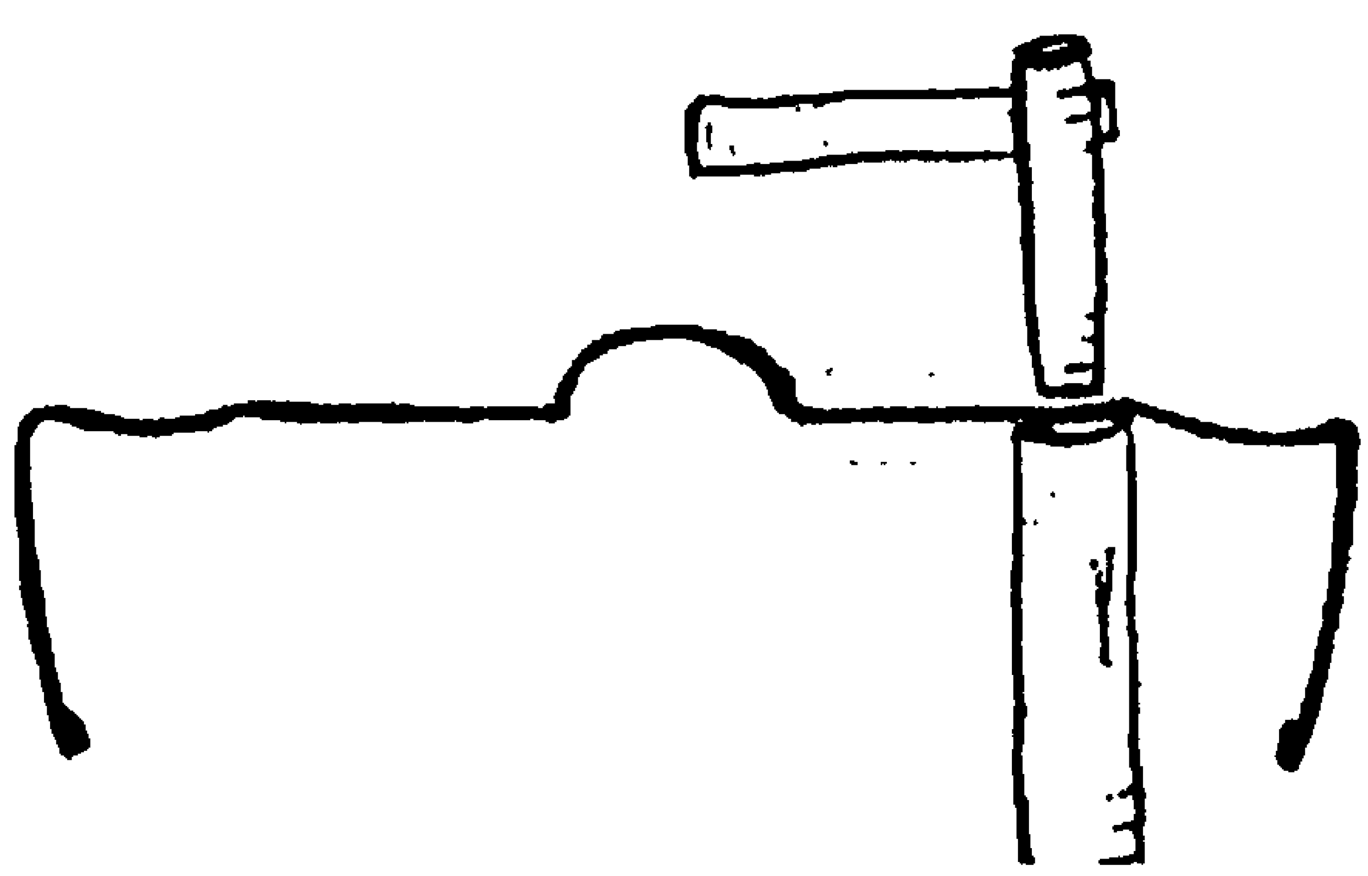


Fig. 39 *Impes.*

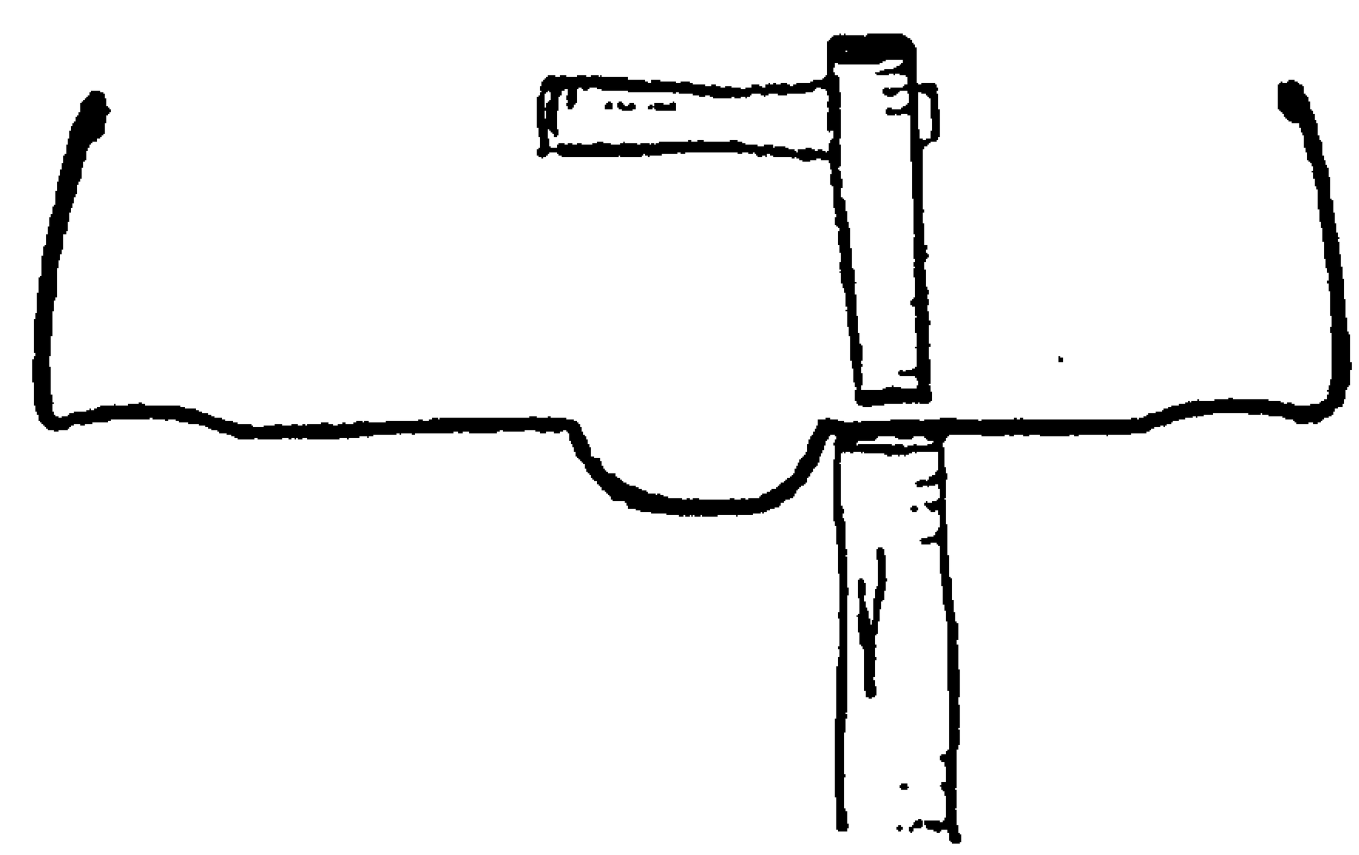


Fig. 40 *Juluk.*

Like *kentheng* and *endak*, the hammering for *impes* and *juluk* must be done with great care, constantly checking the sound of the gong. Even after having experimented with all these hammering processes it may still not be possible to get the gong to sound well. When more than one area is found on the *rai* to place the clay, and these areas are very close to, or on the *pasu* itself, this may be because the *pasu* is not perfectly round. This can be corrected by hammering from the outside, close to *pasu*, with the direction of the blows aimed towards the *recep*. This process is known as *kancing* (see fig. 41).

The *bahu* still has many undulations in it, so after the voicing has been done, the gong is placed on its side on a flat metal anvil and hammered repeatedly to smooth out the surface. This process, known as *selet* or sometimes *kentheng*, is an arduous task taking a good couple of hours for a large instrument, and, for this reason it is delegated to one of the other smiths (refer to fig. 42).

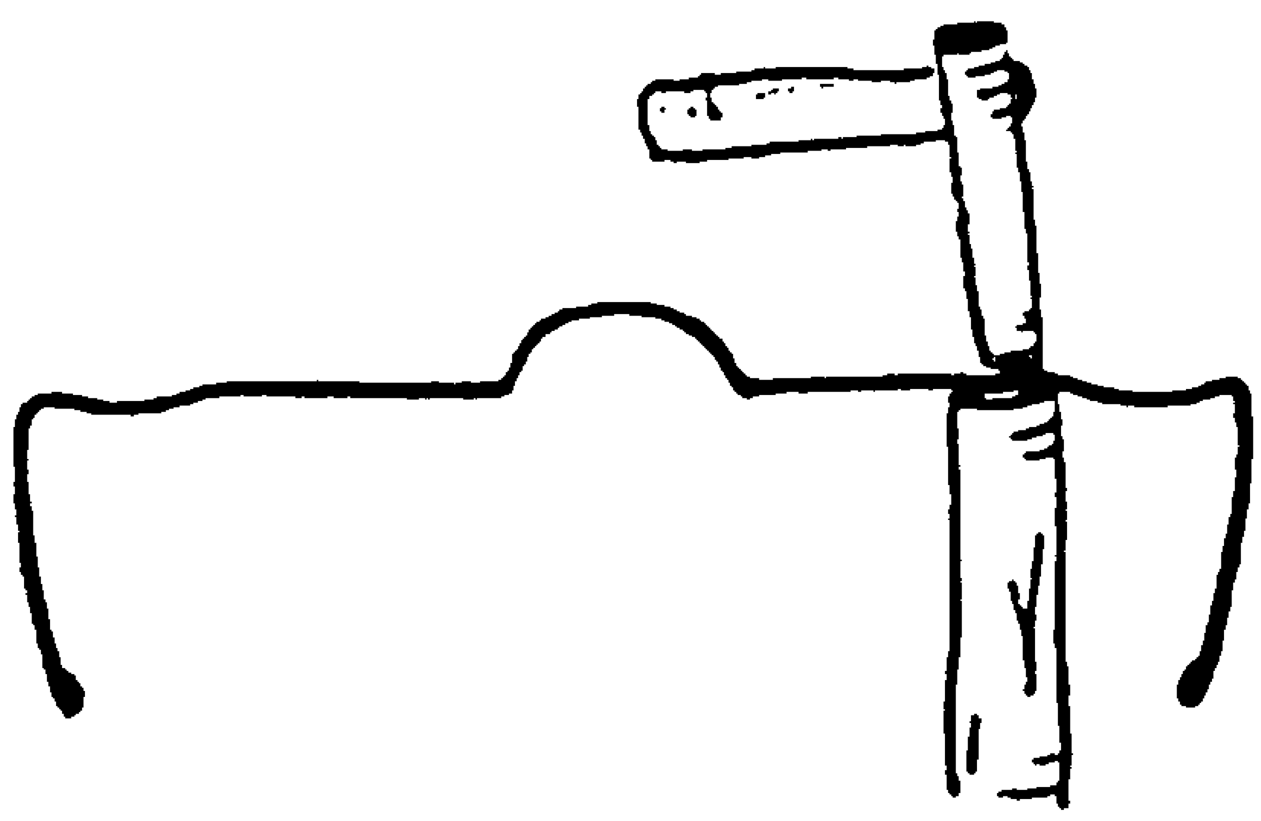


Fig. 41 *Kancing.*

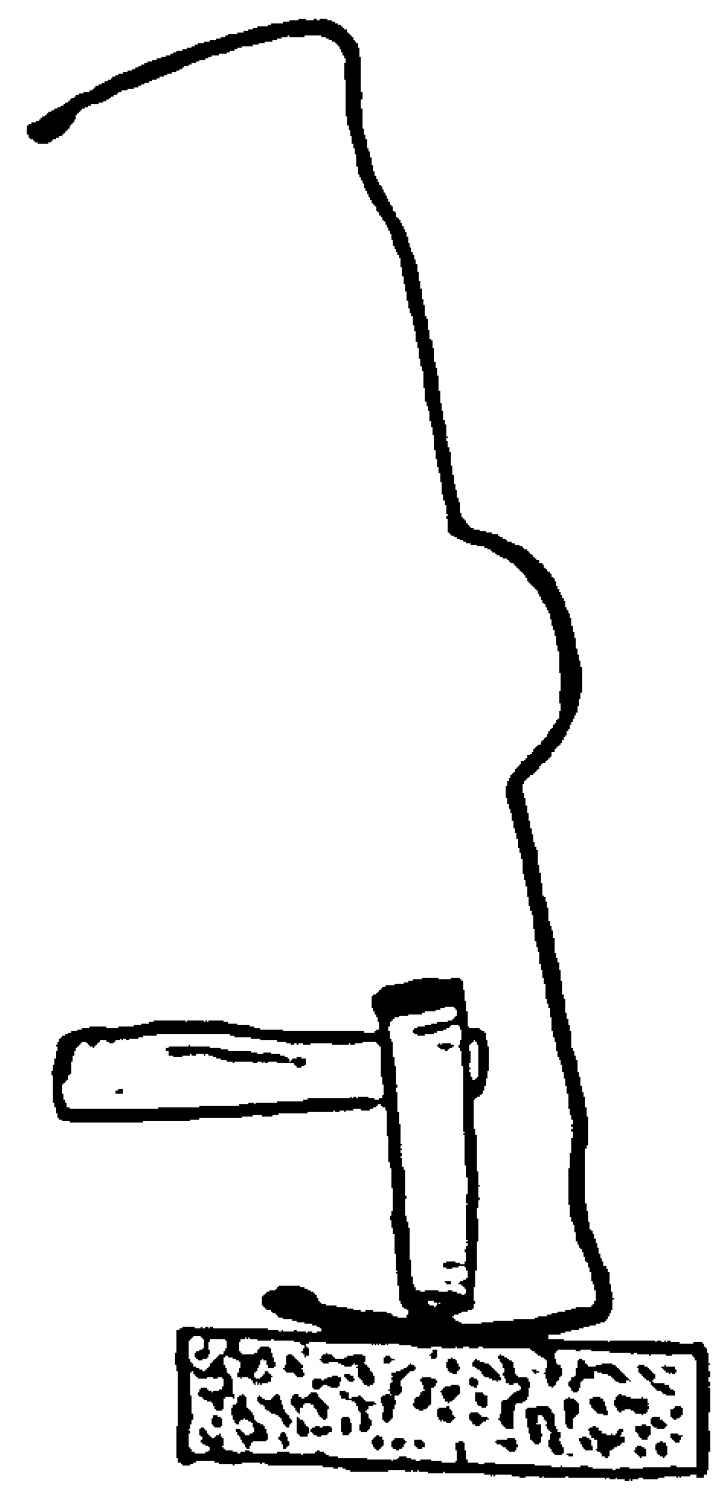


Fig. 42 *Selet.*

The next task is to drill the holes in the *bahu* that locate the supporting rope. The measurement between these holes should be the same as the diameter of the *loloan*.

Tuning

There are two ways of tuning *pencon gandhul*; by filing or hammering. In practice the two are often combined. Most gong ageng are left in the hammered state, the only part which is filed and polished being the *pencu*, and even this is sometimes left unpolished. The only options in tuning this type, known as gong *cemengan*, are hammering alone or, in addition, filing the *pencu*.

Gong voicing and tuning has for many years remained a secret art, little understood in the West. This knowledge, gained through centuries of initial experimentation, and then kept alive through tradition by a very small guild of master craftsmen, has recently been opened up. Pak Tentrem enthusiastically explained detailed processes which were previously kept hidden. Although general principles can be laid down for voicing and tuning, these alone are not enough; the art is learnt over many years by watching, listening, and doing. The 'feeling' that many people refer to is the years of experience built upon a natural ability.

After voicing, the gong must be within one pitch (higher or lower) of the intended final note of the instrument; if it isn't, the gong must be returned to the forge. Usually the pitch is only one half of a slendro tone out, ie. plus or minus 120 cents. This accuracy comes from set measurements of all parts of the gong, and from supreme craftsmanship in the forging.

To understand how a gong vibrates and creates a certain pitch it may be useful to compare it to the working of a simple plate, held taut around its circumference (ie. the *bahu*). If the plate is made thinner, thereby lessening the stiffness, the effect is to slow the vibrations and flatten the pitch. This holds true for a plate of uniform thickness. However, by adding mass to the centre of the plate, this also slows the vibrations, thus lowering the pitch.[25] The vibration patterns of a gong are, however, very complex and more factors than just mass act upon the instrument. Thus it is not possible to merely file the *recep*, *rai*, or *dudu* to lower the pitch, or to file the *pencu* to raise the pitch. By just doing either of these processes alone, the voice of the gong will be lost. This is because during the voicing, the shape of the *rai* is made to vibrate sympathetically with the *pencu*, thus bringing the two pitches together (or slightly apart to produce *ombak*).[26]

The Voicing and Tuning sections have stressed the importance of making the *rai* 'level', or 'flat'. This does not mean that the *rai* must be in a parallel plane to the *loloan*, but rather that there are no undulations or thick spots within the rai. The *rai* may be inclined slightly upwards (towards the *pencu* with the gong placed on the ground). During the voicing process, in order to lose clay from the *pencu* (ie. to lower the pitch) one performs either *kentheng* or *endak,* which very slightly lowers this incline (see fig. 43). Likewise, to lose clay from the *muka* or face, (ie. to raise pitch) one performs either *impes* or *juluk*, which very slightly raises the incline (see fig. 44).

The pitch of a gong is sharpened by raising the level of the whole of the *rai*. This will result in the voice deteriorating, and clay must then be placed near the *pasu* on the *rai*, and *impes* and/or *juluk* performed to retrieve it. To lower the pitch, the whole of the *rai* must be lowered by hammering, causing the need to place clay in the *pencu*, and performing *kentheng* and/or *endak* to lose it.

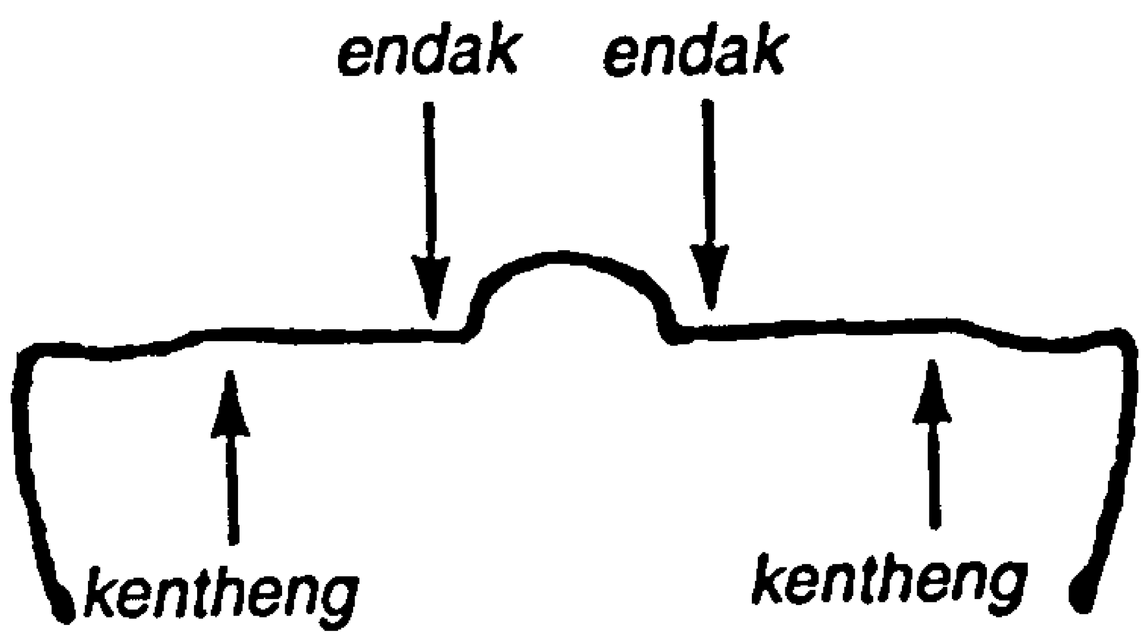


Fig. 43 *Kentheng* and *endak*.

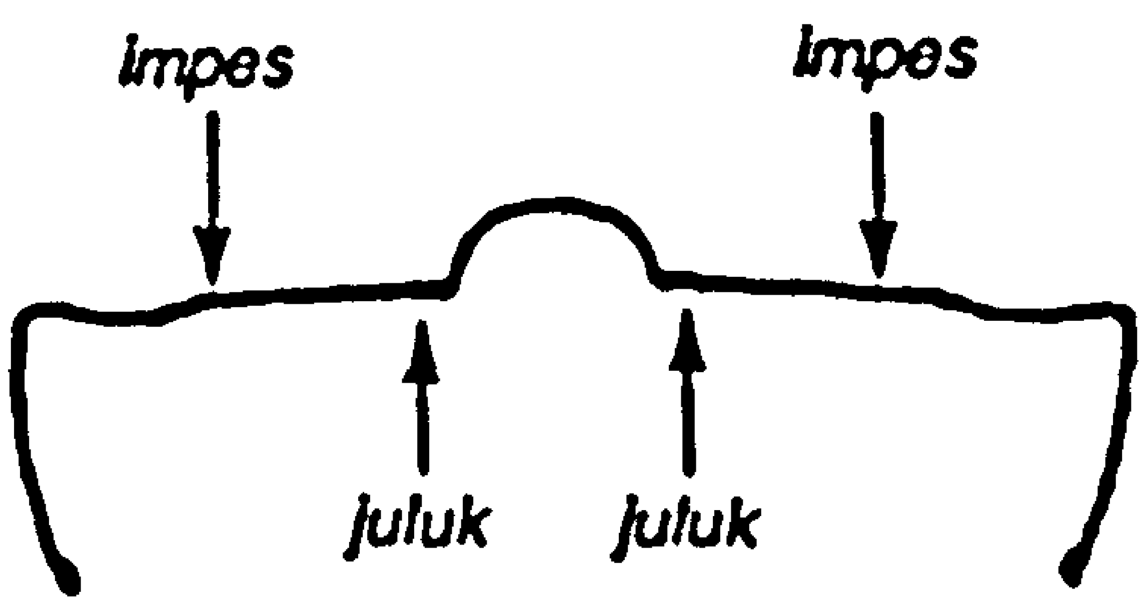


Fig. 44 *Impes* and *juluk*.

The pitch of a gong with a polished *pencu* is raised by filing the *pencu*, followed by *impes* and/or *juluk*. The pitch of a gong can also be raised by hammering from inside at the part of the *recep* near the *pasu*. This process is known as *pancal* (see fig. 45). This method is rather risky since it is very difficult to support the *recep* accurately on the stake so that the metal is sufficiently backed by the timber support to prevent cracking. When tuning and voicing gongs it is necessary to have a helper supporting and holding the instrument to prevent it moving during hammering. Gong suwukan and kempul can be held satisfactorily by the tuner alone.

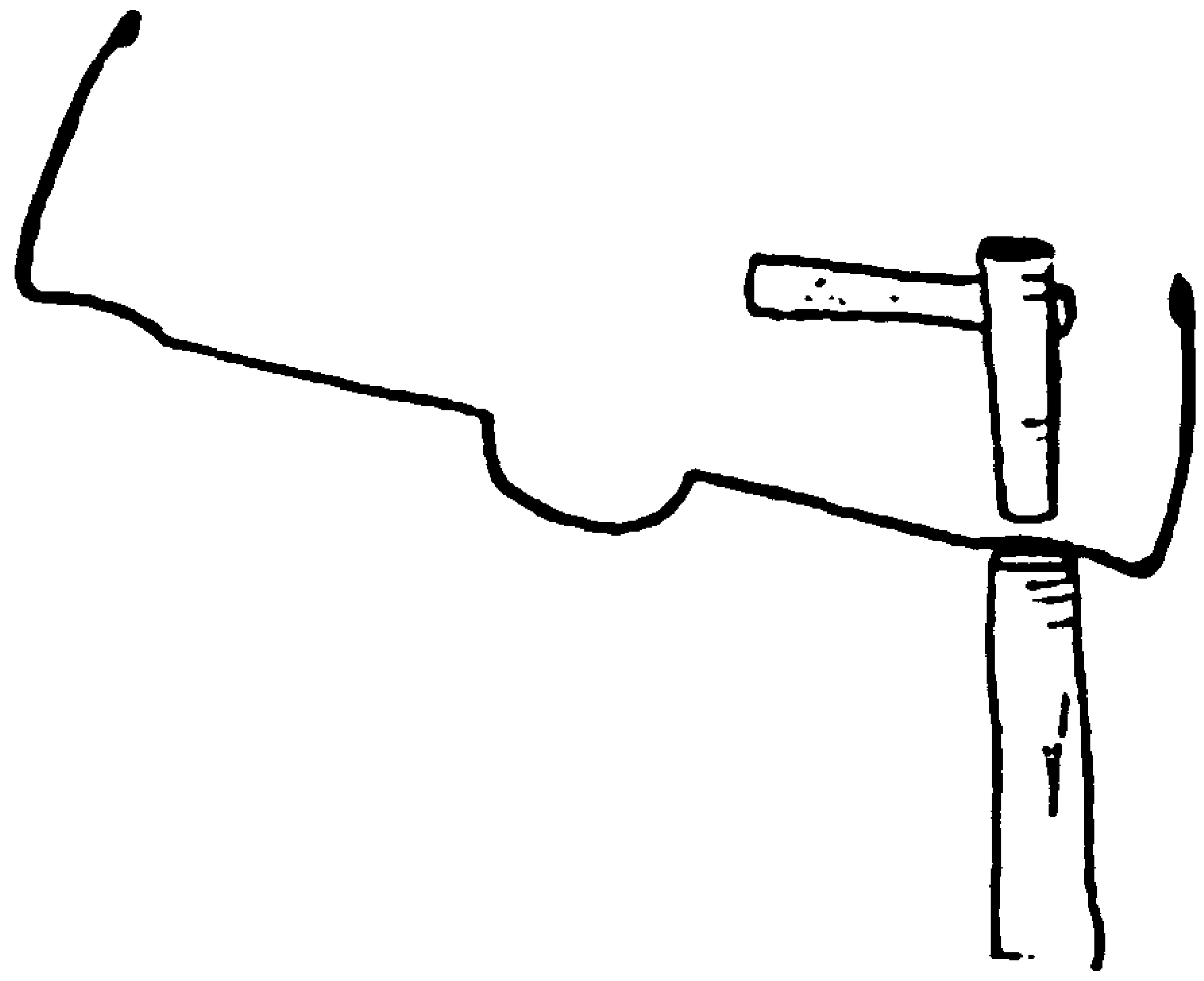


Fig. 45 *Pancal*.

Tuning the gong ageng is always a risky, time-consuming job. The investigations carried out with the clay require much more experimenting than for a kempul. If the tuner incorrectly identifies the area/s to be hit, this compounds the problems of voicing/tuning. It is also extremely important to ensure that the gong is well supported on the *pagol* before hammering commences. This is checked with the gong in position on the stake, and very lightly tapping the metal surface with the hammer and listening for the metallic sound of the hammer; if the gong is not backed sufficiently by the anvil, the impact of the blow will travel past the gong to the space between the gong and the anvil, but if good contact is made with the anvil the impact of the hammer blow will be reflected back from the anvil, into the hammer, resulting in it ringing.

The initial tuning of the gong suwukan and kempul is done by Pak Tentrem. This involves filing the thick spots on the *rai* and *recep*, but leaving the pitch of the instrument between half and one pitch (slendro) higher than the final intention. This is because during the finishing process of filing and polishing it is necessary to remove a lot of metal from the *dudu*, *recep*, and *rai*, which lowers the pitch considerably. Attempting to retrieve the pitch purely by filing the *pencu* is not possible.

Finishing - filing, polishing and tuning

All of the bronze gamelan instruments, apart from the gong ageng, are highly polished. When the instruments come out of the forge they have a rough, dark brown finish, so the whole surface must be filed to reveal the bright metal underneath. Since filing the instrument changes the pitch, the minimum amount of metal needed to produce a smooth surface is removed first; paying little regard to the pitch. The instrument is then tuned by further filing. The worker in charge of the finishing is called *tukang kikir*, (*kikir* = file). Since the filing and tuning are one and the same thing, the *tukang kikir* is also called *penglaras* (tuner). He always assumes this title when working outside the foundry retuning gamelan. There are four tuners and one polisher (sander) working at Pak Tentrem's smithy. An apprentice starts working on the bar metallophones (saron, slenthem, gender) and then progresses to the more difficult gong type instruments as he gains experience. The finishing and tuning of kempul are described here (the tuning of the bar metallophones is included in the section on making saron and gender bars).

The tuner uses two types of file: *kikir patar*, and *kikir besi*. A tuner always has his own set of files, and will usually have five *kikir patar*, and two *kikir besi*. The *kikir patar* is a purpose made, wide set file made from car leaf springs. The set and curved profile of the teeth is similar to the British 'dreadnought' file, allowing fast stock removal without clogging. The *kikir patar* is curved through its length making it easy to use on both large, flat surfaces and concave surfaces. The file is held by its wooden handle with one hand, while the other hand applies downward pressure at the curved end. A set of *kikir patar* (see fig. 46) usually includes one roughing tool with three teeth per 25mm, two medium files with four teeth per 25mm, and two fine files with five or six teeth per 25mm. At the end of each working day the *kikir patar* need to be sharpened; the files are softened by placing them in one of the forges, heating them to red hot and then letting them cool slowly. The next morning the teeth are filed sharp with an ordinary steel file and then tempered by heating to red hot and immersing them in cold water.

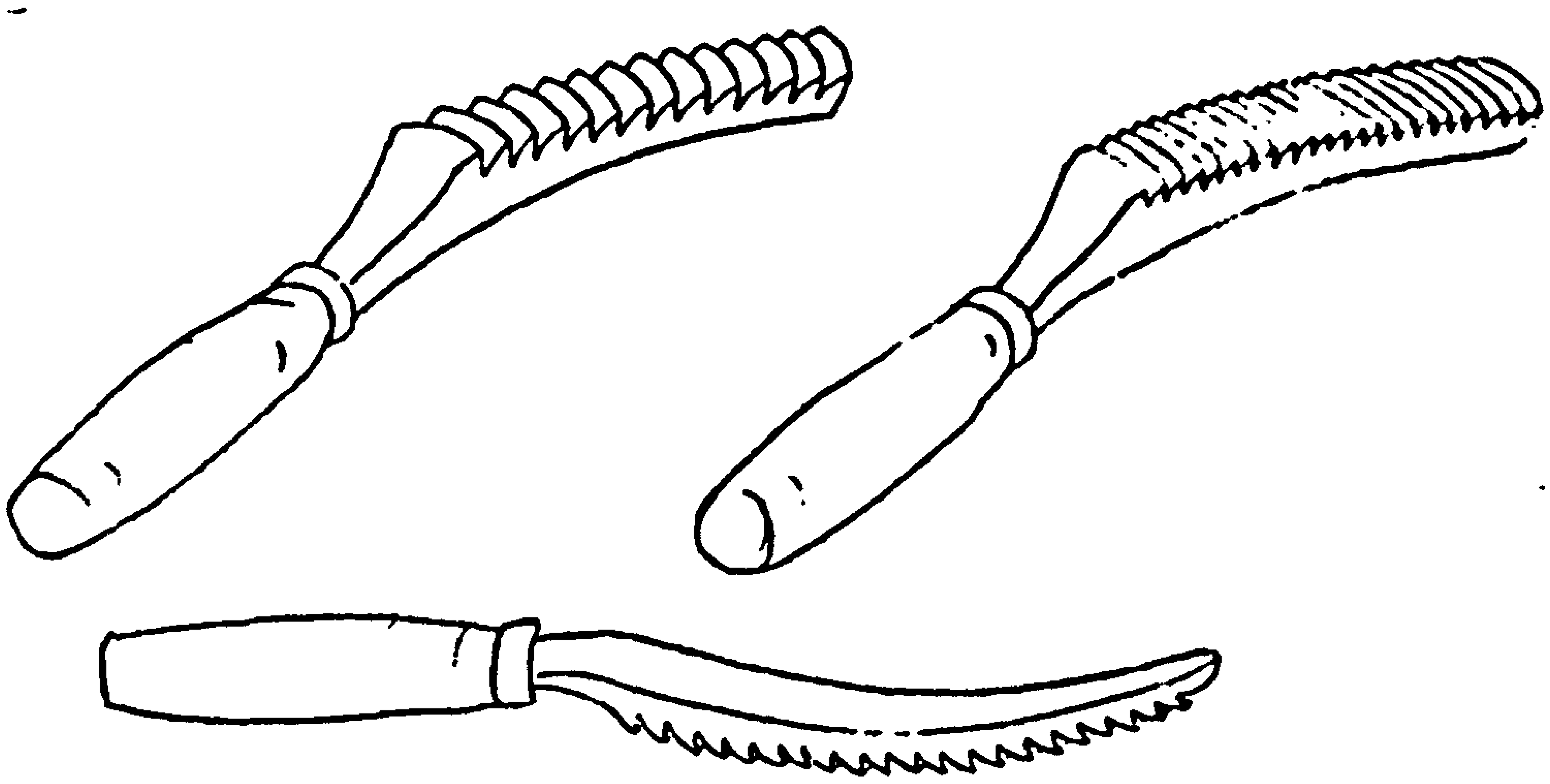


Fig. 46 Types of *kikir patar.*

The *kikir besi* is a standard, flat metal file. It is used on the convex surfaces of the instrument after the roughness has been removed with the *patar.* The *patar* tends to leave ripples on convex surfaces, hence the need for the *kikir besi.*

To produce a very fine finish prior to sanding, a scraping tool called *kesik* is used (see fig. 47). This tool has a curved blade mounted in a wooden handle. The blade, like the *kikir patar*, is made from a vehicle leaf spring for its hardness. The *kesik* is held in both hands at an angle of 45 degrees to the workpiece. With the blade in front of the handle, the tool is pushed away from the body to produce fine shavings.

The various parts of the kempul are always filed in the same order:

1) *recep,* 2), *pencu,* 3) *rai,* 4) *dudu,* 5) *bahu.* Filing the *rai* and *recep* lowers the pitch considerably, filing the *dudu* lowers the pitch only slightly, whilst filing the *pencu* raises the pitch. As mentioned earlier, the whole instrument is filed in the above order to achieve the smooth finish. At this stage the instrument should be slightly sharp of the intended pitch. It will probably also be necessary to add clay to the inside of the *pencu*, or to the face of the *rai* to voice the instrument and hear the pitch.

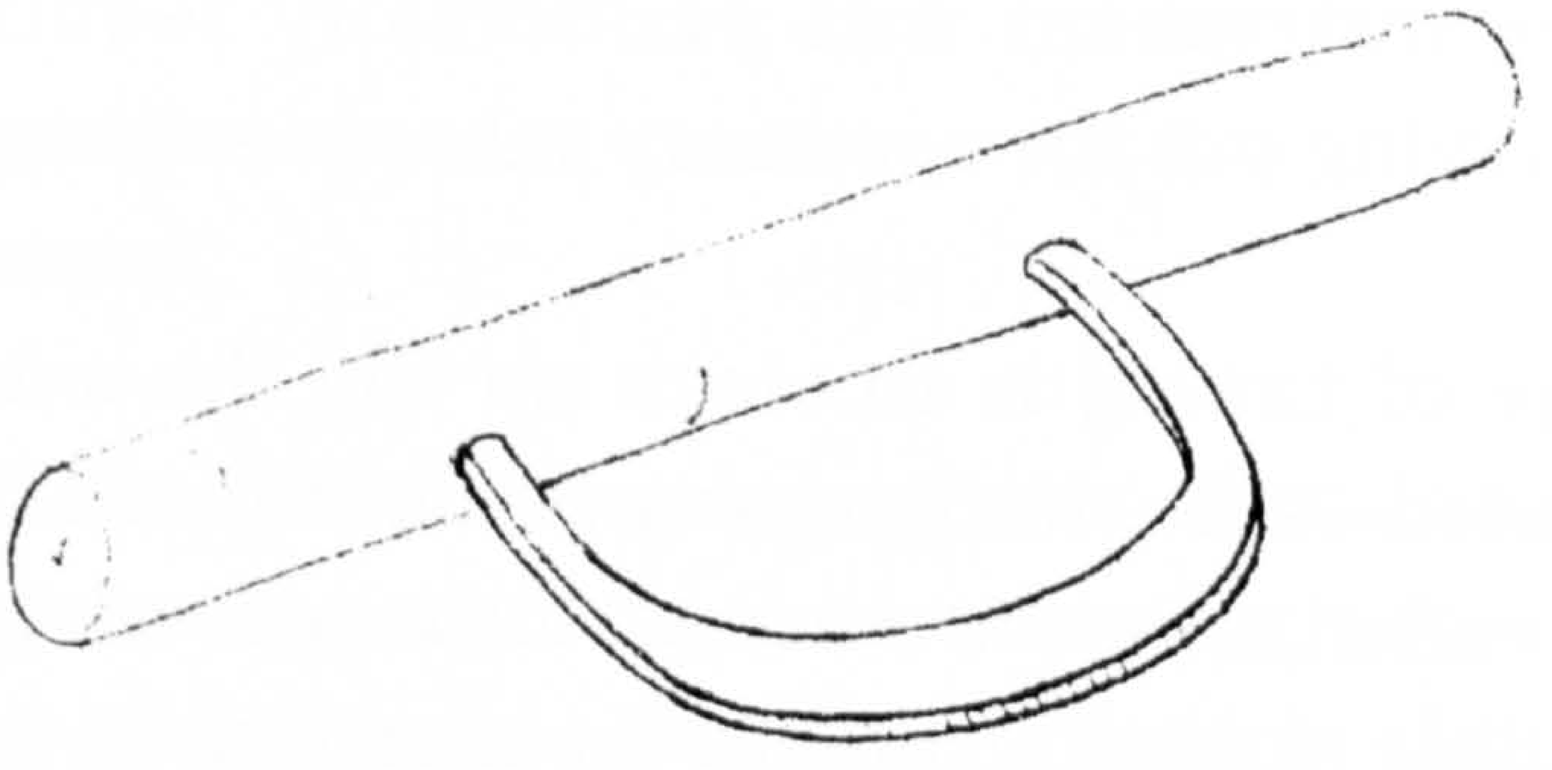


Fig. 47 *Kesik.*

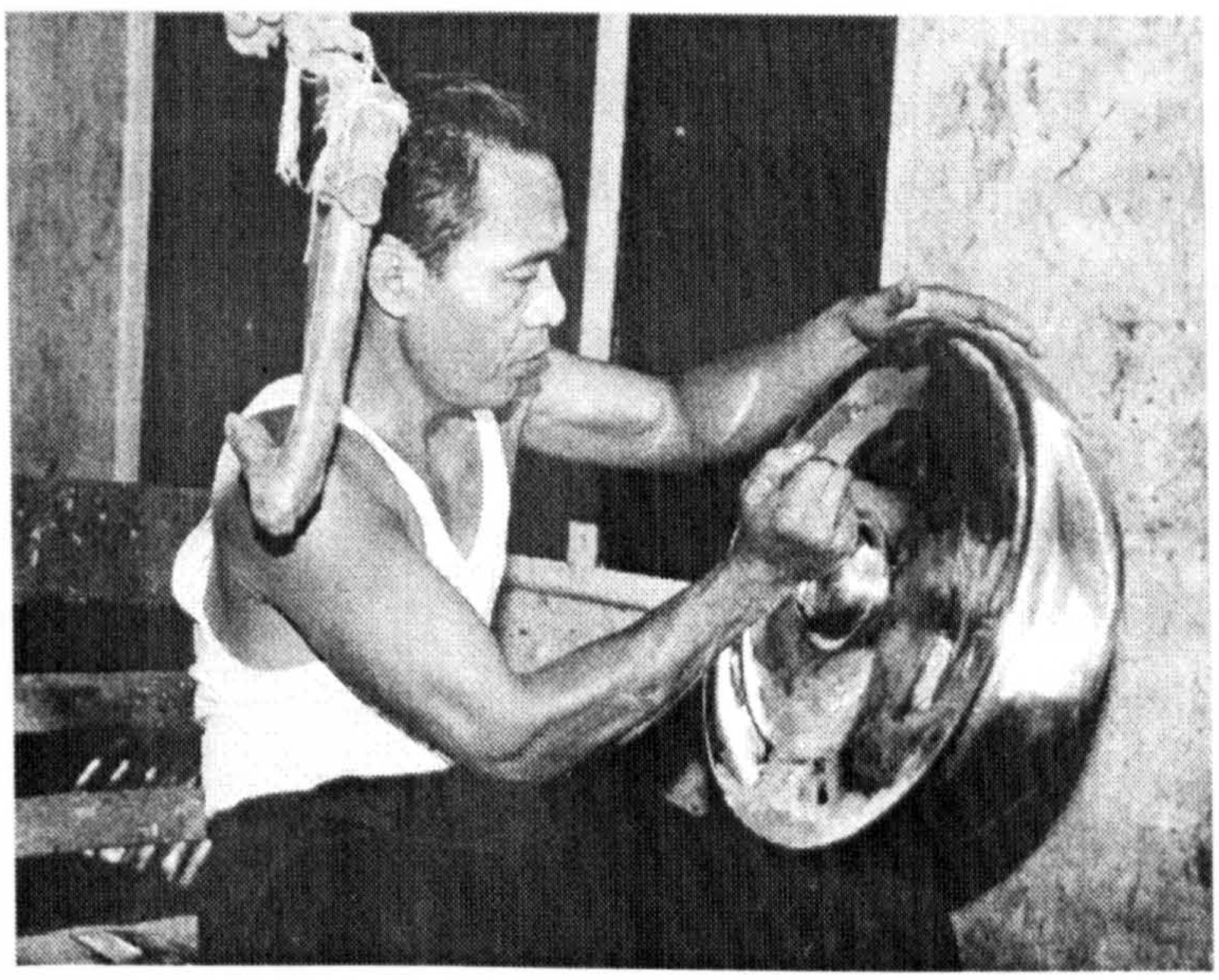


Fig. 48 Pak Tentrem testing a kempul.

A piece of sacking is placed under the instrument during filing to collect all the fine bronze shavings.[27] When filing the *pencu*, *rai*, and *recep*, the instrument is placed on the ground. The *tukang kikir* sits in front of it, holding it firm by wedging a piece of split bamboo between his thigh and the *dudu*. For filing the *dudu* and *bahu*, the instrument is placed upright in a pit whose depth is half the diameter of the workpiece (smaller kempul are raised up by blocks of wood).

The filing of an average size kempul takes three days, and during this time Pak Tentrem oversees most of the work and is consulted by the tuner should any problem arise (see fig.48).

The final tuning takes a further day. During this stage most of the work concentrates on the *rai*, with much tap testing to find the thick parts which can be safely filed. It is difficult to find the thick areas of the *dudu* by tapping, but it is possible to 'feel' thickness on the *dudu* by filing: the easier the file glides over the *dudu* the thicker the metal. During the tuning process the instrument will periodically require revoicing by adding clay and carrying out the necessary subsequent hammering process to lose it.

The final stage of tuning is to clean up the the *widengan*, using a simple hand operated-lathe, known as *cakrak bubutan* (see fig. 49). A small indentation, called *ancer*, is made at the centre of the *pencu* using a punch. The instrument is then placed in the machine so that the tailstock locates the centre of the *pencu*, and the pressure plate is screwed in. The pressure plate has four metal arms extending from its centre; these being used to rotate the workpiece. The front bar of the lathe is used as a tool rest. A scraper chisel (*wegang*) is used to cut the bronze. This tool is made from an old steel file with a sharpened, rounded tapered end. Smoothing the *widengan* in this manner lowers the pitch. The voice of the instrument is checked, and adjusted if necessary to produce a single tone in the case of a kempul, or an *ombak* for a gong suwukan (method as described earlier). Finally, the instrument is sanded all over using emery cloth, and then buffed up with polish.

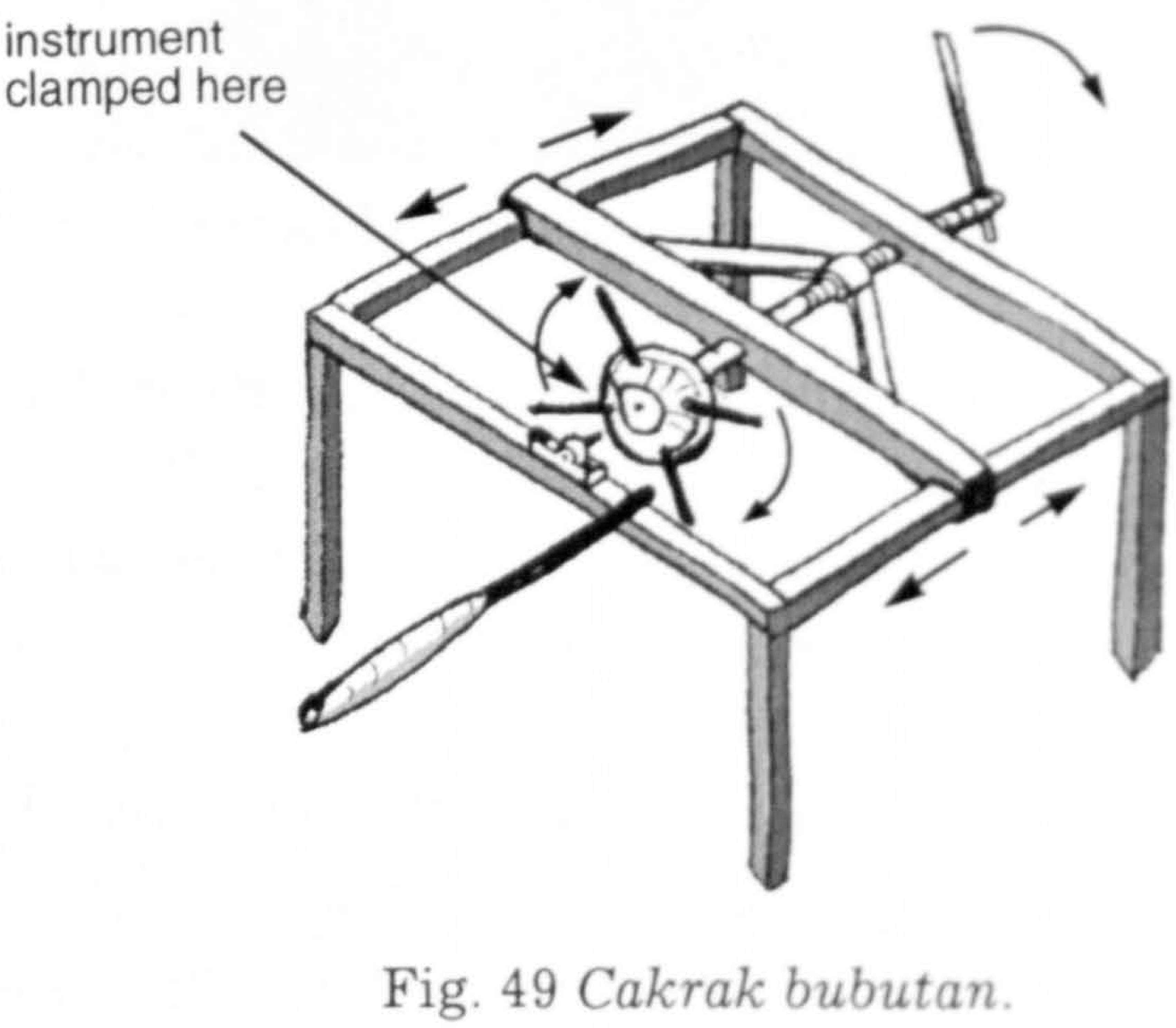


Fig. 49 *Cakrak bubutan.*

THE MANUFACTURE OF BONANG AND KENONG

At Pak Tentrem's smithy, in addition to the principle forge, which is reserved for making the larger instruments such as gong, kempul, and kenong, there are two smaller forges for bonang, *wilah* (bars of the metallophones), kemanak, and kecer. Four workers are usually involved in forging bonang:

1) *panji,*
2) *palu ngarep,*
3) *palu tengah,*
4) *pelamus.*

The *panji* directs all the crucial aspects of making; *mbesot* (melting), *njujut* (testing), casting, and the entire forging process. He controls the reheating of the workpiece, and also does the job of the *pengider*; turning the instrument on the anvil and directing the pounding. The *palu ngarep* (the most experienced smith after the *panji*) carries out most of the forging. During the initial forging (*lambe* and *uceng*), two smiths may be employed in the pounding. The second of these can be called *palu tengah*, but since this term is used when three or four smiths are working together on large instruments where '*tengah*' relates to the 'middle' position, it is common to call the *palu tengah* merely *pemalu* (hammer(er)). The *pemalus*, as well as operating the bellows, will do the job of the *pengalap* (carrying the workpiece from the forge to the anvil).

Enough metal to make up to four bonang is melted at one time. Bonang *penyingen* (moulds) are about 20cm in diameter, big enough to make a 15cm casting. The forging process is almost the same as for kempul, differing only in making the *recep*. Whereas the kempul *recep* is made during the cold hammering *metak* process, the bonang *recep* is made during the forging, after *membuat pasu*. There are two different types of bonang: bonang *wadon* (female) and bonang *lanang* (male). The shape of the *recep* of the *wadon* type is fairly flat, like kempul and gong, whereas the *lanang recep* rises sharply like the kenong (see fig. 50). On the bonang, the lower pitched six or seven *pencon* (collective name for all types of gong pots) are the female shape, and the six or seven higher pitched *pencon* are the male shape. The change in shape from *wadon* to *lanang* is not gradual as one might expect. When asked why not, the smiths said this is how they've always been made. Each style of *pencon* produces a different tone, and it may well be that since the bonang is usually played in parallel octaves, the tonal difference is appreciated because it gives a rich sound. The shape of the bonang *lanang* is necessary to produce the higher pitch whilst keeping the basic size, and therefore loudness, of the two *pencon* the same.

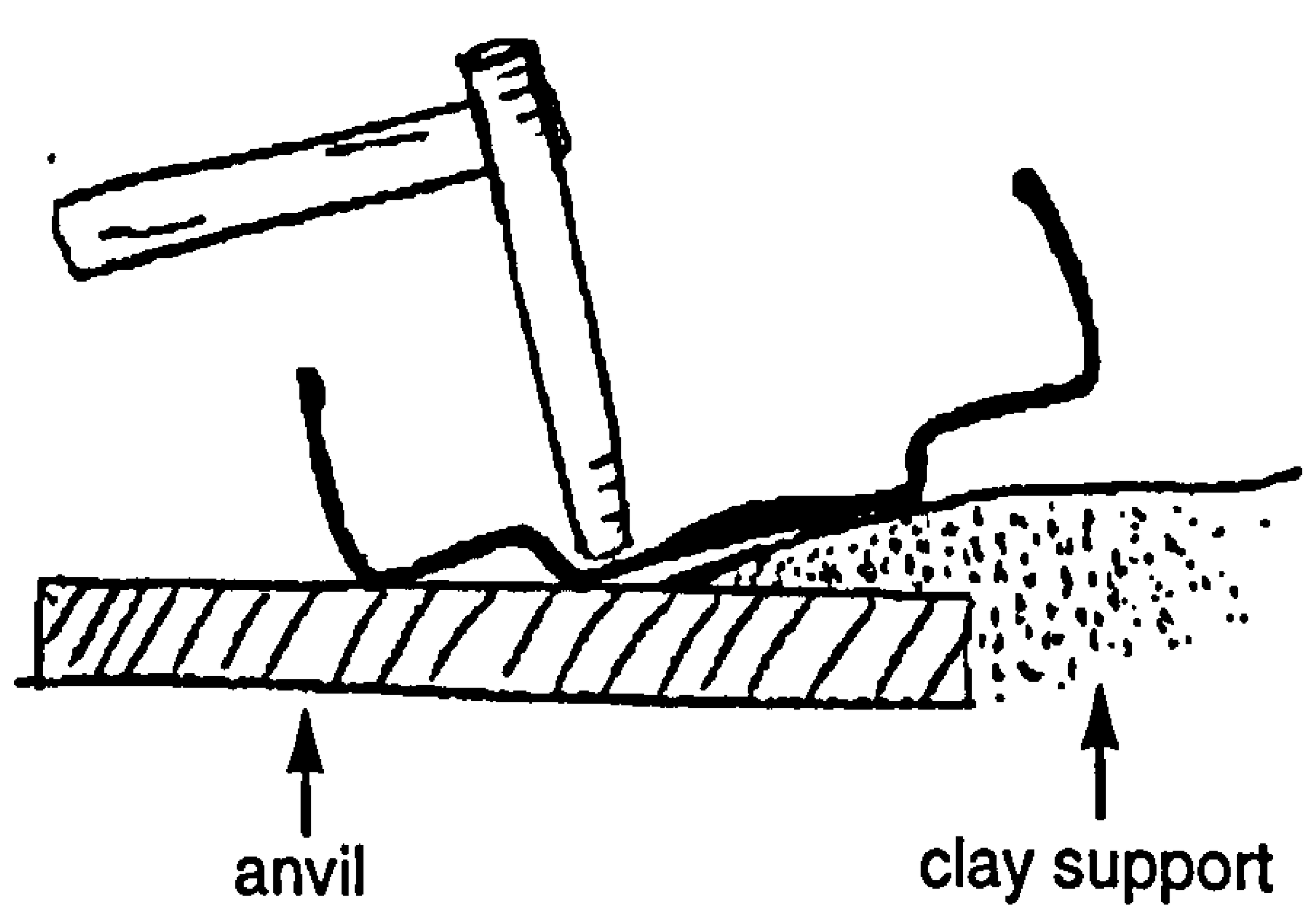
Bonang *wadon* Bonang *lanang*

Fig. 50.

The pounding is started with two smiths wielding *palu besi* to expand the *lakaran*. After a few rounds of hammering, the *lambe* is formed by one smith (see fig. 51). The task of expanding the workpiece (*njleber*) is carried out by one man, wielding a smaller *palu besi* than used for kempul manufacture. The *panji* turns the *jebleran* in between each blow of the hammer. Each bout of pounding can only last about fifteen seconds before the metal becomes too cold to continue. The *njebler* process is repeated until the correct diameter is reached.

Fig. 51 Forging the *lambe*.

The *bahu* is then made using the *ndekung* process as described for the kempul. However, for the bonang, *ndekung* is carried out until the *bahu* is high enough, and is then continued starting from the *uceng*, working outwards and stopping at the *pasu*. This process raises the *rai* so that it is higher than the *dudu*. For the bonang *wadon* this process is repeated only a couple of times so that the *rai* is 12mm higher than the *dudu*. However, for the bonang l*anang*, the process is repeated five times or so, until the *rai* is about 5cm higher than the *dudu*, and assumes the shape known as *welon* shown in fig. 52. It should be noted here that the width of the *rai* is different for each pitch; the narrower the *rai*, the higher the resultant pitch. The smiths use a steel rule marked with chalk to measure this distance. During all of the work described above, the *pencon* is constantly checked for symmetry and shape after each bout of hammering. Before returning the instrument to the forge, any areas that need more work are marked with chalk.



Bonang *wadon*

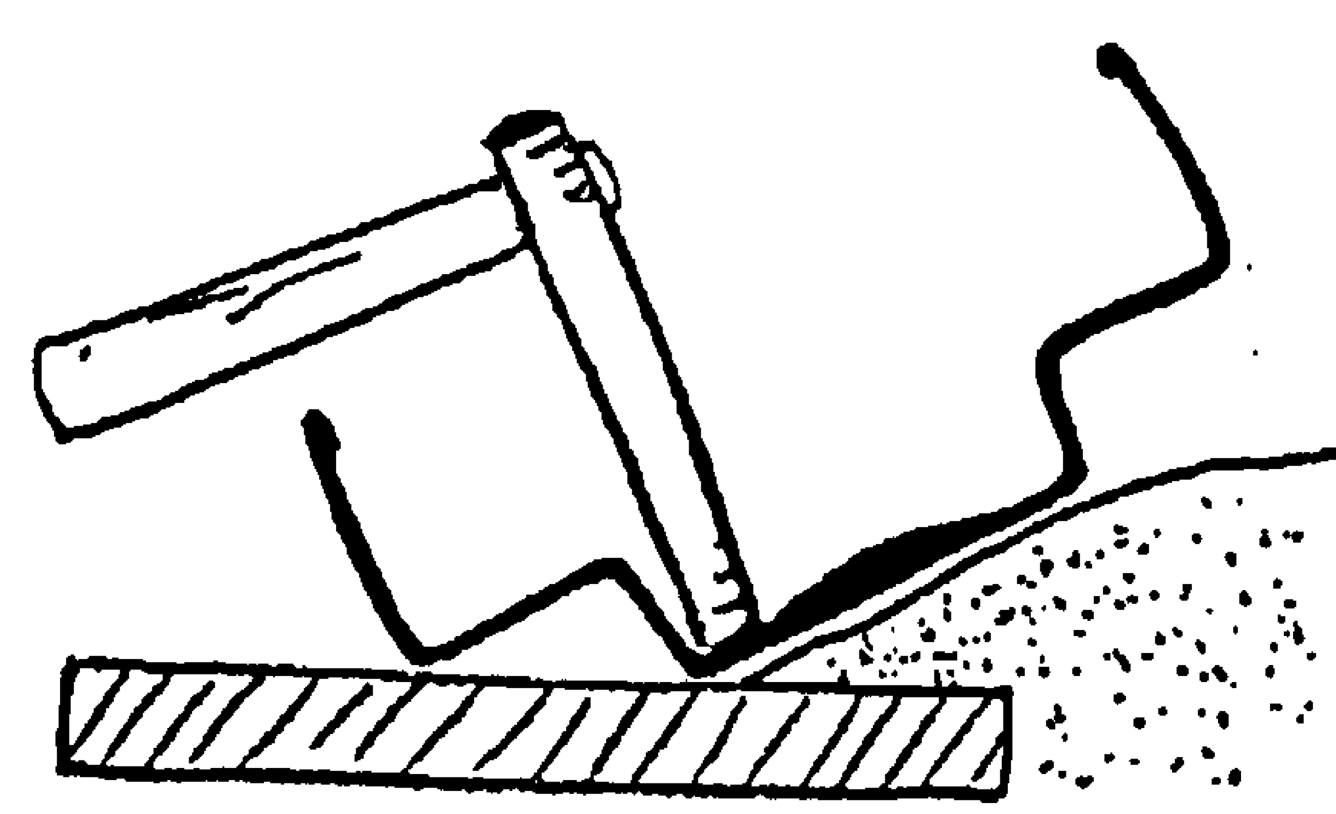

Bonang *lanang*

Fig. 52 *Welon.*

The smiths at Pak Tentrem's foundry make the whole series of pots before making the *pencu* and *recep*. This is done so that it is easier to make all the *pencu* the same size. The *pencu* is forged using a special stone anvil (*dodogkan*) with a half-spherical hole. The workpiece is heated to red hot and then placed centrally over the hole, and hit with a *palu penunjut*. The *pencon* is turned over and the shape of the *pencu* examined before the *pencon* is returned to the forge for reheating (see fig. 53). The depression around the *pencu* (*widengan*) is then made in the same manner as for a kempul.

The process of making the *recep*, known as *munuk*, is different for both the *lanang* and *wadon* style. The *recep* of the *lanang pencon* is made by placing the instrument at an angle on the iron plate anvil, and hammering from inside with a large-headed iron hammer. The *pencon* is supported at the required angle by a clay support with a cutaway for the *pencu* (see fig. 54).

Fig. 53 Examining the *pencu*, note the stone anvil for forging the *pencu* in the foreground.

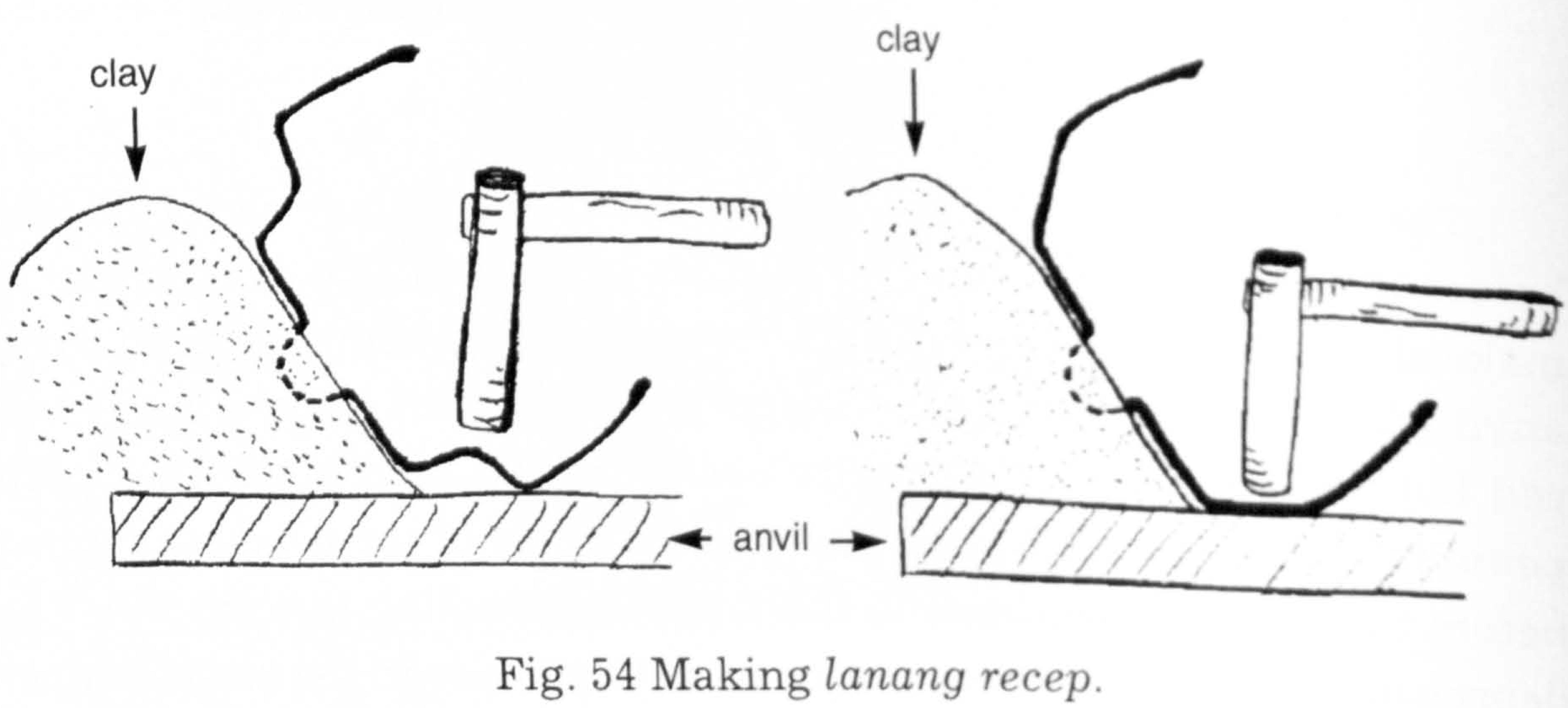


Fig. 54 Making *lanang recep*.

The shape of the *pasu* is checked and marked on the inside with chalk. Once again the *pencon* is reheated, and returned to the *ladok tandes*, where the wooden *palu alang* is used to clarify the *pasu*. Before using the metal *palu alang*, the *pasu* is checked for position and roundness. At this stage the *recep* may be slightly convex, so this is corrected by gently slapping the *recep* with a 5cm wide steel bar, with the bonang in the upright position on the flat *ladok tandes*.

The *recep* of the bonang *wadon* is made by first hammering the line of the *pasu*, as detailed above. A narrow piece of timber roughly 2.5cm wide and 6mm thick is then placed on the *ladok tandes*, and covered with a thin layer of clay. The *pencon* is heated and placed on the anvil in the position shown in figure 55. The action of pounding the *rai* forces the *recep* to rise and take shape.

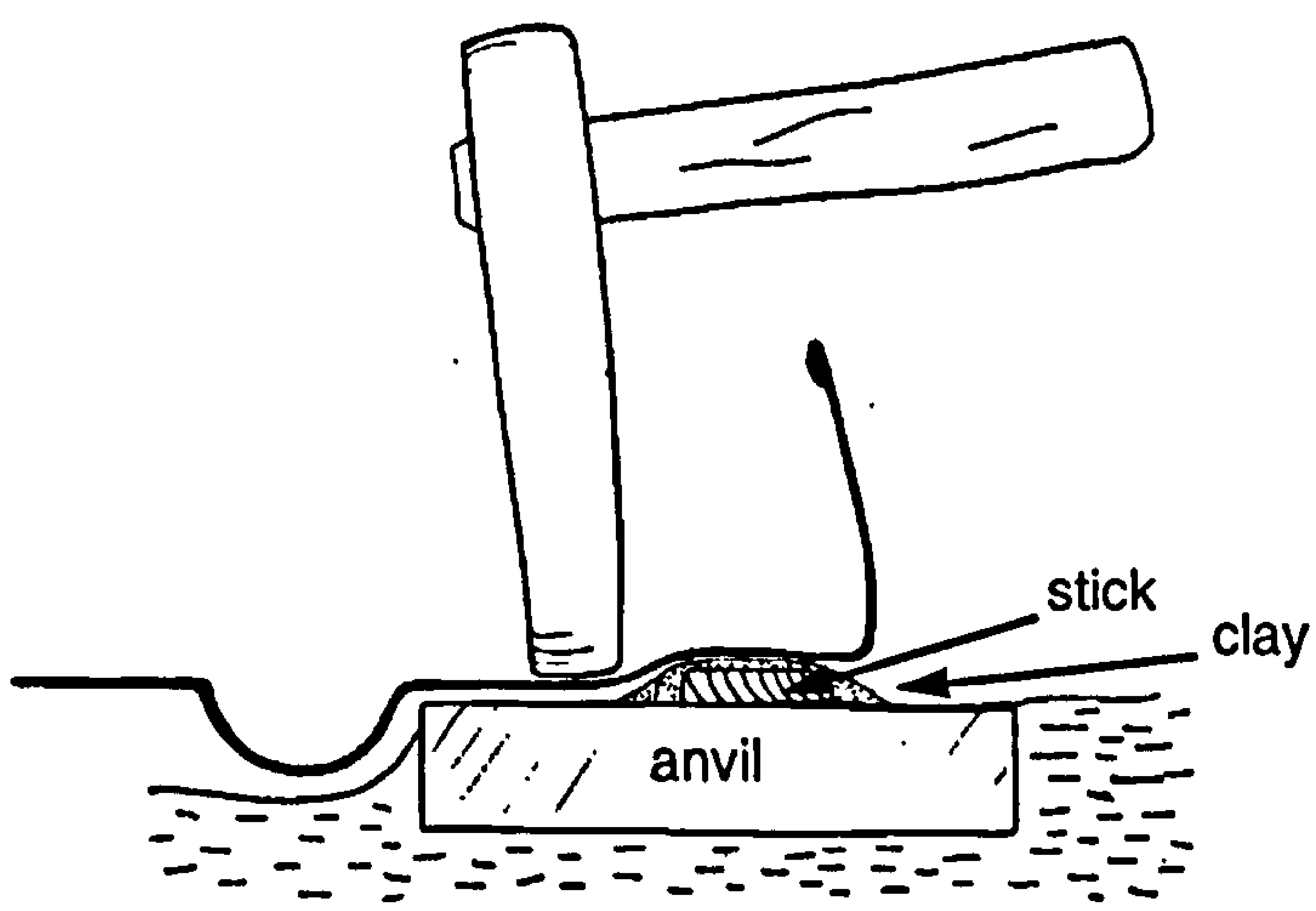


Fig. 55 Forming the bonang *wadon recep*.

The processes of *mapak* (smoothing the *rai*) and *menda* (smoothing the *bahu*) are carried out in a similar way as for kempul. Due to the problems of working on a small *pencon*, the smith usually turns the instrument with the tongs himself at the same time as hammering.

During these final stages, the pitch of each bonang is tested whilst still hot by striking the *pencu* with a thin metal rod. When hot, the tone of the bonang is dull, with a quick decay, making the pitch difficult to judge accurately. The hot bonang produces a pitch about one slendro tone lower than when cold. Since the bonang are made one slendro tone higher (when cold) than the final intention to allow for the amount of filing, the hot pitch is made the same as the tone the bonang will be tuned to.

Finally the bonang is heated evenly to red hot, the *klowong* hoop placed around the *lambe*, and then both are immersed in cold water. It is still possible to hammer the *pencon* when cold to shape and tune. The pitch of the cold *pencon*, before any filing is done, should be one pitch higher than the tone intended.

To raise the pitch the bonang is placed on the *pagol* and hammered from inside on the *rai*. This process is known as *juluk*. To lower the pitch, the *pencon* is turned over and hammered on the *rai* from outside. This process is known as *endak*. However, if the *pencon* is more than half a tone out, it must be returned to the forge. Any unevenness in the *rai* and *bahu* is hammered out from inside, with the part of the instrument being pounded resting against a flat metal anvil. During this stage it is important to make the surface of the *rai* level; if it is not, the tone of the instrument will not ring clearly, and produce a 'deg-deg-deg' sound.

The filing of the different parts of the *pencon* follow the same order as for kempul; 1) *rai*, 2) *pencu*, 3) *recep*, 4) *dudu*, 5) *bahu*. The filing and tuning process takes one day for one bonang. The final tuning is done whilst cleaning up the *widengan* on the lathe (*cakrak bubutan*) periodically removing the *pencon* from the machine to check the pitch. Finally, the bonang are sanded and polished.

The process of making kenong is very similar to bonang *lanang*. Kenong are always made in the principal forge due to their large size. The first stages of forging are the same as for kempul; using four smiths during the heavy pounding. The smiths consider kenong more difficult to forge than kempul, especially as the instrument gains shape, because the height of the *bahu* coupled with the relatively small *loloan* calls for extremely accurate hammering to avoid hitting the *lambe* and ruining the instrument. Due to this difficulty, kenong can take longer to forge than kempul, although they are still usually completed in one day. The tuning and finishing is done in the same manner as for bonang *lanang*.

THE MANUFACTURE OF METALLOPHONE BARS.

Three different types of bar shape (*bentuk*) are used for the bar (*wilah* or sometimes *bilah*) metallophones in gamelan:

1) *bentuk blimbingan,*
2) *bentuk polos,*
3) *bentuk pencon.*

The *blimbingan* bar shown in figure 56 is used for the gender barung, gender penerus and slenthem. The *polos* bar shown in figure 57 has a smooth rounded surface, and is used for the saron family of instruments. Within the saron family, three different *bentuk polos* exist, each distinguished by the cross-section of the end of the bar:

a) *bentuk nyigar penjalin* has an almost semi-circular cross-section, and is used for the very thick, narrow bars of the saron penerus,

b) *bentuk nggeger sapi* has a half-elliptical cross-section, and is used for the saron,

c) *bentuk nyirah lele* has a soft-curved cross-section, and is used for the relatively thin, wide bars of the saron demung.

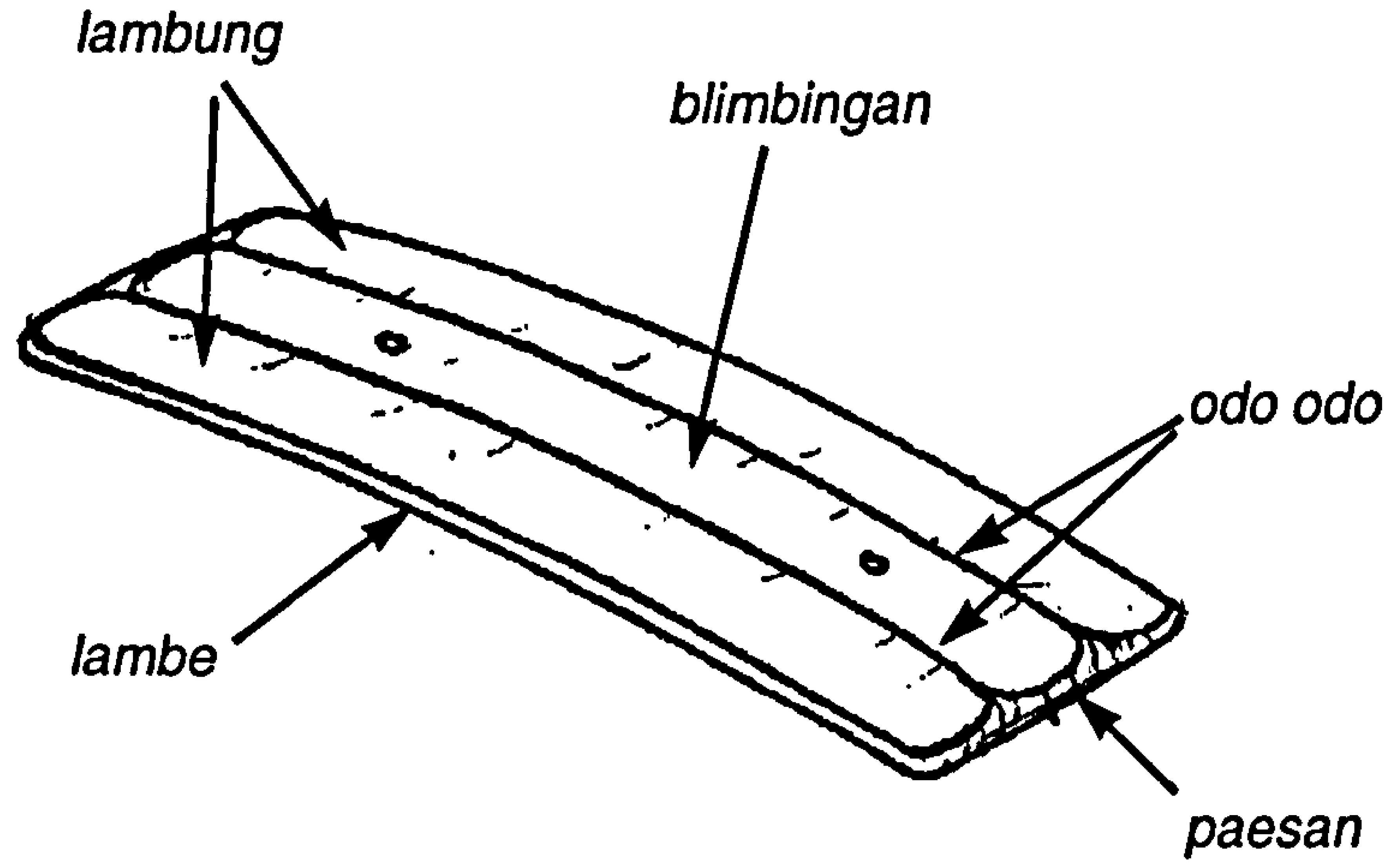


Fig. 56 *Bilah blimbingan.*

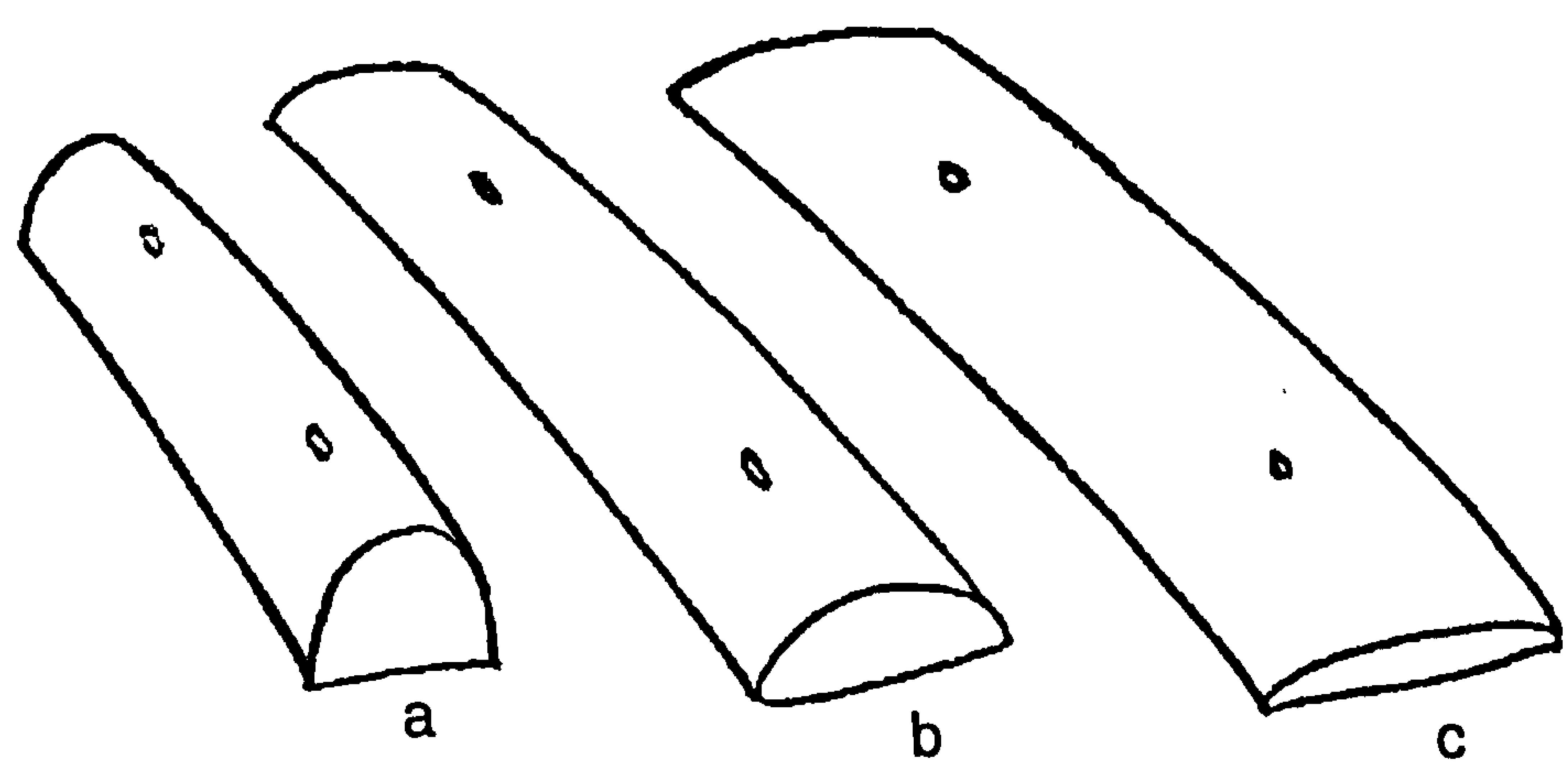


Fig. 57 *Bilah polos.*

The third kind of bar, *bilah pencon*, is a thin, gently curved bar with a central boss (see fig. 58). This type of bar is most frequently found on the gong *kemodhong*. This gong consists of two *bilah pencon*, suspended over either one or two large resonators (made of clay or zinc sheet). The bars are tuned slightly apart to produce *ombak.* Although the loudness of the gong kemodhong is not as great as a bronze gong, the length of decay is just as long. Although quite rare, bars with bosses are sometimes used on the slenthem, in which case it is known as *slento.* A kenong substitute instrument, known as kenong *renteng,* uses wide bars with a central boss. These latter *bilah pencon* are more often found made in brass.

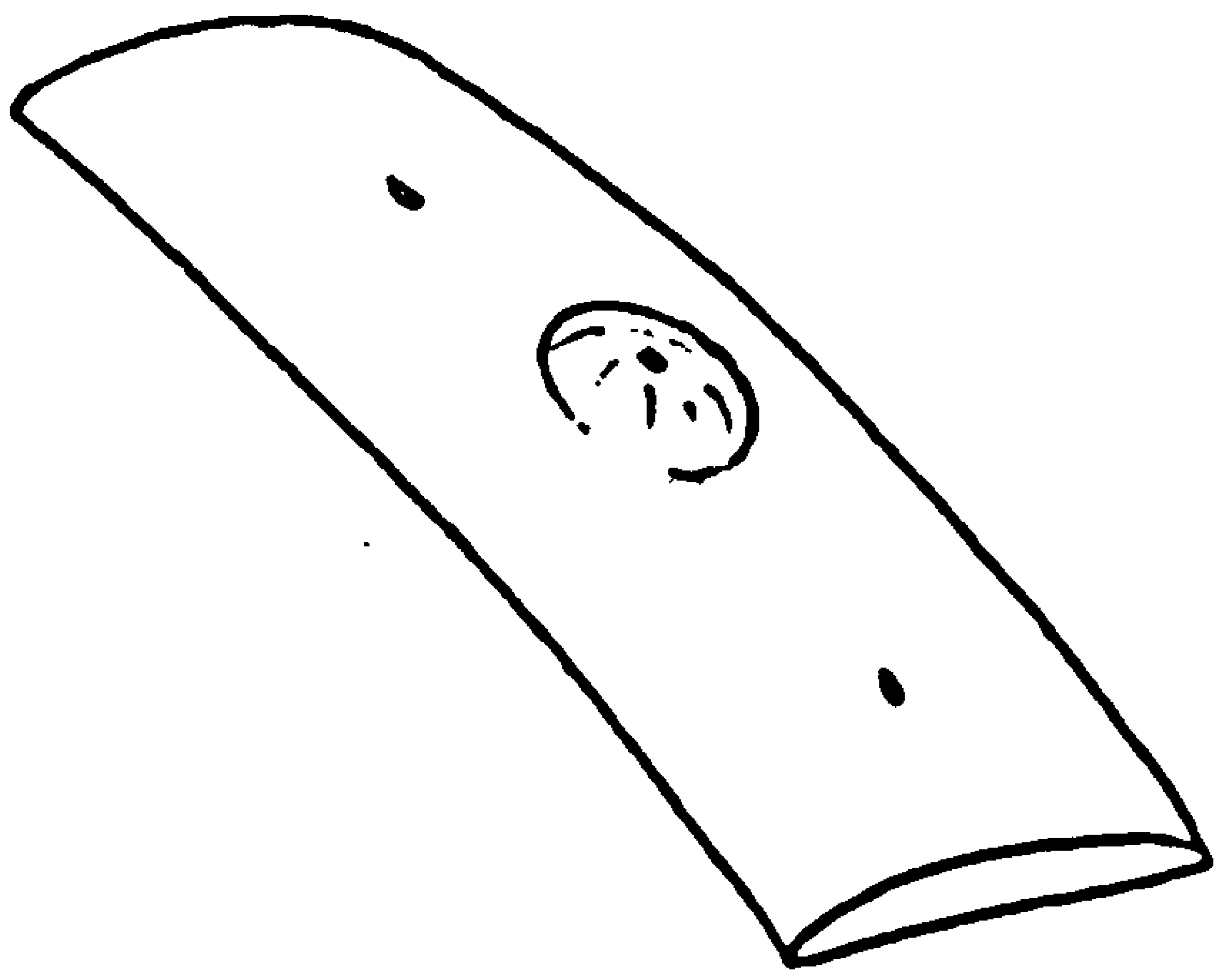


Fig. 58 *Bilah pencon.*

The forging of the bronze metallophone bars is considered the easiest job in the foundry. However, making a good set of bars requires a lot of work. The longevity of any bronze gamelan instrument is dependant on the amount of pounding during forging. Hammering the red hot bronze changes the molecular structure of the alloy from the cast state by compressing the structure, and expelling any gases. Pak Tentrem explained this by saying that the alloy of a bar that was insufficiently forged would oxidise, causing it to become brittle with age and consequently break. When such bars break it is possible to see the green oxidisation within the structure of the alloy.

At Pak Tentrem's forge, there are two workers who specialise in bar making: one *panji* who also performs the *pengider*'s duties, and one *pemalu* who also works the bellows. The processes of *mbesot* (melting), *njujut* (testing), and casting, are all performed in the manner described previously.

Two moulds are used in the casting of a set of saron bars, one being slightly larger than the other. It is important to ensure that the moulds are perfectly level. This is done by heating the mould, melting wax into it, and adjusting the level if necessary. The wax, which remains liquid, is displaced and burnt off by the molten alloy. Usually all the bars are cast together.

The largest and smallest bars are forged first, with reference to already finished examples paying regard to pitch as well as size. The other bars are then forged to fit in between these first two. The first task of forging is to hammer the bars narrower than the original cast state in order to form the *lambe* and compress the bronze. Much time is then spent pounding the middle of the bar along its length. Again the width is reduced, and then the two sides of the bar are hammered whilst it is resting flat on a metal plate anvil. This has the effect of bending the bar quite considerably. Once the bar has been hammered along its entire length on one side (this will involve the bar being reheated approximately five times), the same process is performed along the other side to straighten it. The whole process of pounding the edges, middle and sides are repeated until the bar is the same shape as the referent bar. Attention is paid throughout to the pitch of the bar. A saron bar should be one slendro pitch higher than the final intention to allow for the filing necessary to produce the polished finish. This means that the bar must come out of the forge very accurately shaped so that the minimum of filing is required. Finally, the bar is bent along its length by holding the bar at one end with a pair of tongs, and lightly hammering the other end onto an iron plate anvil (refer to fig. 59). After bending the bar, it is reheated and laid flat, playing surface uppermost, on a large steel plate. If all four corners of the bar do not touch the plate, pressure is applied at the centre of the bar to ensure no twists are present along its length. All the bars of the gamelan metallophones are made slightly curved. This curved shape, known as *luk*, is said to produce a more even sound by strengthening the fundamental (especially in the thin, low pitch gender and saron demung bars).

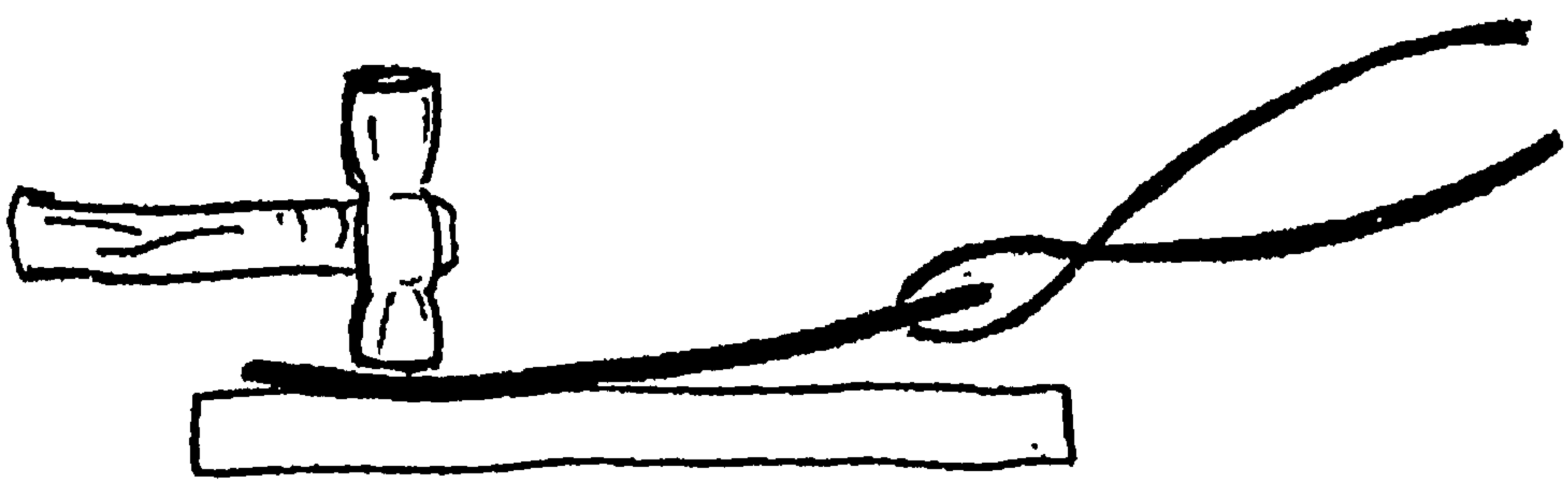


Fig. 59 Producing the curved, *luk* shape.

The forging of gender and slenthem bars is slightly more difficult due to the *blimbingan* shape. After the initial forging to reduce the size of the bar and compress the metal, the pounding is then continued on a 75mm square iron stake anvil which is securely held in a large baulk of timber implanted in the floor of the smithy (refer to fig. 60).

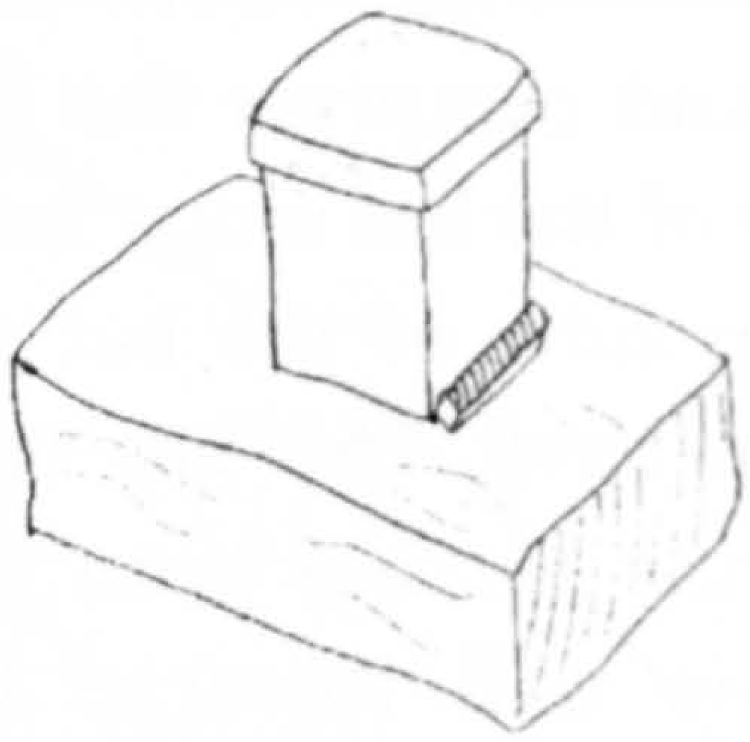


Fig. 60 Iron stake anvil.

The two ridges running the length of the bar, known as *odo odo* or *njodo* (refer to fig. 56 *bilah blimbingan*), are formed by hammering flat the centre of the bar first, and then pounding at an angle the sides of the bar (refer to fig. 61). Using a flat hammer (ie. non-rounded) enables the ridges to be accurately formed. The *odo odo* must be parallel. Pak Tentrem called the central part of the bar *blimbingan*, and the two sides *lambung*. However, some other makers refer to these parts as *rai* and *recep* respectively.

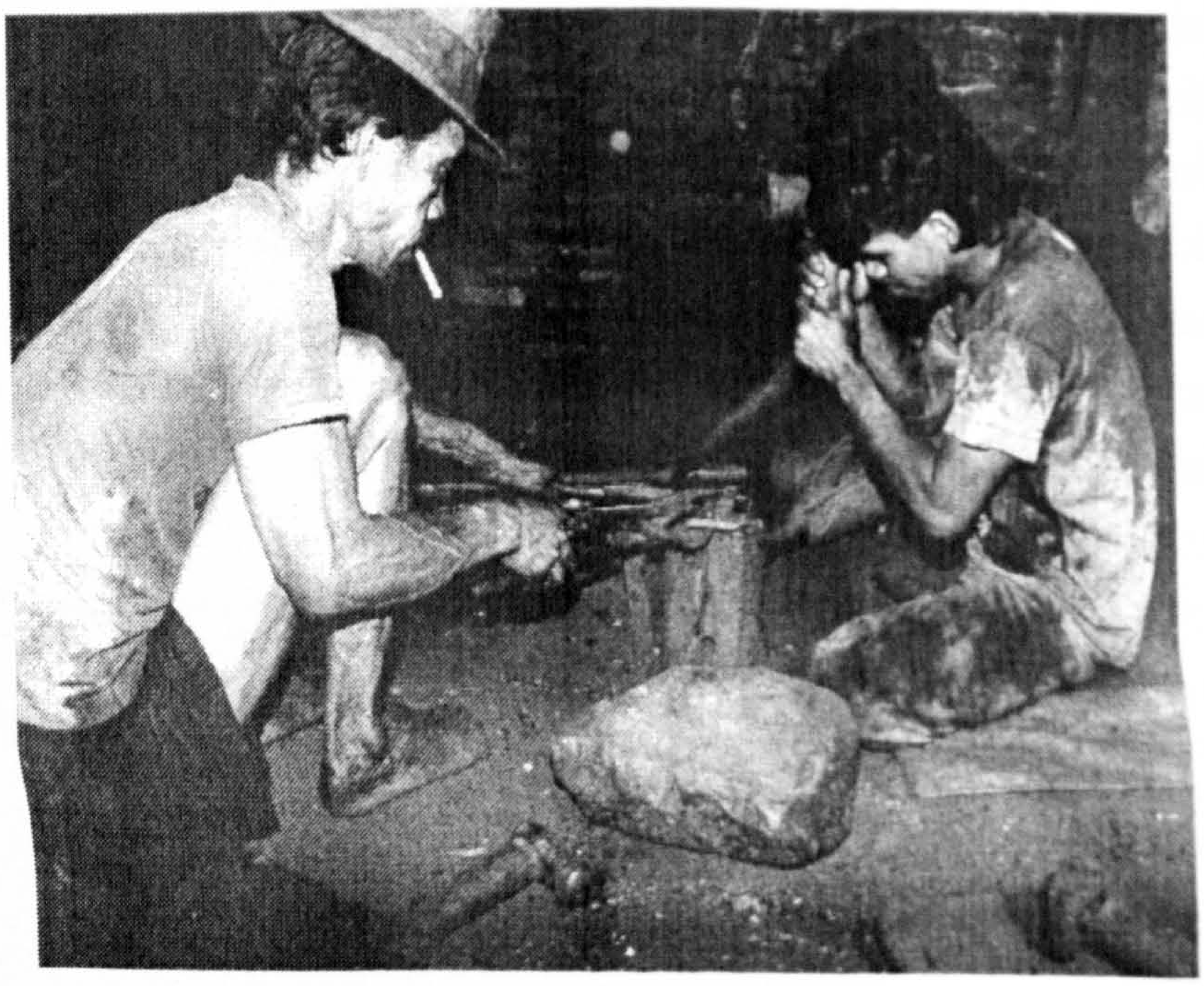


Fig. 61 Forming *odo odo*.

The *blimbingan* and *lambung* are forged flat, rather than concave, this shape being formed during the filing. The *luk* shape is formed in the same way as described earlier. Gender and slenthem bars are made at least two slendro tones higher than the final intention due to the amount of filing needed to produce the concave areas, and the lowering in pitch this produces.

All the bars are placed in order on the ground, and a straight line is drawn between the ends of the largest and smallest bars, so as to produce an even trapezoid shape. The ends of the bars (usually only 6mm or less) are then sawn off using a hack saw. The length and shape of the thick saron and peking bars are usually forged accurately enough to avoid using a saw.

Before the bars are handed over to the *tukang gilap* for filing and tuning, the holes through which the supporting cords pass are drilled at the nodal points. The nodal points (0.224 of the length from each end for a bar of uniform thickness) are found on the largest and smallest bars, and then all the bars are laid out in order. A straight edge is laid across the bars so that the nodal points of the largest and smallest bars line up. A line is then drawn across all the other bars to mark their nodes. The holes are then drilled with a hand-operated pillar drill.

The filing and tuning is carried out entirely on the top surface and ends of the bar. Any retuning that may be necessary at a later stage is generally done on the underside to retain the finish. The *polos* type bar of the saron family is first filed all over to produce a smooth surface and reveal the shiny bronze alloy. The pitch of the bar should now be close to the required note, and preferably slightly sharp since it is more difficult to raise the pitch than lower it. Filing between the two nodes lowers the pitch, and filing at the ends of the bar beyond the nodes raises the pitch. The tuners at Pak Tentrem's smithy have a set of tuned iron bars to hand. Once the pitch of the workpiece gets very close to the required note so that beating occurs between the two, clay is often used to help work out whether the workpiece is flat or sharp.

Filing the *blimbingan* type bar of the gender and slenthem is slightly more difficult. The *blimbingan* and *lambung* areas of the bar are flat when they come out of the forge and these need to be filed using the *patar* to make the concave troughs. Making these troughs parallel is very difficult and requires much concentration and skill. Following this, the ends of the bar, *paesan*, are shaped. The *paesan* should be rounded off smoothly since the heel of the player's hand (and thumb) touch this part of the bar to dampen the sound. Shaping the *paesan* is done now because this raises the pitch, and further shaping of the *blimbingan* and *lambung* can then be done to lower the pitch to the required note.

The *bilah pencon*, as used for the gong *kemodhong*, follows the same processes of manufacture as the *polos* type bar. *Bilah pencon* are the most difficult to forge. This is due to the large size of the bar, its relative thinness, and the problems inherent in forging a boss in a large bar. Forging the *pencu* is the last stage in the process. In order to successfully forge the *pencu*, the centre of the bar must be left slightly thicker than the surrounding area. The *pencu* is forged using a purpose made stone anvil, similar to that used for forging bonang *pencu*, but larger with a bigger depression for hammering out the boss. The same principles apply to tuning *bilah pencon* as for the other types of bars.

Kemanak

Pak Tentrem is one of the few gamelan smiths in Java still capable of producing good quality bronze kemanak. Kemanak are said to be one of the most difficult instruments to voice and tune, ranking, surprisingly, alongside the large gongs. All the other instruments in the smithy are forged by Pak Tentrem's workforce with him overseeing, but during the latter stages of forging kemanak Pak Tentrem takes over. . The testing of the alloy, *jujutan*, is very important for kemanak since the bronze has to be hammered very thin and then bent over, without cracking to form a tight curved tube. The kemanak *lakaran* is cast in a special mould shown in figure 62.

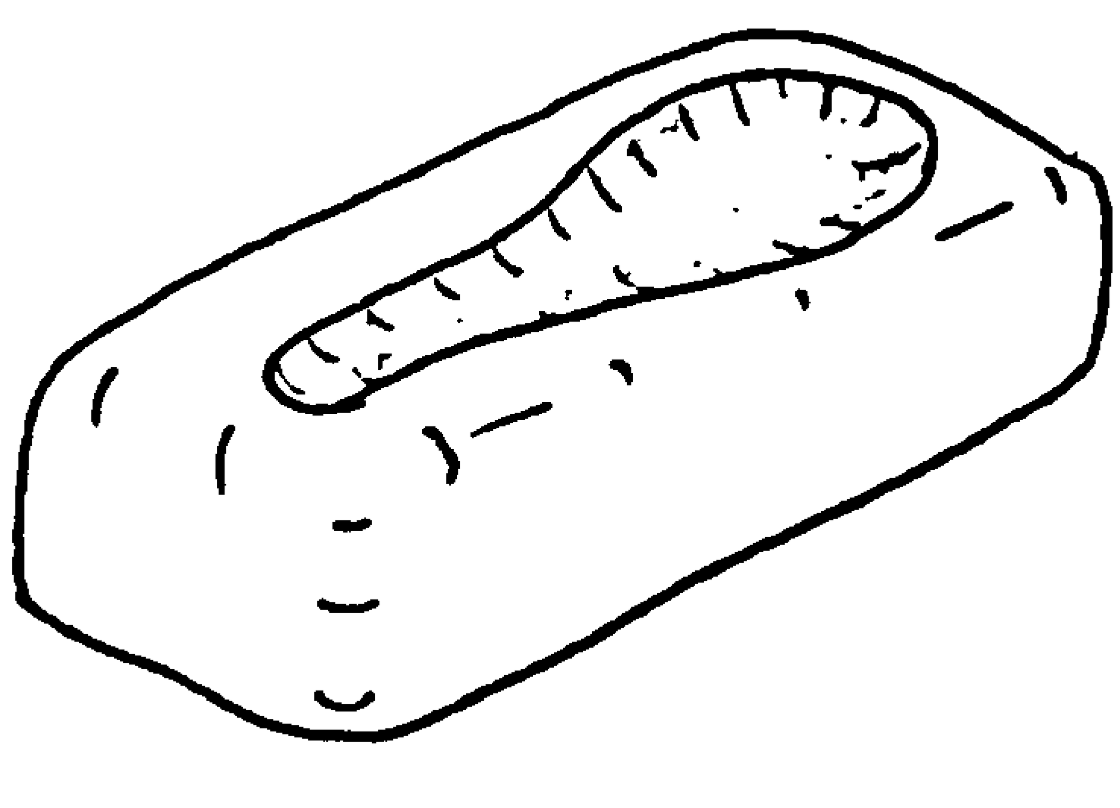


Fig. 62 *Penyingen* kemanak.

The casting is hammered to an almost uniform thickness, leaving the centre slightly thicker. This initial forging, enlarging the workpiece and compressing the alloy, is usually done by other smiths. From here, Pak Tentrem takes over. The workpiece, which now resembles a vanity mirror in shape, is immersed in cold water and closely examined for differences in thickness; any areas that require further pounding are marked with chalk. The required width of the workpiece is checked by measuring the circumference of an existing kemanak. The workpiece is then returned to the forge and the areas requiring more hammering are attended to. Once the required size is reached, much time is spent smoothing the surface of the metal by hammering it against a large flat iron anvil, turning the workpiece periodically until all undulations and thick spots have been smoothed out. Achieving a uniform thickness in both sides enables the flat mirror-shaped object to be bent evenly to produce a smooth curve. The extra pounding involved in making kemanak helps prevent the alloy cracking during the bending operation.

The kemanak is now placed on a wooden former, and the instrument hammered to bend up both sides (see fig. 63).

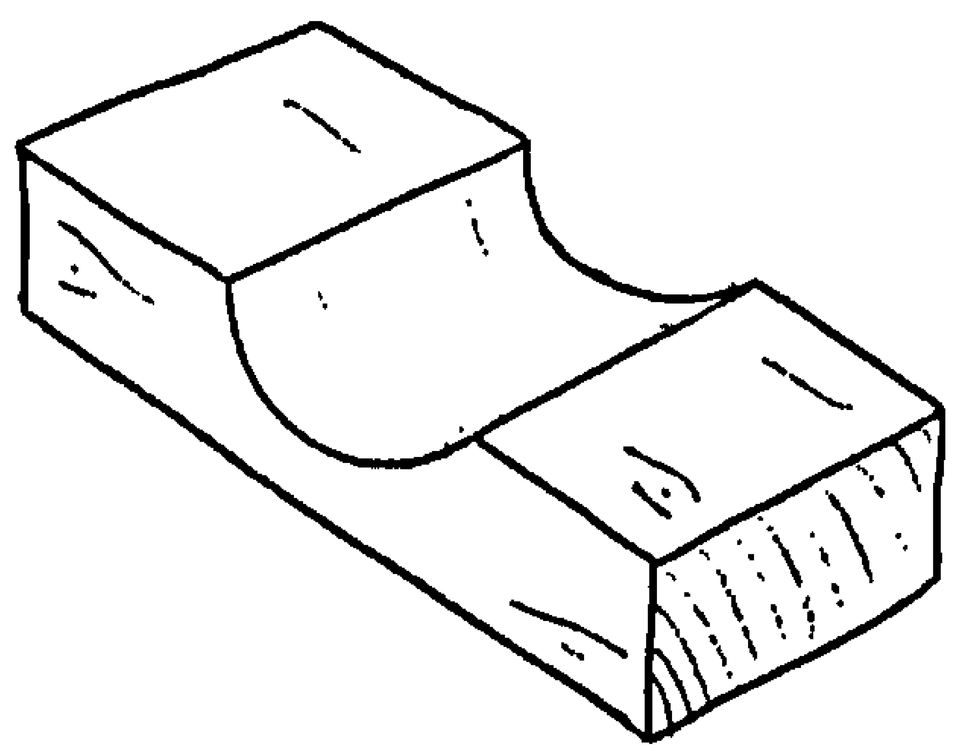


Fig. 63 Kemanak former.

Once the kemanak has taken the curved shape of the wooden former, the two sides are hammered to bring them closer together (see fig. 64 - stages of kemanak). From this stage tongs are used to gently squeeze the sides together. Bending the sides together in this manner is extremely risky; the kemanak must only be worked on when red hot to prevent cracking. The hammer and tongs are now used alternately, until the sides are bent over and almost touch, leaving a 6mm gap. Finally the sides are hammered together further from the top until the gap is closed down to about 3mm.

The final stage of forging is to shape the handle. The end of the handle is bent round a steel rod to produce a hook, and then the whole handle is forged to a gentle curve using the head of a large wooden hammer as a former. The kemanak is then reheated to red hot and immersed in the cool water of the *planden.* At this stage the instrument sounds completely dead.

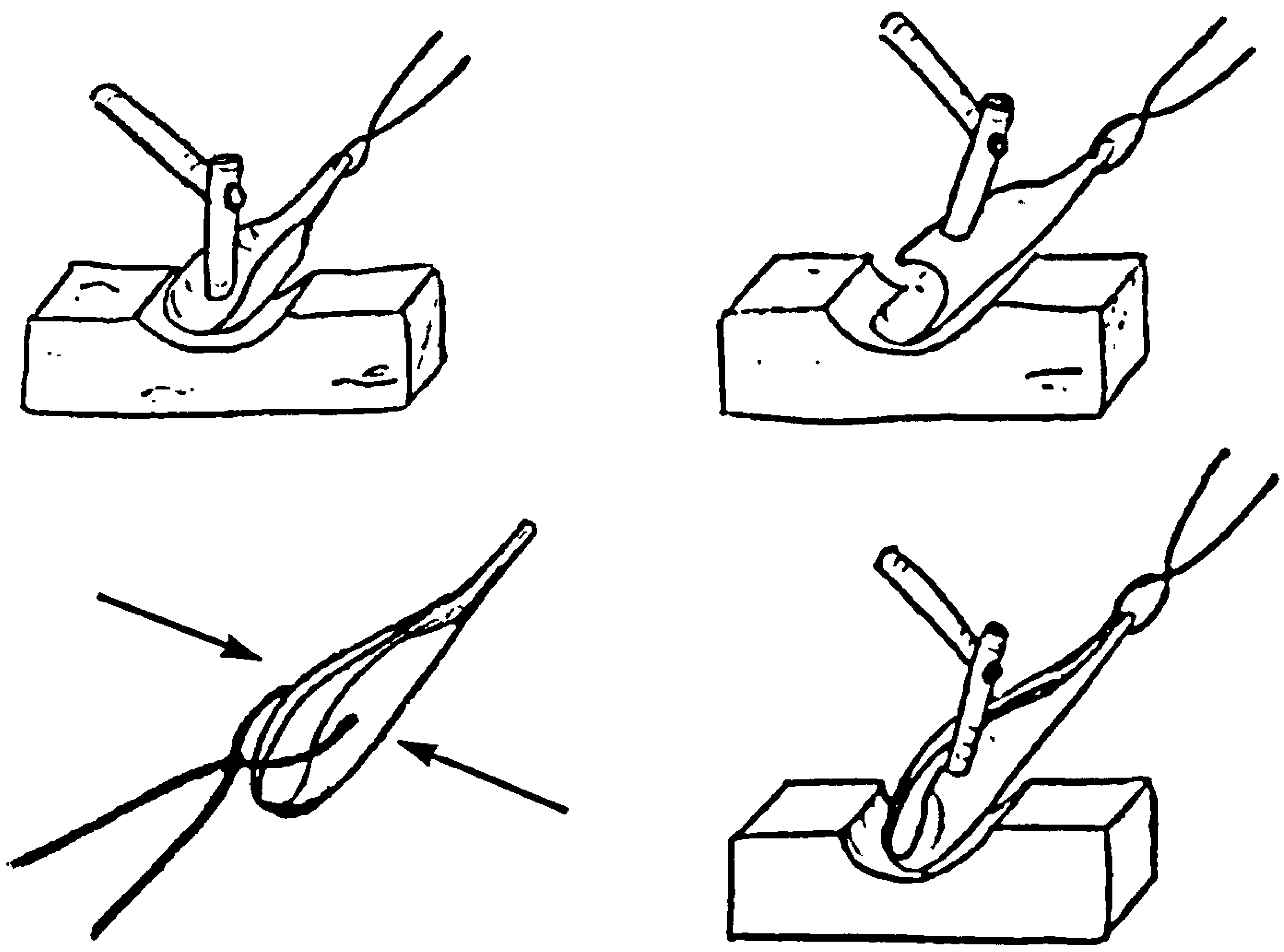


Fig. 64 Stages of making kemanak.

The initial stage of filing is done by one of the filer/tuners. Once the shiny bronze has been revealed all over, Pak Tentrem takes over to voice the instrument. The kemanak is tapped all over to check for differences in thickness that stifle the voice. Each side of the kemanak will have a different pitch at this stage, and so it is necessary to equalise the two. The side with the lower pitch is worked on first, by tapping, listening and then filing. Filing the sides lowers the pitch, and this is continued until Pak Tentrem is satisfied that an even voice has been achieved all over the one side. The other side is then worked on in a similar way until the two pitches are made the same (refer to fig. 65).

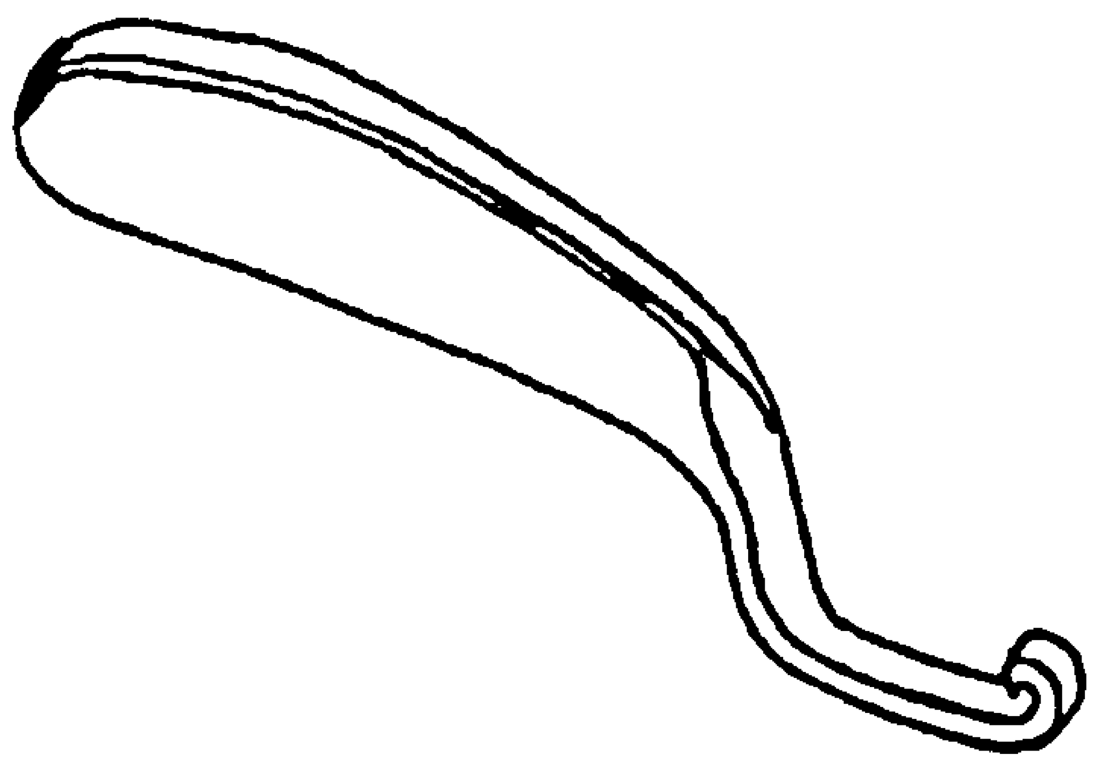


Fig. 65 Kemanak.

Having equalised these two sides, it is now possible to improve the voice of the instrument by filing the back of the kemanak. This involves much tapping and listening to work out where thinning is necessary. The thin areas sound slightly hollow. However, it is very difficult to hear these differences because the back of the instrument is quite thick, and the variations are very small. Gradually the voice gets stronger until the optimum is reached. During this voicing, the pitches of the two sides will change slightly. The kemanak should still be sharp of the required pitch because raising the pitch is difficult and only possible by widening the gap. The two sides are filed down until the desired pitch is reached.

CHAPTER IV

THE MANUFACTURE OF IRON AND BRASS GAMELAN BY BAPAK MULYADI, IN SOLO, CENTRAL JAVA

The field work for this study was carried out in Solo during March, 1989. A number of instruments, including brass bonang barung, iron saron, and gambang were commissioned from the iron/brass gamelan maker, Pak Mulyadi. The manufacturing techniques of these and other instruments were studied.

Pak Mulyadi has a small home workshop in the Lojiwetan district of Solo, where he employs five workers. The open-fronted workshop is situated at the front of the family home, looking onto the small side street. The front room of the house is used as a reception, entertainment, and instrument display/store area. Customers and friends are welcomed in true Javanese fashion with glasses of hot, sweet tea.

Pak Mulyadi carried out his apprenticeship with Pak Tentrem, after which he continued to work as a gong smith before starting his own workshop. Pak Mulyadi now employs four apprentices, most of whom are relations from his home village outside of Solo.

Fig. 66 Pak Mulyadi with a brass bonang made by himself.

The main part of the following text details the making of brass bonang (see fig. 66). The same basic techniques are used for the other *pencon* instruments; kenong, kempul, and gong. Manufacturing techniques of the bar metallophones are described later.

MATERIALS

The alloy, steel, made from iron and carbon, is the main material used. Instruments are either made from reclaimed sheet steel in the form of old oil drums, or from new sheet material bought from the local metal merchants. The reclaimed metal is much cheaper, but is rather thin, and does not produce the resonance of the thicker, new sheet steel. A common compromise is to use both the new and old materials for different parts of the same *pencon*. In such a case the new steel is used for the *rai* or 'sounding' part of the *pencon*, and the reclaimed steel for the *bahu*.

All *pencon* are made with a brass boss, hammered out from sheet material. Brass is a soft alloy made from copper and zinc. Most of the brass Pak Mulyadi uses has to be bought new, at a high cost, from the local supplier. A *pencon* made entirely from brass produces a superior sound to a steel instrument, but the cost of a brass instrument can be six times that of a steel equivalent.

Saron bars are generally made from either new, thick sheet steel, or from reclaimed vehicle leaf springs. The high tensile steel of leaf springs produces a better sound than the mild steel plate. Leaf springs are in high demand, not only from instrument makers, but also from tool makers who value the superior quality, high carbon metal. Consequently, this reclaimed material commands a higher price than new mild steel. Brass is sometimes used for saron keys, but this is quite unusual due to its high cost (more than leaf springs) and the often superior sound quality of instruments made from leaf springs. Brass saron are often bought for aesthetic reasons where a steel instrument would not fit in with a gamelan made entirely of brass.

On the other hand, brass is the preferred material for the gender family of instruments, producing a quality of sound bettered only by bronze.

Generally speaking, an instrument made from reclaimed oil drum steel costs about one twelfth of the bronze equivalent, an instrument made from new sheet steel is about one sixth the cost of bronze, and a brass instrument is roughly half the cost of the bronze equivalent.

THE MANUFACTURE OF PENCON FROM SHEET METAL

This section details the making of a brass bonang barung. Bonang *pencon* are either of the *wadon* (female), or *lanang* (male) shape. The two styles require slightly different manufacturing techniques. However, the techniques used to make bonang *wadon* are the same as those used to make the other *wadon pencon* ie. gong, suwukan, kempul, kempyang, and kethuk. Likewise, the same techniques are used in making bonang *lanang* and kenong.

Sheet metal *pencon* are made up from three separate parts which are cold-hammered and then riveted together. These parts are the boss (*pencu*), the top (*rai and recep*), and the sides (*bahu*) as shown in figure 67.

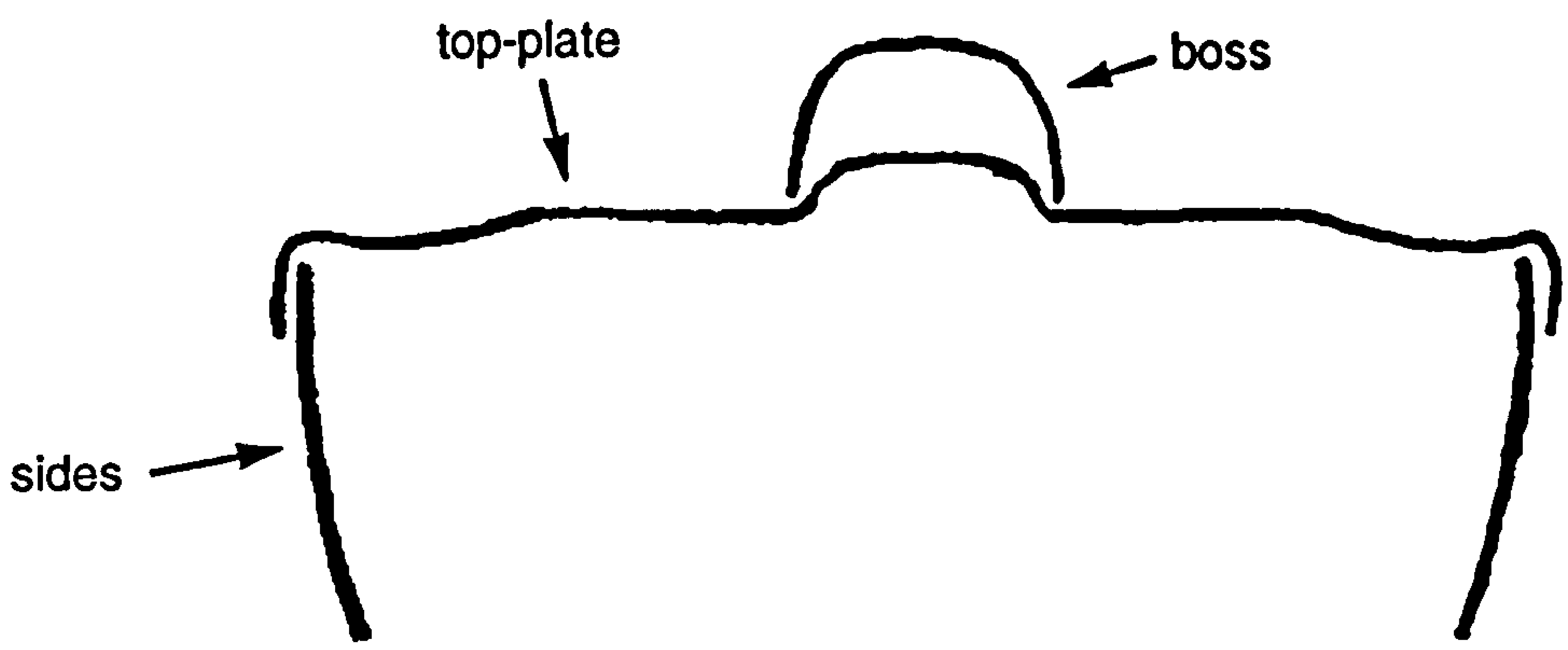


Fig. 67 Separate parts of *pencon*.

The first task is to cut out all the separate parts. Pak Mulyadi has a set of metal templates including one for each part of every instrument made in the workshop. Having marked the shape using the appropriate template, the sheet metal is cut out using a hammer and cold chisel. This is a laborious job, especially if one considers that it is necessary to cut out forty-eight parts to make a slendro bonang (the *bahu* are usually made up using two pieces to save on material). Consequently, this job is normally done by the apprentices.

All the twelve or fourteen *pencon* of a bonang barung use the same dimensions for the top-plates and *bahu*. Those of the bonang penerus are slightly smaller, but again, all start off the same size and it is the position of the *pasu* and height of the *rai* that determine the pitch. As mentioned earlier, a slightly different technique is used to make the top-part of the *wadon* style and *lanang* style. The top-parts are made before the *bahu* for both styles because the circumference of the *bahu* is determined by the circumference of the top-plate.

Bonang wadon

A circle is scored with a pair of dividers 10mm from the edge of every top-piece. This line marks the position of the lip. An inner circle is then scored to mark the position of the *pasu*. The lip is formed first by hammering on the outer scored line using a wedge shaped hammer (see fig. 68). The plate is hammered onto a tree stump which is used both for forming the lip, and the bowl shape required for the *lanang* style *pencon*. The top of the stump is hollowed out for forming the bowl shape, and a groove cut for making the lip. The plate is first of all held almost flat, and as the lip begins to form the plate is raised gradually until it is eventually held vertically. Once the lip has been bent over in this way it is necessary to smooth, or uncurl all the creases. This is done with a ball hammer using the flat end, and hammering the lip onto a flat metal anvil.

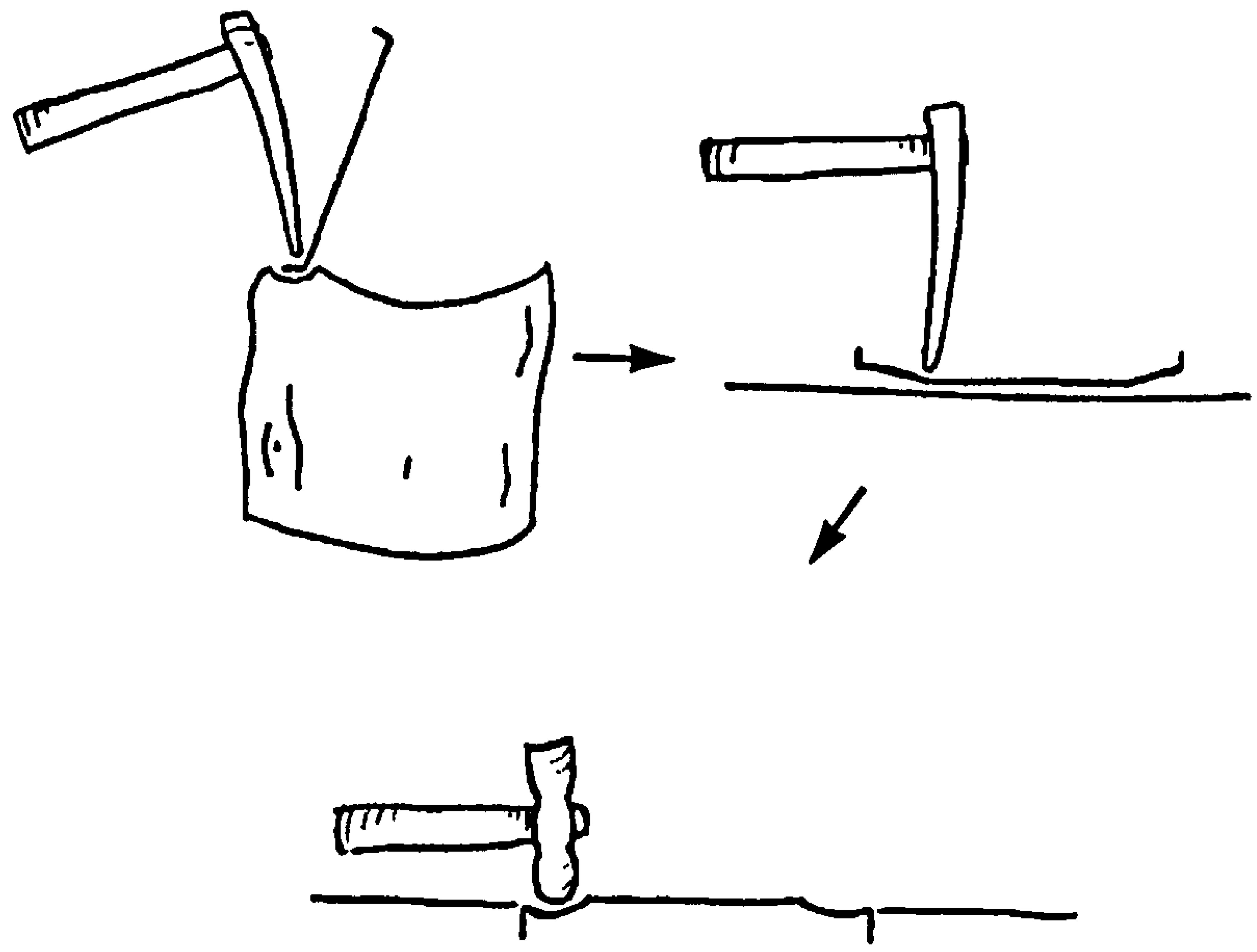


Fig. 68 Making the lip, *pasu* and *recep*.

The *recep* is made next. The plate is placed upside down on the earth floor of the workshop and then the scored line for the *pasu* is hammered. This process slightly raises the height of the *rai*. The plate is then turned the right way up, and whilst still on the earth floor, it is rotated back and forth so that the lip digs itself into the earth, and the *rai* rests flat on the floor. In this position the *recep* is carefully formed by hammering with a round ended hammer, making sure that the curve of the *recep* is the same around the entire circumference of the plate. This action tends to distort the *rai*, and so the top is placed upside down on a metal plate anvil and hammered flat.

Bonang lanang

The first task of making the *lanang* style *pencon* is to hammer the top-plate into a bowl-shape, using the tree stump as a former. When starting this process the plate is held with a cloth in one hand to lessen the sharp impact transferred to the plate from the hammer. Starting with pounding the outer edge, the plate is rotated so that the hammer blows form a spiral working towards the centre of the plate. The bowl-shaped plate should be made as even and smooth as possible. This process demands considerable skill and accuracy and can easily take one hour from start to finish. Figures 69 and 70 show the stages of shaping the top-plate for the *lanang* style *pencon*.

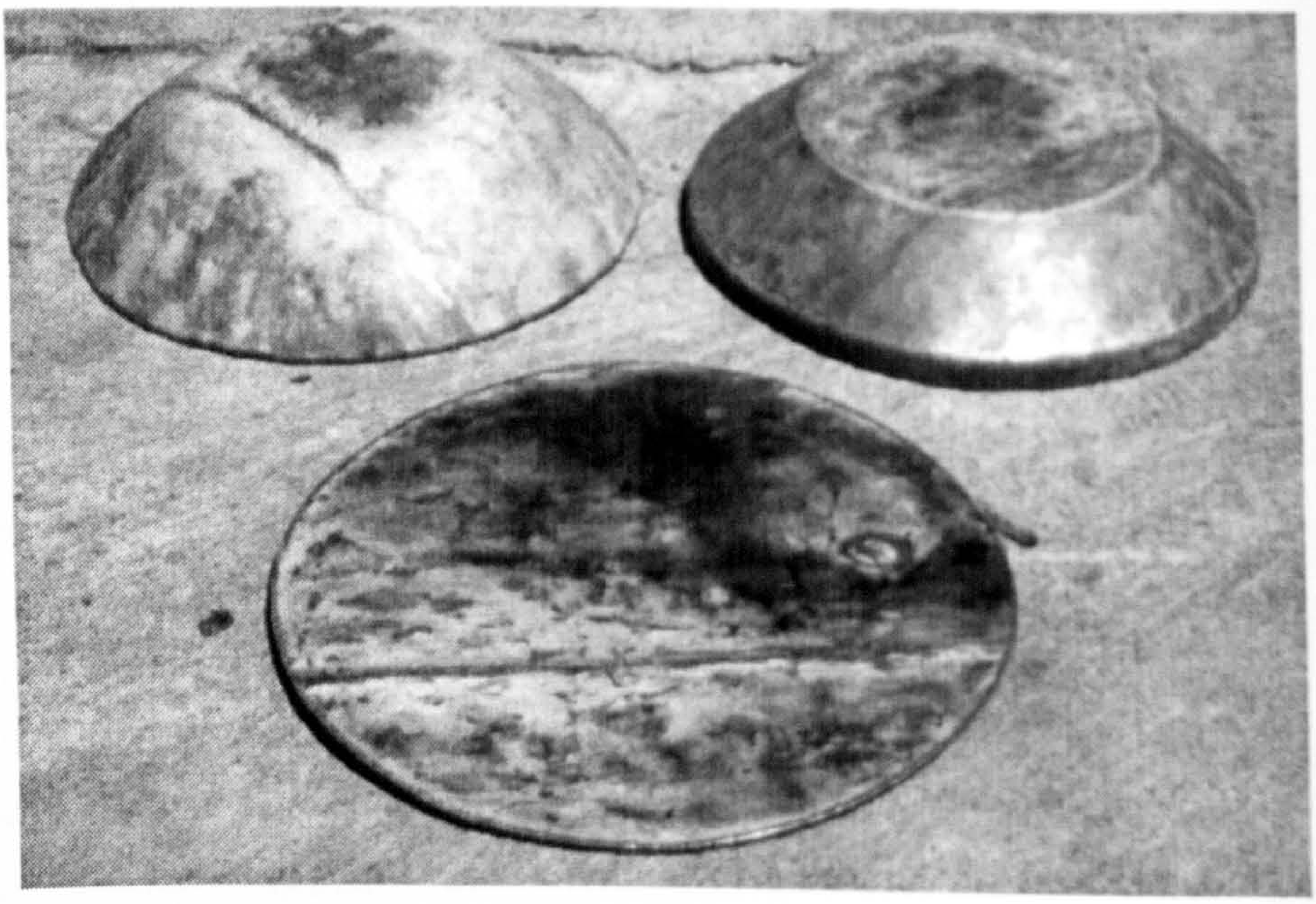


Fig. 69 Progressive stages of shaping *lanang* top plate.

The lip is now made, in the way as described earlier for the *wadon* style *pencon*. The position of the *pasu* is scored with dividers, the plate is then placed upside down on the earth floor, and using a cold chisel, the circle is hammered. The *recep* of the *lanang* style needs to be flat, and this is achieved by placing the plate on a large metal anvil so that it rests on the *rai*, and then hammering with the flat side of a ball hammer (see fig. 70).

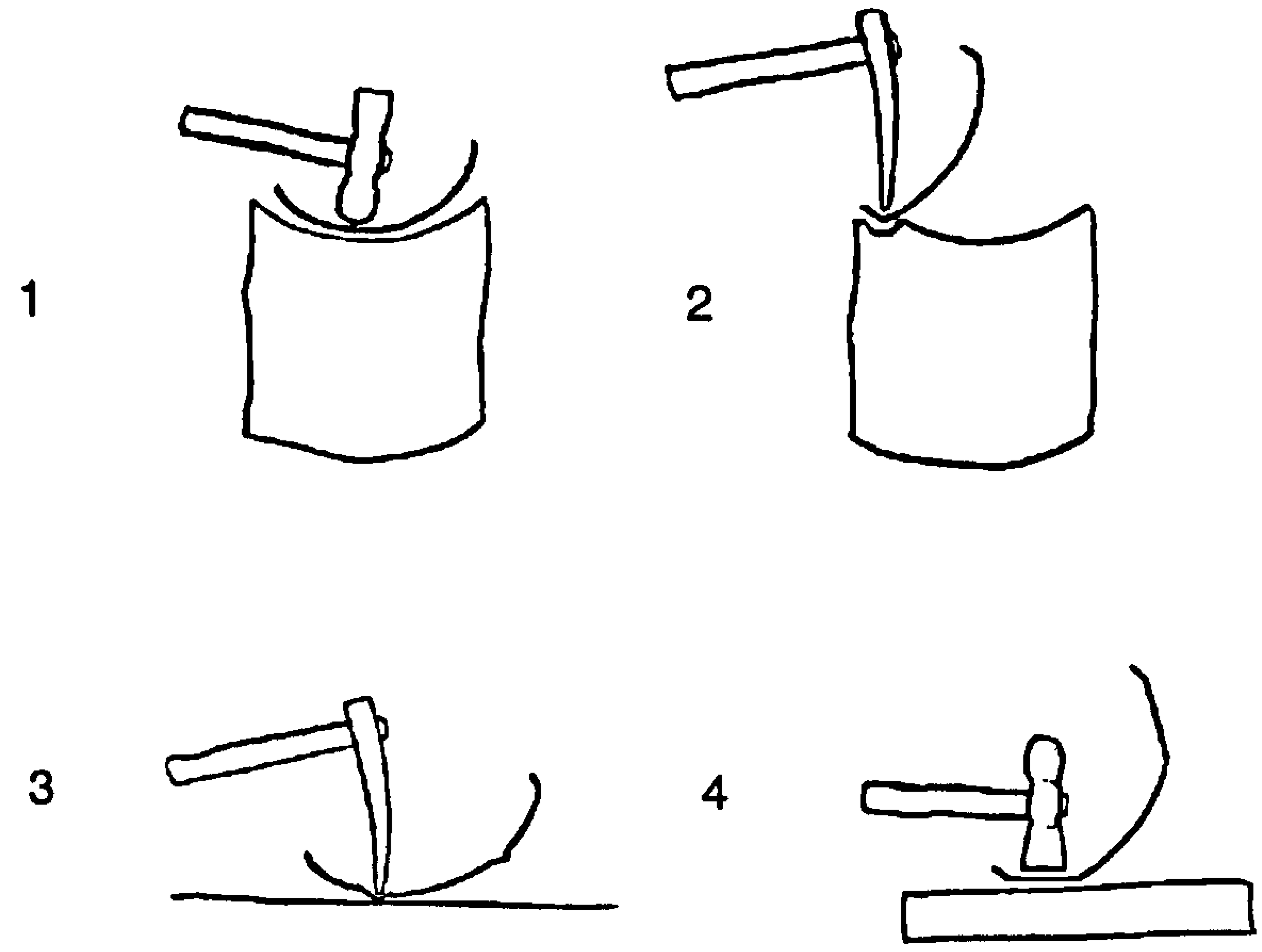


Fig. 70 Progressive stages of shaping *lanang* top-plate.

The plate is now placed on the anvil the right way up, and the central part inside the *pasu* is pounded using a flat hammer. This area is hammered right up to the *pasu* so that a clean line is formed between the *rai* and *recep* (see fig. 71). It is now necessary to hammer this central part flat by turning the plate upside down, working with a flat hammer from inside (see fig.71). The shape of the *recep* is checked, and adjusted if necessary.

It is now necessary to hammer the lip of the top-plates again. This can be seen as a continuation of smoothing out the creases as described earlier, but now the purpose is to hammer the edge of the lip thinner so that when the top and sides are riveted together the seams are smooth. This process takes half an hour for each top-plate.

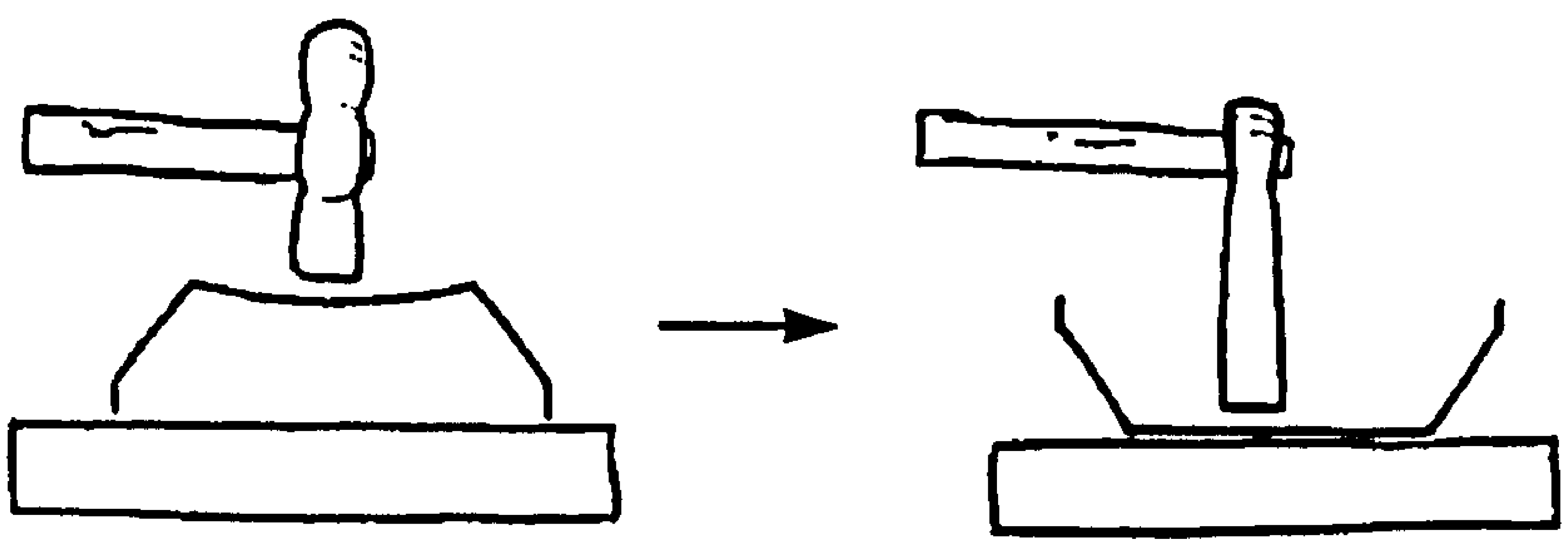


Fig. 71 Shaping the *rai*.

Having reached this stage, the tasks of making the boss, sides, and riveting all the parts together are the same for both types of bonang.

A circle is now scored on the inside of the plate where the boss will be positioned. This area is hammered out, but only slightly, not to the full depth of the brass boss that covers the top (see fig. 72). Lorry wheel hubs are used as anvils for hammering out the centre of the top-plate, and also for forming the bosses. Pak Mulyadi has a number of these hubs, each with a different central hole to fit each size boss, going right up to the size needed for the boss of a gong.

Making the pencu

The circular brass discs that are cut out for the *pencu* of the bonang *lanang* are slightly larger than those for the *wadon* style (7.5cm as opposed to 7cm) because the *lanang pencu* is hammered out deeper so that it sits higher on the bonang.

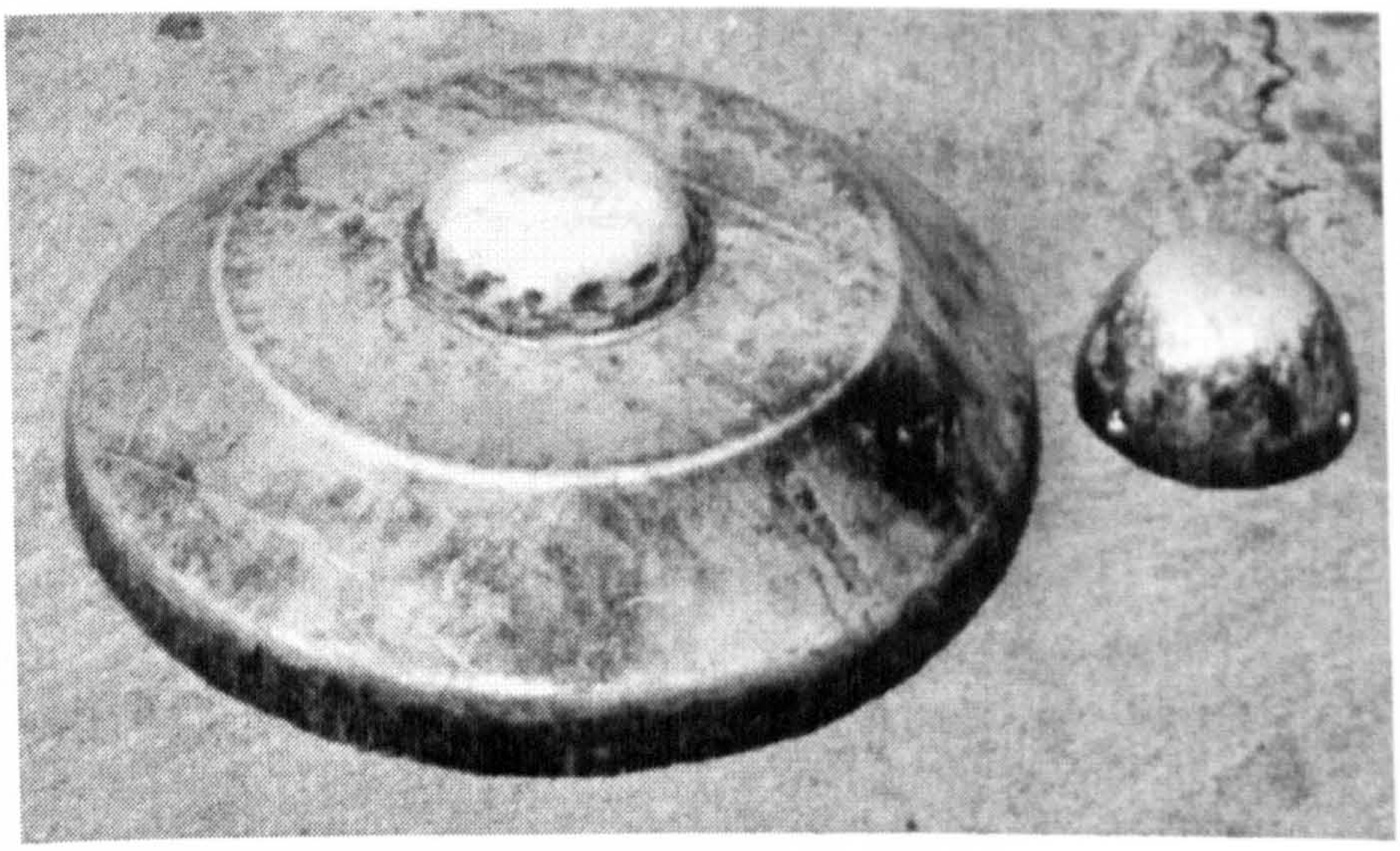


Fig. 72 Top-plate prior to riveting the boss.

The disc is held over the wheel hub anvil, and the hammering (using a ball hammer) is started around the edge of the disc, gradually working inwards in a spiral-fashion. Initially the discs are only lightly hammered to form a gentle cup shape. Having reached this stage with all the discs, they need to be annealed so that they can be fully shaped without risk of cracking. This is done by heating them in a charcoal fire for half an hour and then letting them cool slowly.

The process of hammering out the bosses is continued until the boss assumes the shape shown in figure 72. Hammering the bosses into the hollow wheel hub produces a rough surface on the metal. These undulations are smoothed out using a ball hammer, with the boss being hammered from the inside against a large flat iron anvil. The bottom edge of the *pencu* is now hammered thin in the same manner as the plate-lip, so that a good join can be made between the *pencu* and top-plate.

Three holes are made around the base of the *pencu* for the rivets that secure the *pencu* to the top-plate (refer to fig. 73). The rivets are put through these holes, and a special punch is placed over the rivet on the inside of the *pencu*. This punch has a hole drilled in its centre so that it does not touch the end of the rivet, but hits the *pencu*, and when hammered, forms an indentation on the outside of the *pencu* so that the rivet lies almost flush with the external surface (see fig. 73).

The fit of the *pencu* on the top-plate is checked. The *pencu* should be a tight push fit over the central hammered out section of the top-plate; if it fits loosely, the hammered out dome on the top-plate is made larger. The positions of the rivet-holes on the *pencu* are transferred to the top-plate with a punch, marking the position of the boss. Holes are made on the plate at these marks, and then the *pencu* and top are riveted together (see fig. 73). Once riveted, the seam is hammered smooth by placing the top-plate on an anvil and hammering from inside, thereby squashing the two metal surfaces of the top-plate and *pencu* together to prevent any vibrating and buzzing (see fig. 74).

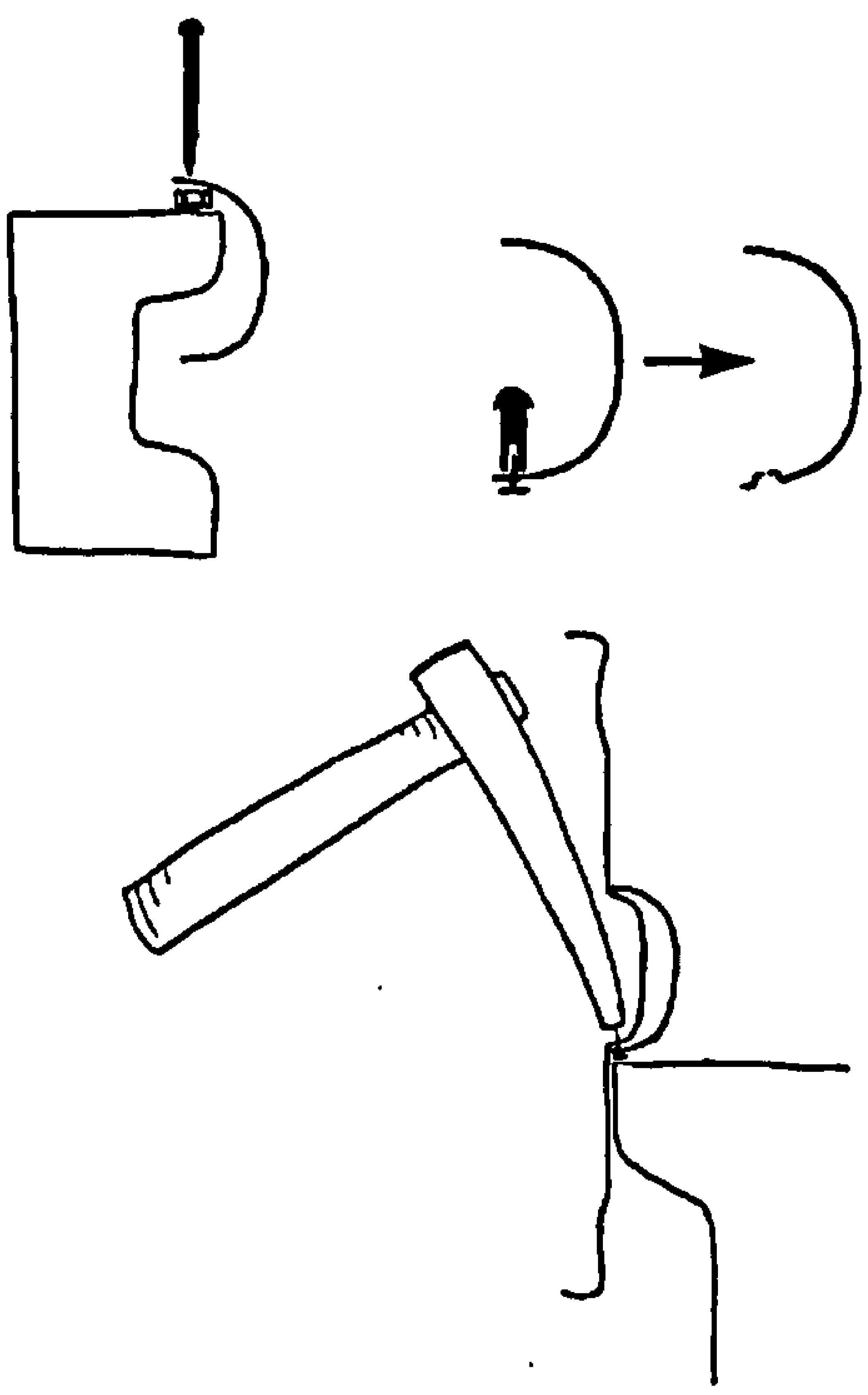


Fig. 73 Making the rivet-holes on the *pencu*.

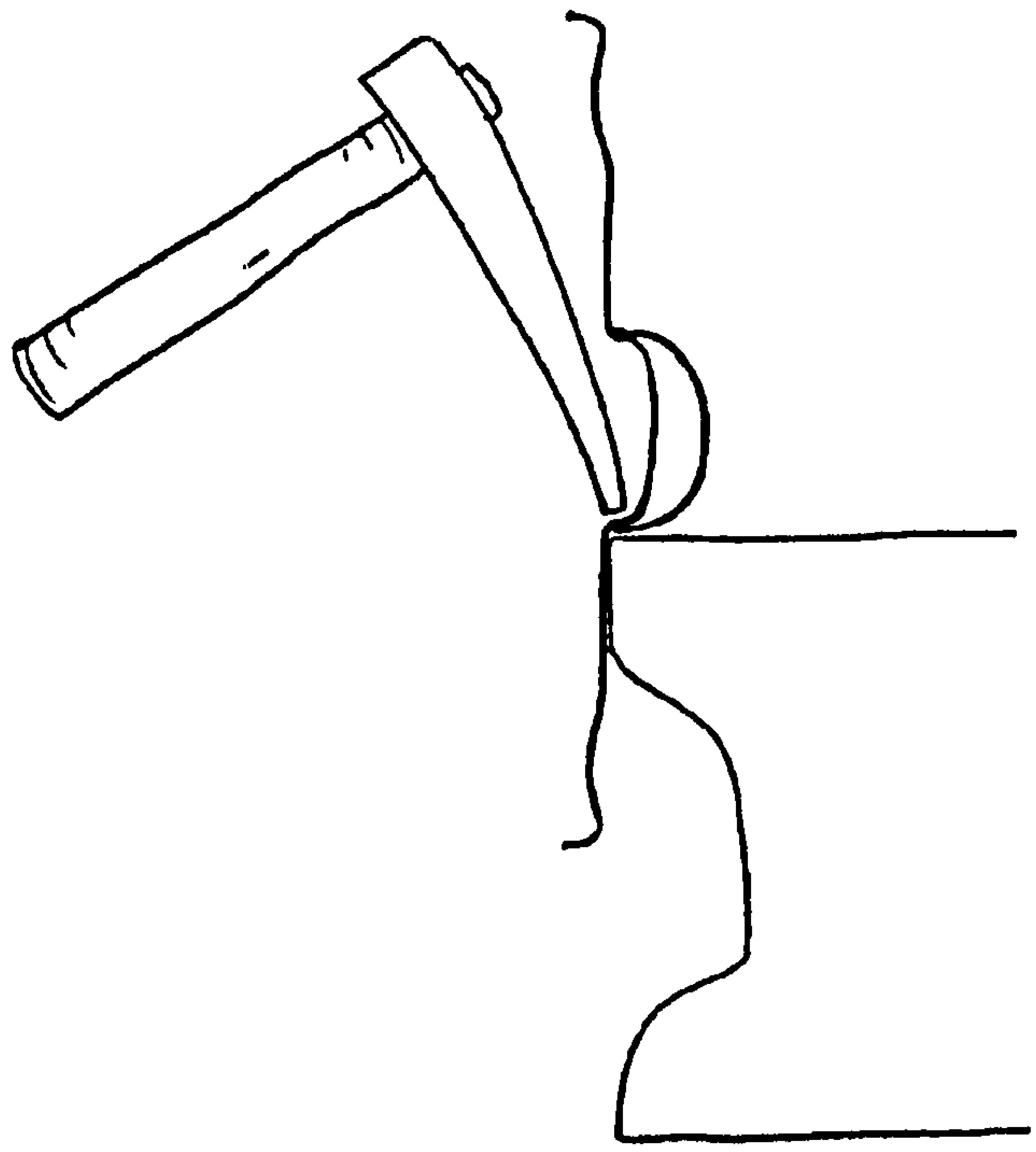


Fig. 74 Forcing the seam.

Making the bahu

The *bahu* or sides of the instrument are normally made up of two curved pieces of sheet metal riveted together. For the larger instruments such as kempul or gong, the sides may be made up from three or even four pieces. Steel templates are used to mark out the pieces that will form the *bahu*. Different templates are used for each instrument, ie. bonang, kenong, kempul etc.

Before riveting the two pieces together, it is necessary to make two cutaways on one of the two sheets of metal as shown in figures 75 and 76. These cutaways are made on the lower edge that is bent over to form the *lambe* (lip). If the cutaways were not made, a ridge would be formed on the *lambe* by the double thickness of the overlap.

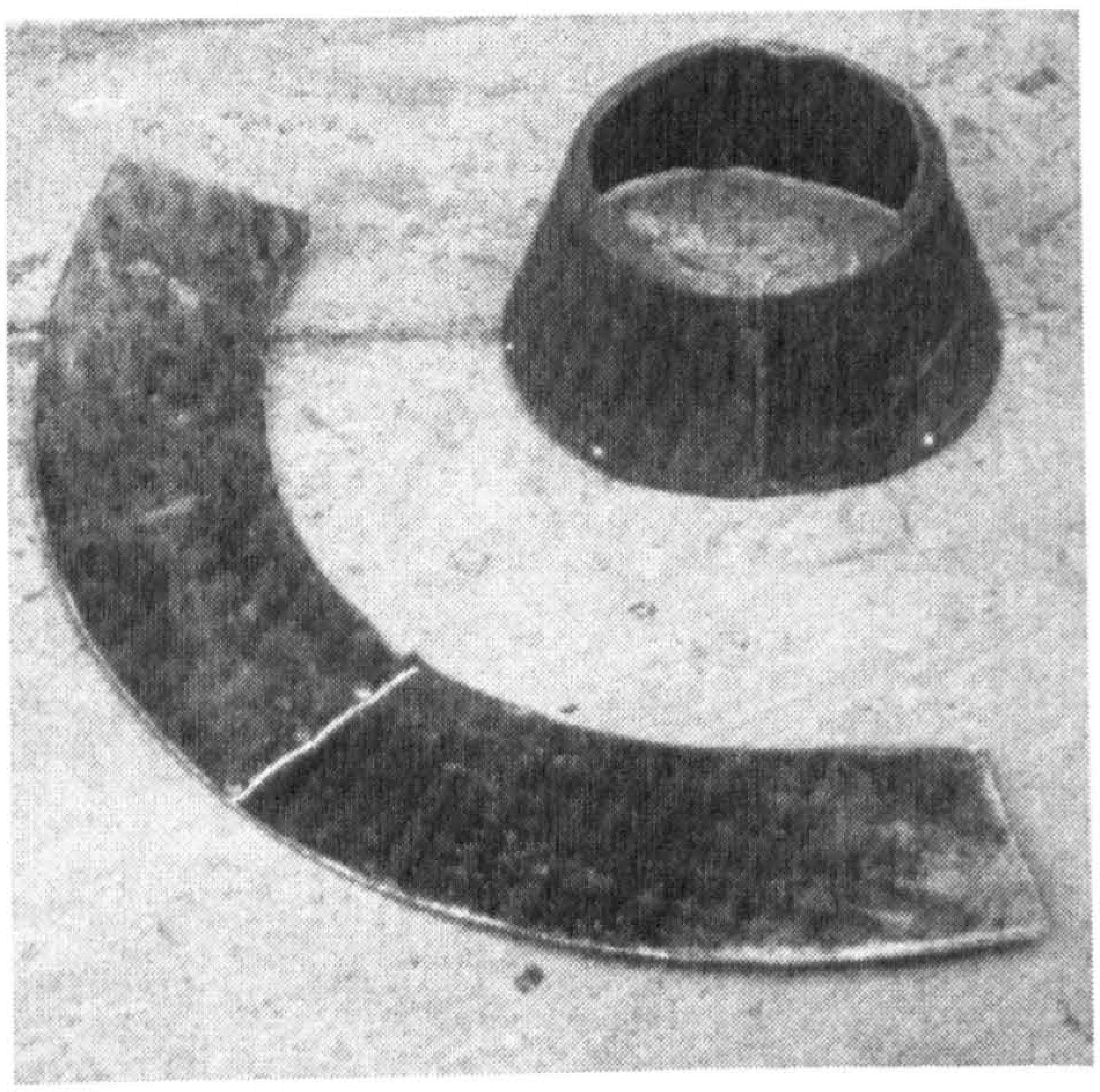


Fig. 75 Making the *bahu*.

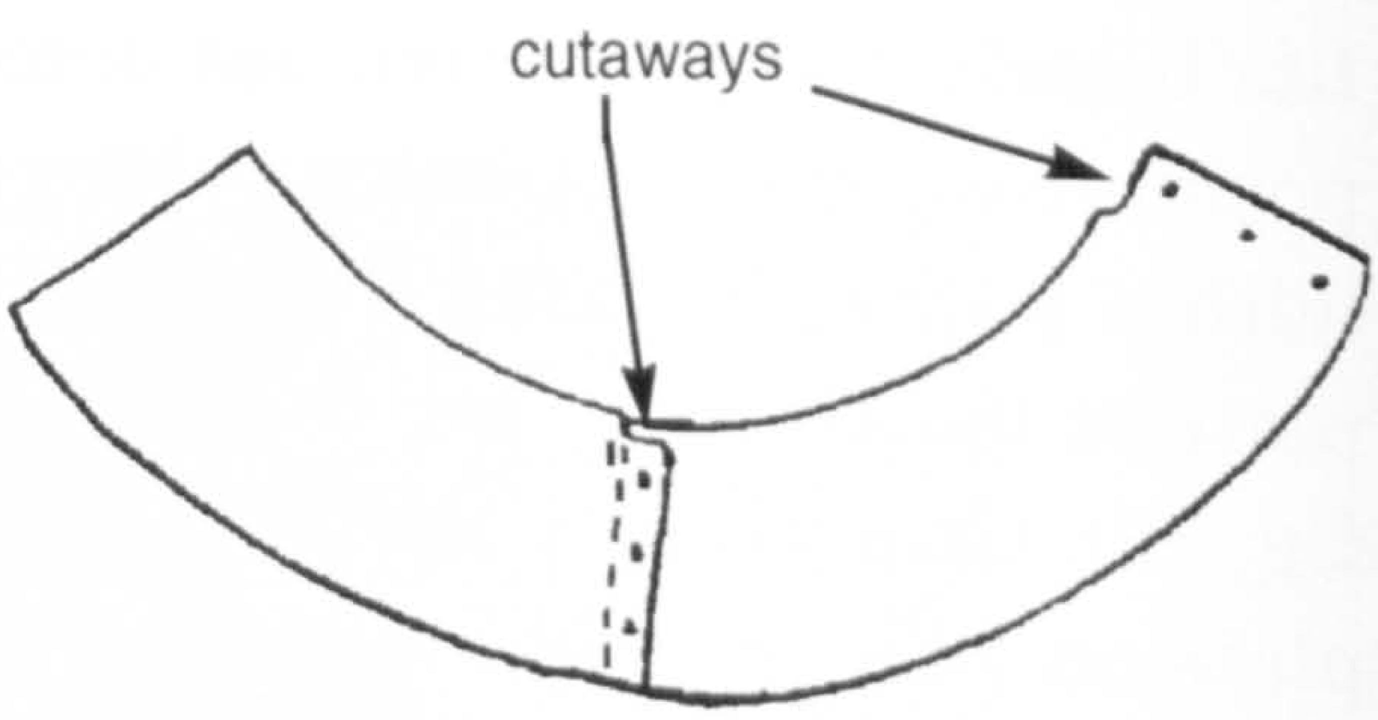


Fig. 76 Making the *bahu*, showing the cutaways.

The two pieces are now riveted together, and the top-plate is then rolled round the outer edge of the riveted side section to determine the circumference. This measurement is increased by about 20mm to allow for the bending over of the top-part of the side as described later. An overlap for riveting is also added to the measurement, and then the waste is cut off with a chisel.

The riveted side section is now bent round, mostly by hand but also with a little hammering, to form a cone. The circumference is checked and it is then riveted together (see fig. 75).

It is now necessary to make the *lambe* (lip) by bending over the lower edge of the *bahu*. A line is scored with a marking gauge about 10mm from the lower edge of the *bahu*. This line is hammered with a chisel-shaped tool as shown in figure 77. The *bahu* is then turned upside down, and the edge hammered over, until it can be placed on its side and completely hammered flat to form the *lambe* (see fig. 77).

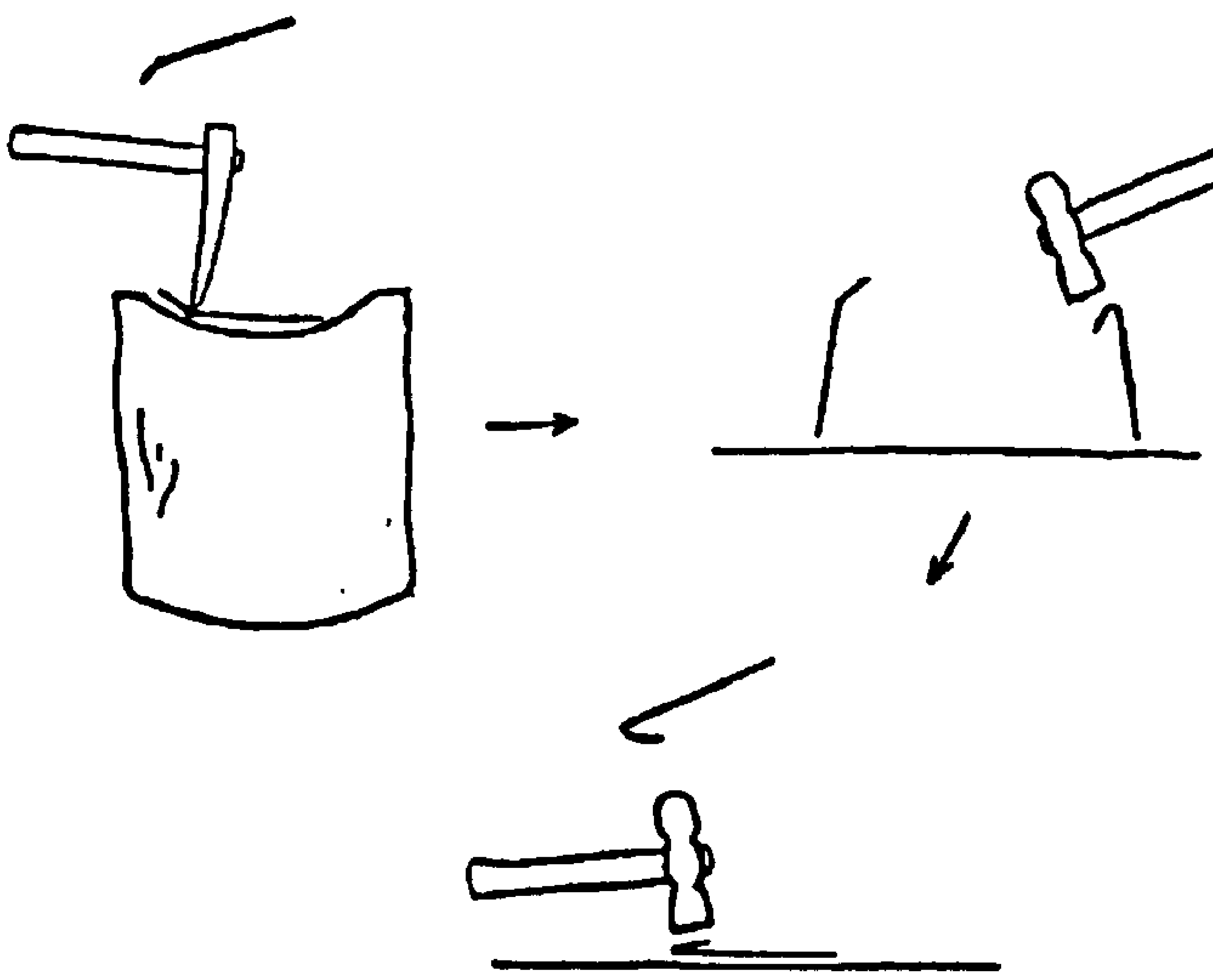


Fig. 77 Stages of making the *lambe*.

The sides of the *bahu* are still straight at this stage, so it is now necessary to form the curved shape with a large-ball hammer, hitting the *bahu* onto the hollowed out tree stump as shown in figure 78. The bulges this produces in the metal are smoothed out by hammering the *bahu* onto an iron anvil.

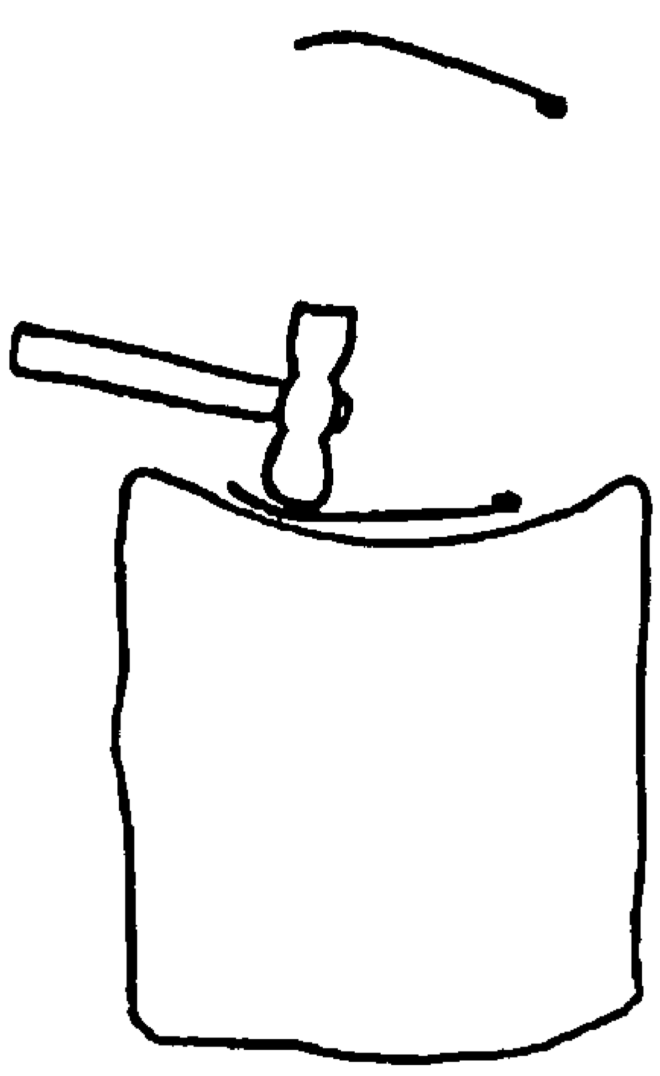


Fig. 78 Shaping the *bahu*.

Having finished the top-plate and *bahu*, they are now riveted together. The top-plate is placed on the *bahu* and hammered home tight. If the two pieces fit together loosely, the top of the *bahu* is hammered out to a larger diameter until a good tight fit is achieved. After marking the position where the two parts fit together best, the holes for the rivets in the top are punched through at every 50mm. The top-plate is then placed on the *bahu* again and hammered down tight. The rivet-holes are transferred to the sides, and three nails temporarily hold the two parts together whilst the riveting is done.

The final stage of constructing the *pencon* is to hammer all the seams from the inside of the instrument onto a heavy anvil to make them as smooth as possible, and thus cut out any vibration from loose or open joints. At least an hour is spent hammering the seams of a brass *pencon*, so that when the instrument is filed and polished the seam is barely visible.

Tuning and finishing

The process of filing and polishing brass *pencon* is very similar to the finishing techniques used for bronze instruments. The surface of the brass instrument is made smooth using the *kikir patar*, *kikir besi*, and the scraper, *kesik*. Finally the metal is sanded with wet and dry abrasives, and then polished.

Iron instruments are left unpolished, apart from the brass boss. Many iron gamelan makers paint their instruments with gold paint.

Tuning iron and brass *pencon* is a relatively simple procedure. A maker will have his own predetermined sizes of *rai*, *recep*, and height and angle of *recep* for each particular pitch in the scale. Assuming the *rai* is level, and the shape of the *recep* consistent around its circumference, the *pencon* should produce a good voice. If the *pencon* produces a muted, or deg-deg-deg sound, it is necessary to adjust the shape of the *rai* and/or the *recep*.

Tuning the *wadon* style bonang can be achieved by hammering both the *rai* and/or the *recep*. To raise the pitch the *pencon* is held upside down in the hand, and hammered from the inside on the *rai*, thus raising its height. Using this method, the resultant change in pitch from each blow of the hammer can be heard. To lower the pitch, the *pencon* is placed upright on a flat surface, and the *rai* hammered down. Following the above methods, care should be taken to ensure that the *rai* is not hammered excessively in one place, thereby making the surface of the *rai* uneven. The hammer blows should therefore be many, and light in force spread over the entire surface of the *rai*.

It is also possible to tune the *pencon* by hammering the *recep*, but this method is generally only used when tuning the *rai* causes the voice of the *pencon* to deteriorate, ie. when uneven tensions are built up between the *rai* and the *recep* resulting in the *rai* being damped by its relative position to the *recep* which prevents the *rai* from vibrating freely. Hammering the *recep* from above, ie. lowering its position, raises the pitch, and hammering from inside the *pencon* on the *recep* lowers the pitch.

Tuning *lanang* style bonang, and kenong can only be achieved by hammering the *rai* since it is important to retain the angled position of the *recep*.

Making saron and gender bars

Saron bars, as mentioned earlier, are made from mild steel plate, vehicle leaf springs, or sheet brass. The mild steel and brass bars are cut to length, shaped, and hammered cold. However, due to the difficulties of working with the very hard high tensile metal of leaf springs, the initial cutting to length and forging is done by a general blacksmith. The final shaping and tuning of the leaf springs is done in Pak Mulyadi's workshop using an improvised mini forge comprising of a domestic clay charcoal burner in combination with a pressurised paraffin burner to boost the temperature.

Making saron bars from all of the three materials follows the same basic procedure: the keys are cut from flat sheet material, and tuned by bending along the longitudinal axis, so that the keys are dome-shaped in cross-section (see fig.79).

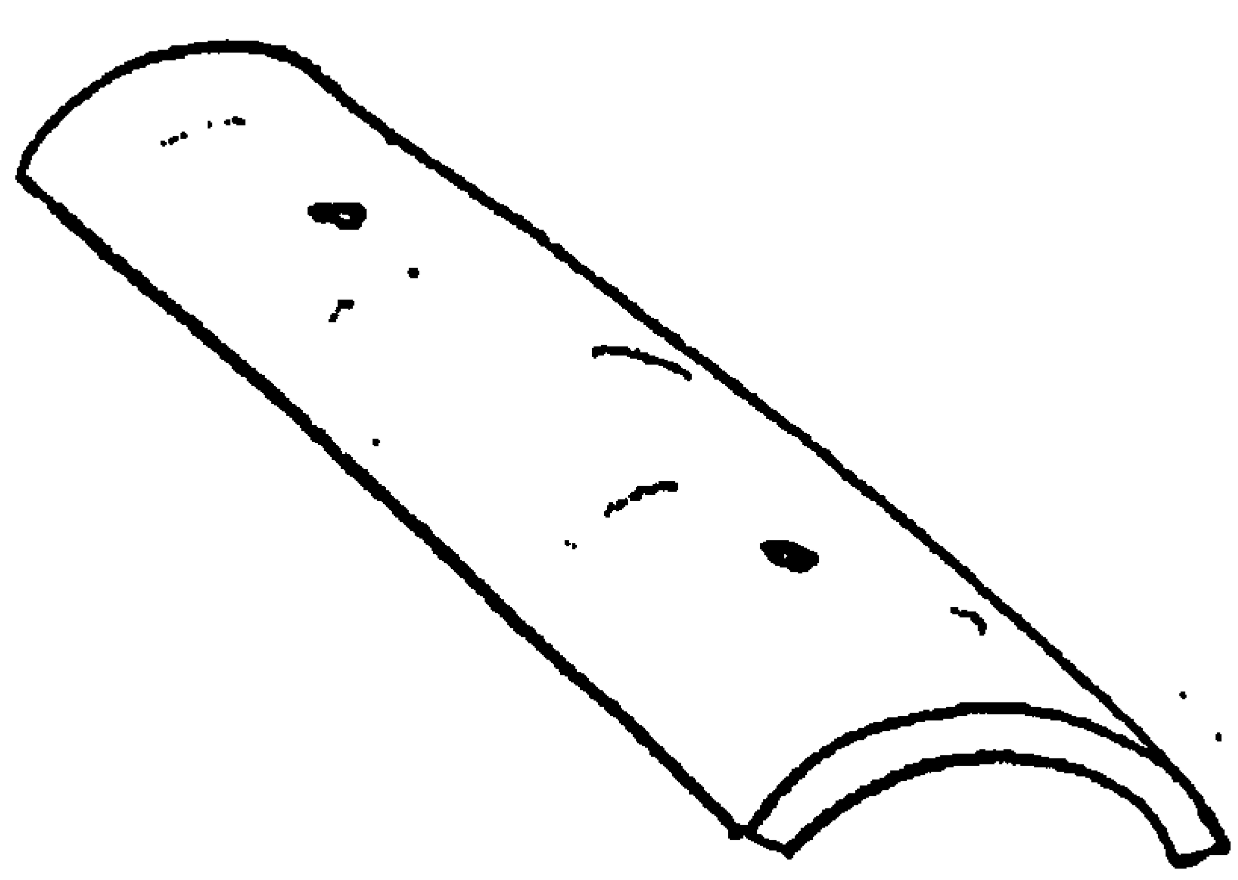


Fig. 79 Shape of saron bars.

The pitch of a bar is raised by increasing the longitudinal bending. When bending the bars, care must be taken to ensure that the curvature remains constant throughout the entire length of the key; if it does not the bar will be muted. During the bending, the shape of the bar is checked in two ways: firstly by looking along its length, and secondly by placing it on a flat surface to check that it rests squarely on all four corners. If it does not lie flat, any twisting is hammered out.

It is unusual to find gender and slenthem bars made from any material other than bronze or brass (although gender in village gamelan quite often have iron keys). The reasons for this are:

a) The vastly superior sound of brass over steel in a soft style, resonated instrument. The difference in sound quality between brass and steel is much more apparent in an instrument with very thin bars such as those used on the gender. Thin brass bars, when resonated and played with a soft-padded beater, produce a mellow, long-ringing tone, whereas the steel equivalent tends to produce a tinny, metallic tone of shorter duration. Using the term 'metallic' as a criticism of a metallophone may appear strange, but the desired tone quality of the gender is better described as that produced by an aero-idiophone.

b) Aesthetics in gamelan are always an important consideration, and since the gender is placed at the front of the orchestra in full view of the audience, a brass instrument in addition to producing a superior sound, also looks much better than its steel counterpart.

Brass gender and slenthem bars are made from sheet alloy, varying in thickness from 2mm to 4mm, the thicker material being used for the high pitch bars. Each bar is marked out using a template and then cut by hand with a hacksaw. Brass gender bars are fluted like bronze gender bars. Two lines are marked out on the underside along the length of each bar dividing it into three roughly equal sections. These lines will form the ridges, or *odo odo*, and the area in between will form the central flute, *blimbingan*, and the two outer flutes, *lambung*. The flutes are made by hammering a cold chisel along each line, with the bar resting on a section of railway track to act as a former/anvil (see fig. 80).

Care must be taken to ensure that the flutes are made to the same angle and depth along the entire length of the bar. Any changes along the bar will result in a damped tone. At this stage the pitch of the key is checked. It should be half a slendro tone (120 cents) sharp of the required pitch to allow for the filing and polishing which reduces mass, and therefore lowers the pitch. Tuning gender bars follows the same principles as described earlier for saron bars; pitch is raised by increasing the curvature of the cross-section of the bar, and lowered by lessening the curvature.

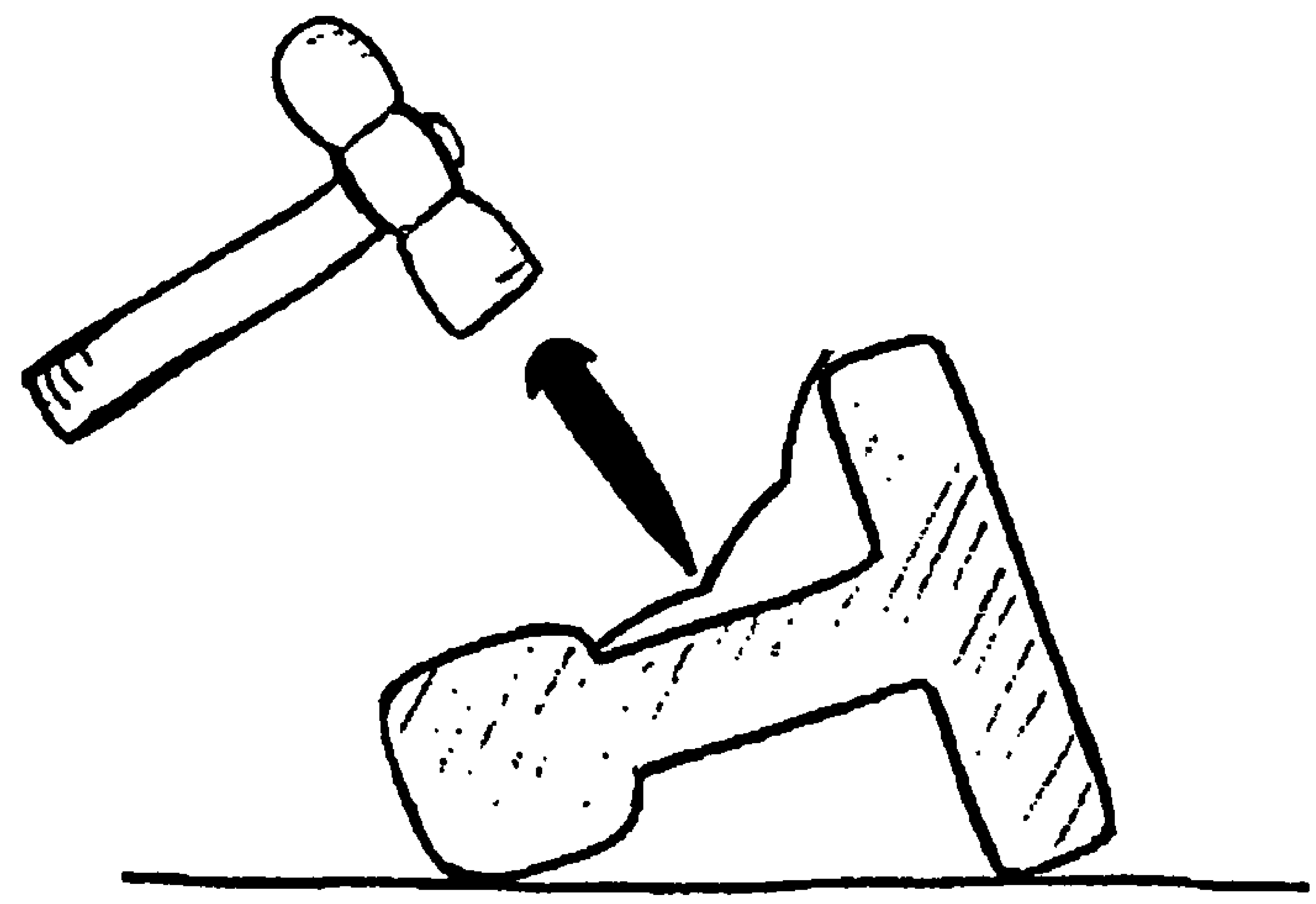


Fig. 80 Forming the fluted shape.

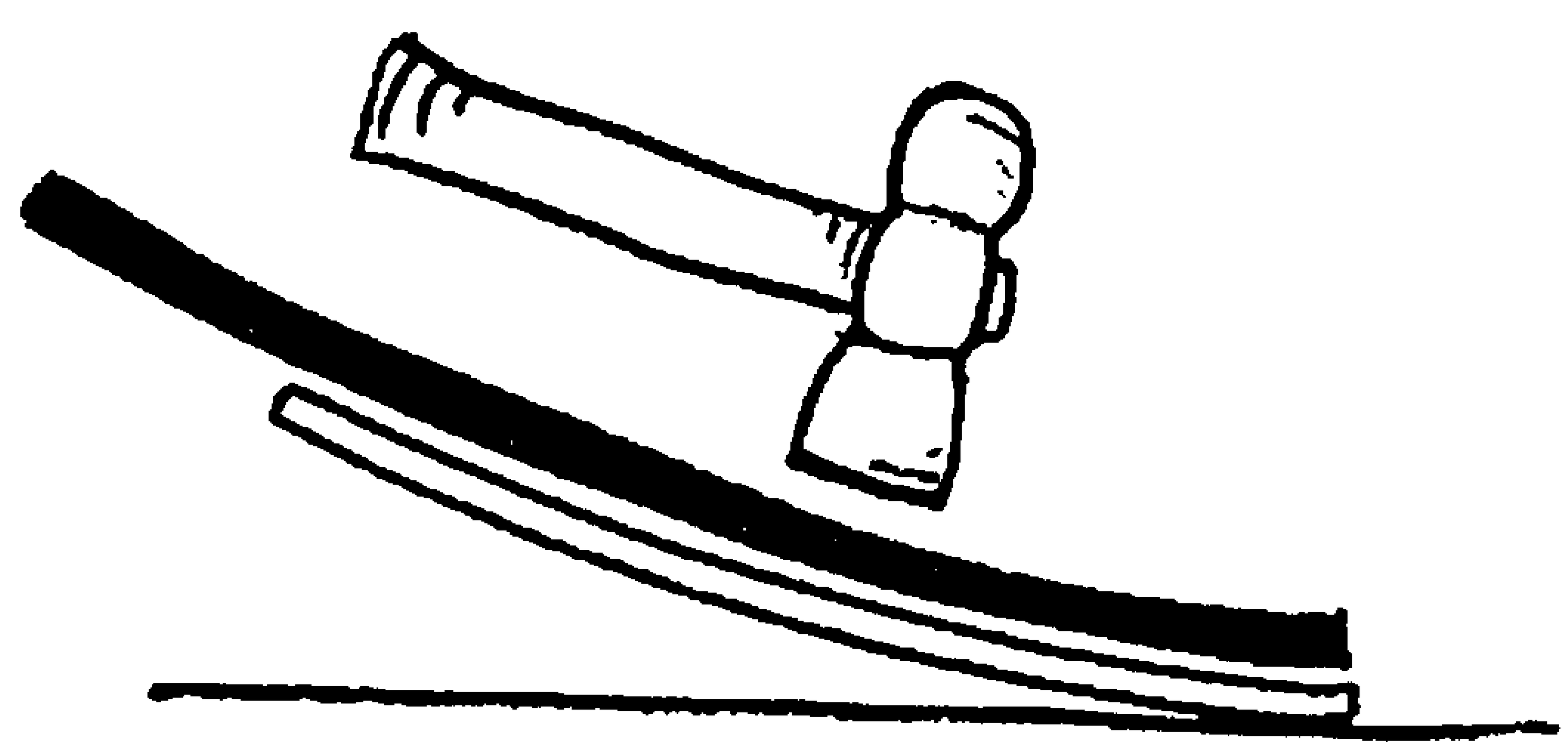


Fig. 81 Bending the key.

Having roughly tuned the bars, it is now necessary to bend them to produce a gentle curve as shown in fig 81. Bending in this way does not affect the pitch, but is said to make the tone more mellow. The brass bar is not hammered directly because this would result in an uneven curve; instead a gradual smooth curve is achieved by hammering a bent steel rod onto the bar so that it assumes the shape of the rod. The bar is then laid on a large flat, steel plate and checked for twisting.

The bars are cleaned-up, filed, and polished in the same way as for a bronze gender: using a *kikir patar* to smooth and shape the concave *blimbingan* and *lambung*, followed by scraping with a *kesik* to produce a fine surface before finishing off with wet and dry abrasives. Minor adjustments in tuning are done by filing the underside. Finally, the bars are laid out in order, the nodal positions marked, then drilled.

CHAPTER V

THE MANUFACTURE OF METALLOPHONE RESONATORS

Gender penerus, gender barung and slenthem have individual, sympathetically tuned tube resonators (*tapun*), whereas the saron family of instruments have non-specific trough resonators. The soft-style metallophones require individual resonators because the tone from the bars alone would be barely audible. The large, heavy bars of the saron produce sufficient volume when struck with the wooden headed mallets.

Traditionally, Javanese gender resonators were made of bamboo. However, bamboo tends to split with climatic changes[1], so nowadays most resonators are made of thin galvanised ferrous sheet. A few customers still specify bamboo resonators, which produces a more mellow tone.[2] The Balinese gender wayang instruments still use bamboo resonators.

Pak Tentrem usually orders gender frames, complete with resonators, from the case maker, Pak Diran.[3] Pak Mulyadi has resonators made at his own workshop. I saw resonators being made at Pak Diran's and Pak Mulyadi's workshops; both use the same method of manufacture, but Pak Diran uses zinc sheet of 0.2mm thickness, whereas Pak Mulyadi specifies material of 0.3mm thickness, claiming it gives a fuller tone. The resonators are made oval in cross-section so that they fit tightly into the frame to avoid buzzing.[4] *Tapun* are made in the following way:

THE MANUFACTURE OF GENDER RESONATORS

A set of templates is used to mark out the sheet zinc for each resonator, which is then cut out using tin snips. A seam, 2mm wide is hammered over on the two shorter sides of the rectangular piece of zinc to form smooth edges for the top and bottom of the resonator.

A 5mm. wide seam is hammered over along each long side of the rectangular piece of zinc as shown in figure 82. These seams are prised open slightly to form lips on opposite sides of the flat piece of zinc (see fig. 82).

The flat piece of zinc is bent by hand round a metal tube. The two lips are locked together and hammered flat onto a stout iron tube to make the seam (see fig. 83), which is made air-tight by hammering a small, square-ended cold chisel along one side of the joint (see fig. 83).

The ridges made when bending the metal are smoothed out by placing a stout steel tube in the *tapun* and rubbing the surface with a slightly concave piece of timber.

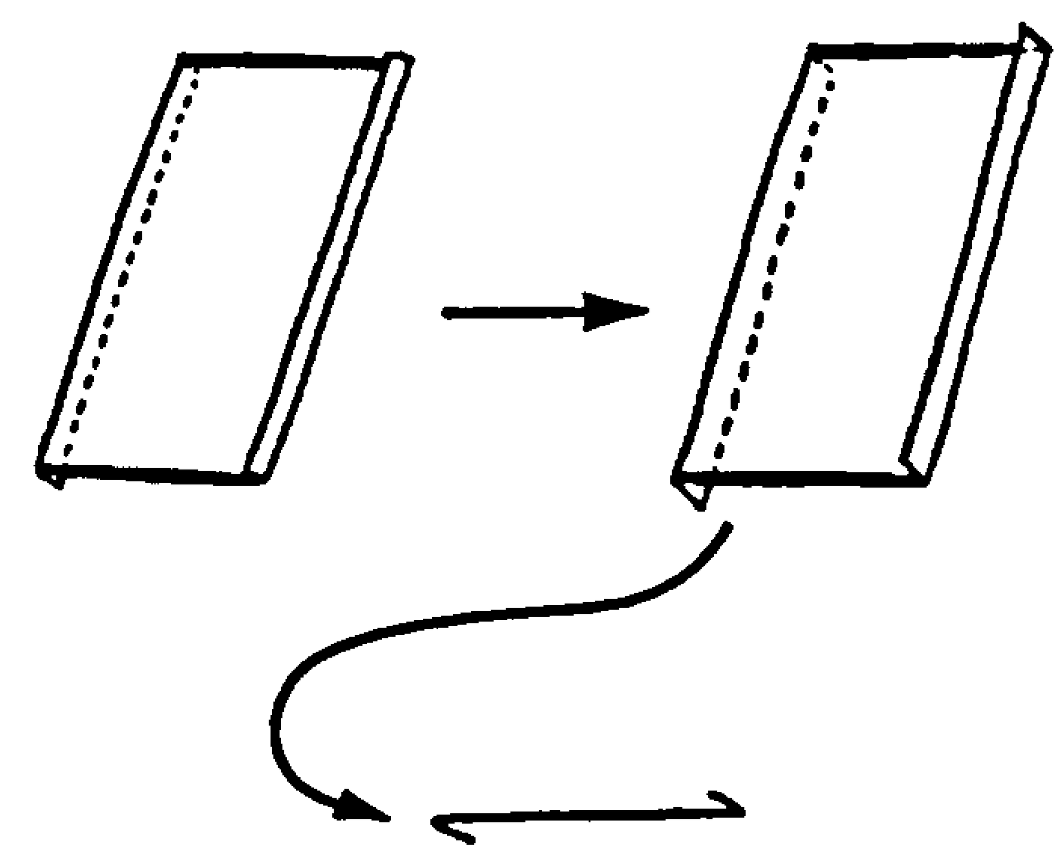


Fig. 82.

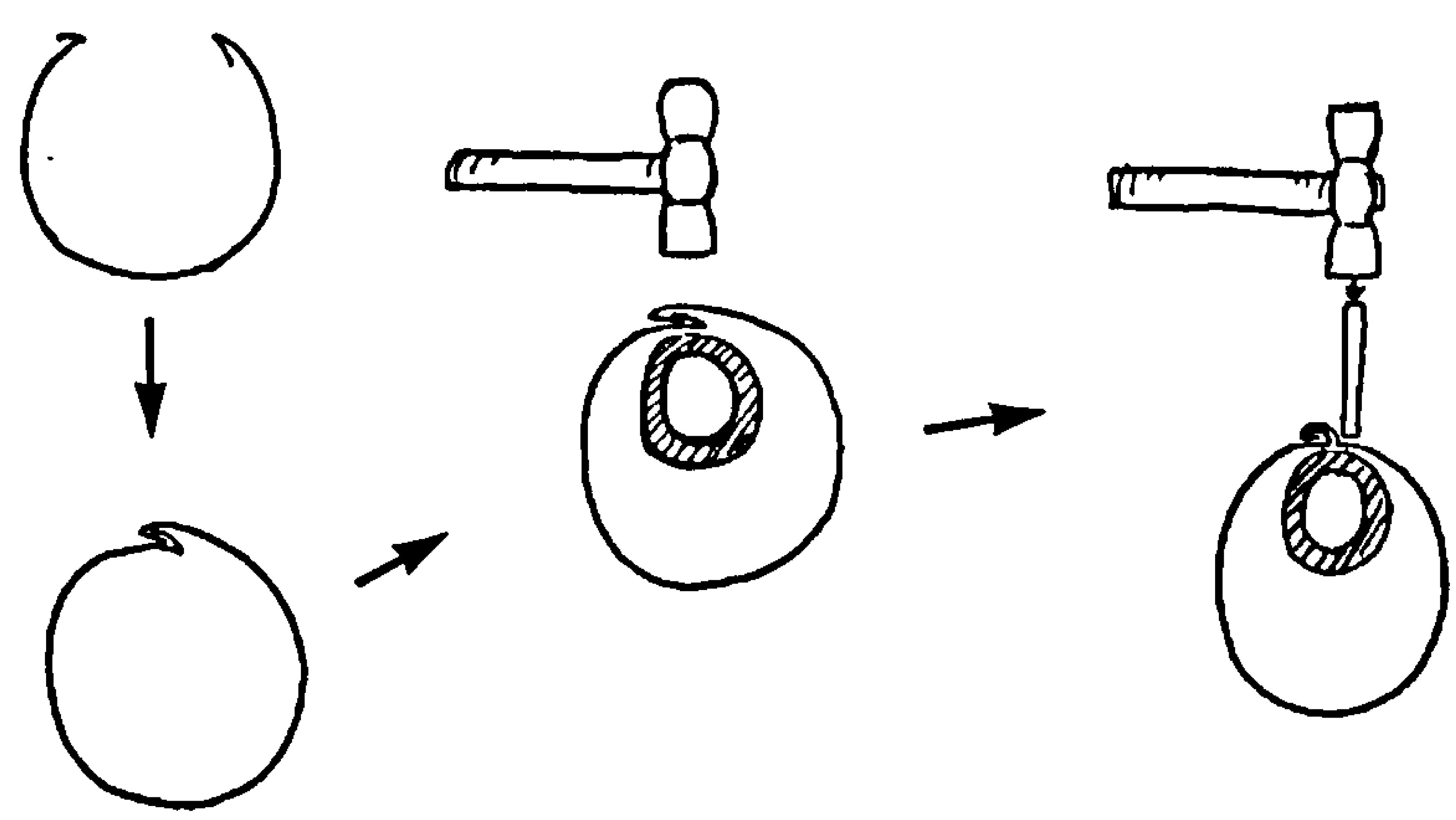


Fig. 83.

Tuning the resonators.

The overall length of the resonators of the gender penerus and gender barung are all the same. Each resonator is tuned either by placing a stop inside the tube to raise the pitch, or by partially closing the top of the tube with a cap, to lower the pitch. Since the wavelength of the lowest-pitched key of the penerus is usually shorter than the length of the resonator, it is not necessary to lower the pitch with a cap. However, the resonators for the slenthem and the five lowest-pitched gender barung resonators all require partially-closed tops.

The position of the stops for gender penerus are found by immersing the tube vertically in water, playing the key over the tube whilst raising or lowering the tube's position until the tone becomes loud and strong (see fig. 84). This position is marked on the resonator. An oval disc of zinc is cut out, and the edges bent over so that it fits snugly inside the tube at the required position.

Fig. 84 Tuning the resonator.

The disc is soldered inside the tube to make an air-tight join. This is done by dipping a thin metal rod in *air keras* (hydrochloric acid) and painting the join. Solder is melted and allowed to solidify into droplets on a piece of wood. These are dropped into the resonator and melted with a hot copper soldering iron (see fig. 85). The acid makes the solder run into the gaps and seals the joint.

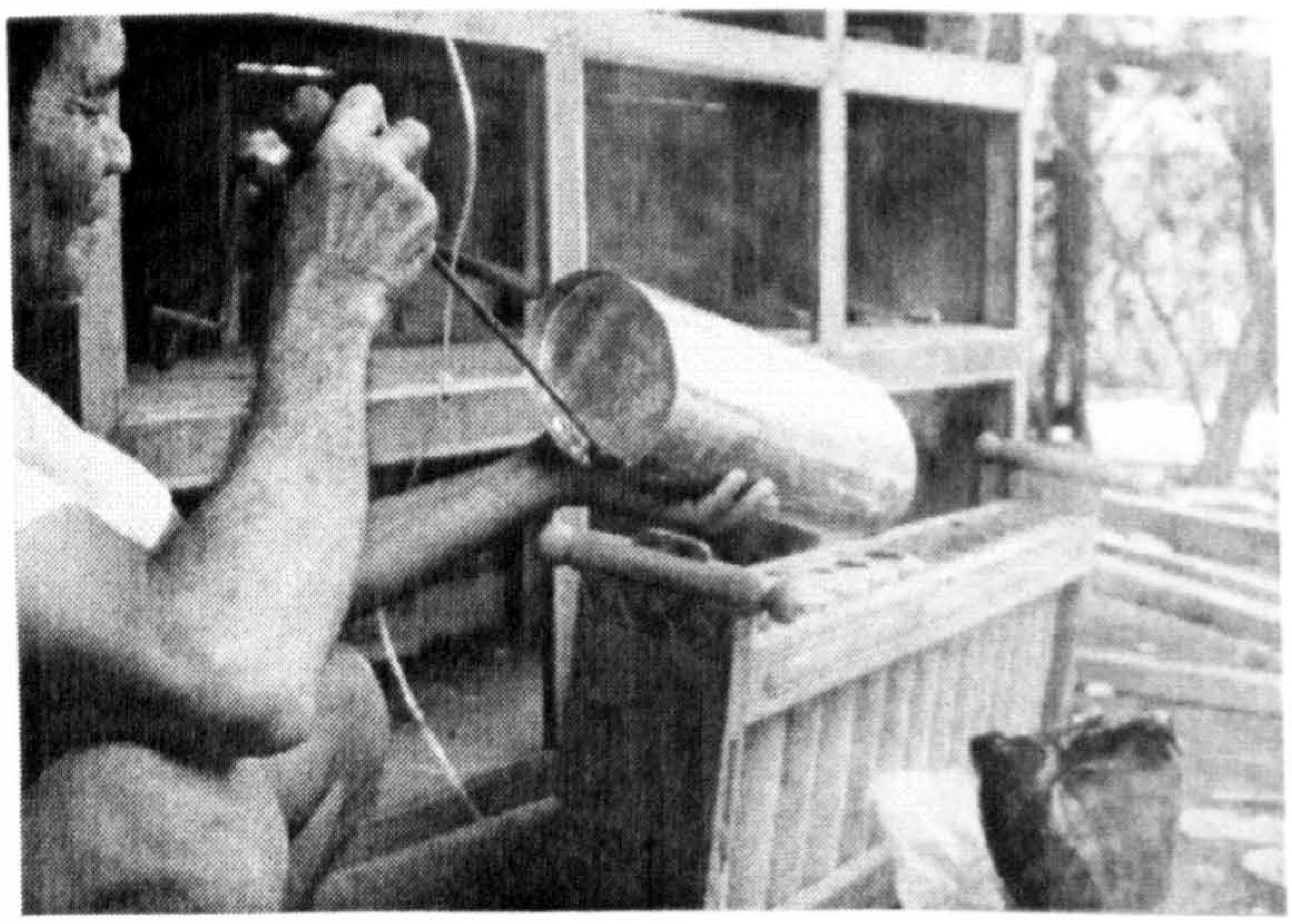


Fig. 85 Soldering the stop into the resonator.

The low-pitched resonators of the gender barung and slenthem, which require a partially closed aperture, have the top fitted first. The top is made by cutting out an oval disc of zinc and bending over the edges so that it fits securely into the top of the tube (see fig.86). Before soldering the top, it is necessary to cut a hole of the correct diameter in the disc (the smaller the hole the lower the pitch).[5] The diameter of the hole is taken from an existing resonator of the same pitch. The top is then soldered in place. The correct position of the bottom disc is found in the same manner as for the higher pitched resonators.

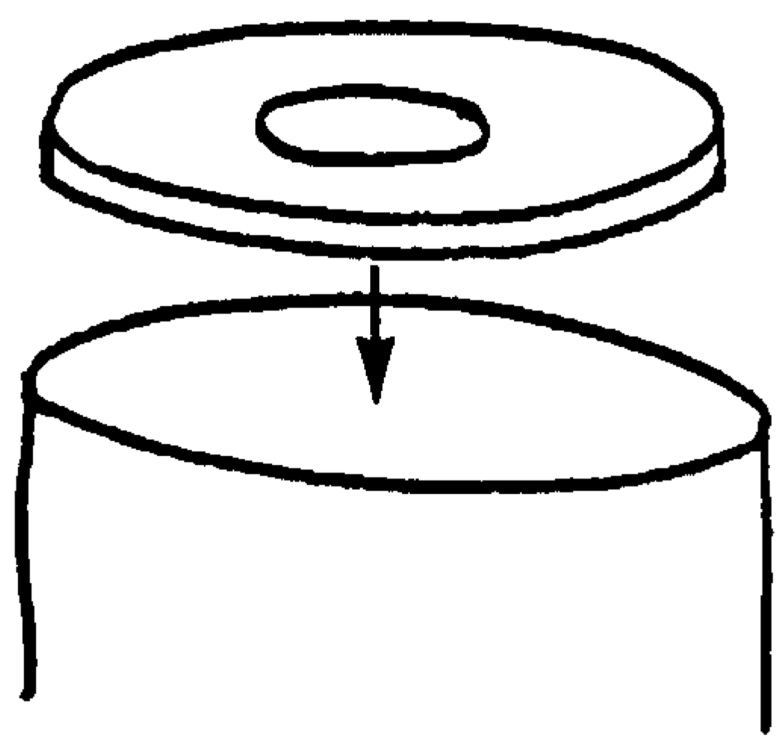


Fig. 86.

It is usually necessary to fine tune the resonators once the instrument is set up with the bars and *tapun* in position. This is done by playing the bar whilst it is damped lightly by the other hand. If the tone produced is flatter than that of the undamped bar, the resonator is flat. This can be rectified by increasing the size of the aperture (in the case of partially closed resonators), or cutting down open resonators. If the damped tone is sharp of the undamped tone, this can be rectified by making the aperture smaller (in the case of partially closed resonators) or making a lip around the top of the resonator by adding a strip of zinc. Makers try to avoid this as it is more difficult to lower the pitch of a resonator.

SARON TROUGH RESONATORS

Saron frames are usually made up in three sections: the base, which is 50-75mm thick, the central section which is no more than 25mm thick and forms a moulding, and the top which can be anything from 75-125mm thick (see fig.87). These three parts of the frame are cut out, shaped and carved before assembling. The trough resonator of the Solonese style saron is almost always fully open at the top, ie not partially closed as is the case in the gambang resonator. The saron trough is never deeper than the thickness of the top-section, so the resonator of the saron demung and saron cannot be tuned specifically. The trough is carved out so that it is deeper at the bass end of the instrument.

Some Yogyakarta-style saron are made with partially-closed trough resonators which can be tuned [6] (see fig. 88). The trough is carved out with square vertical sides, like the Solonese saron, but then two boards are fitted over the top of the trough with a central gap which is made narrower at the bass end.

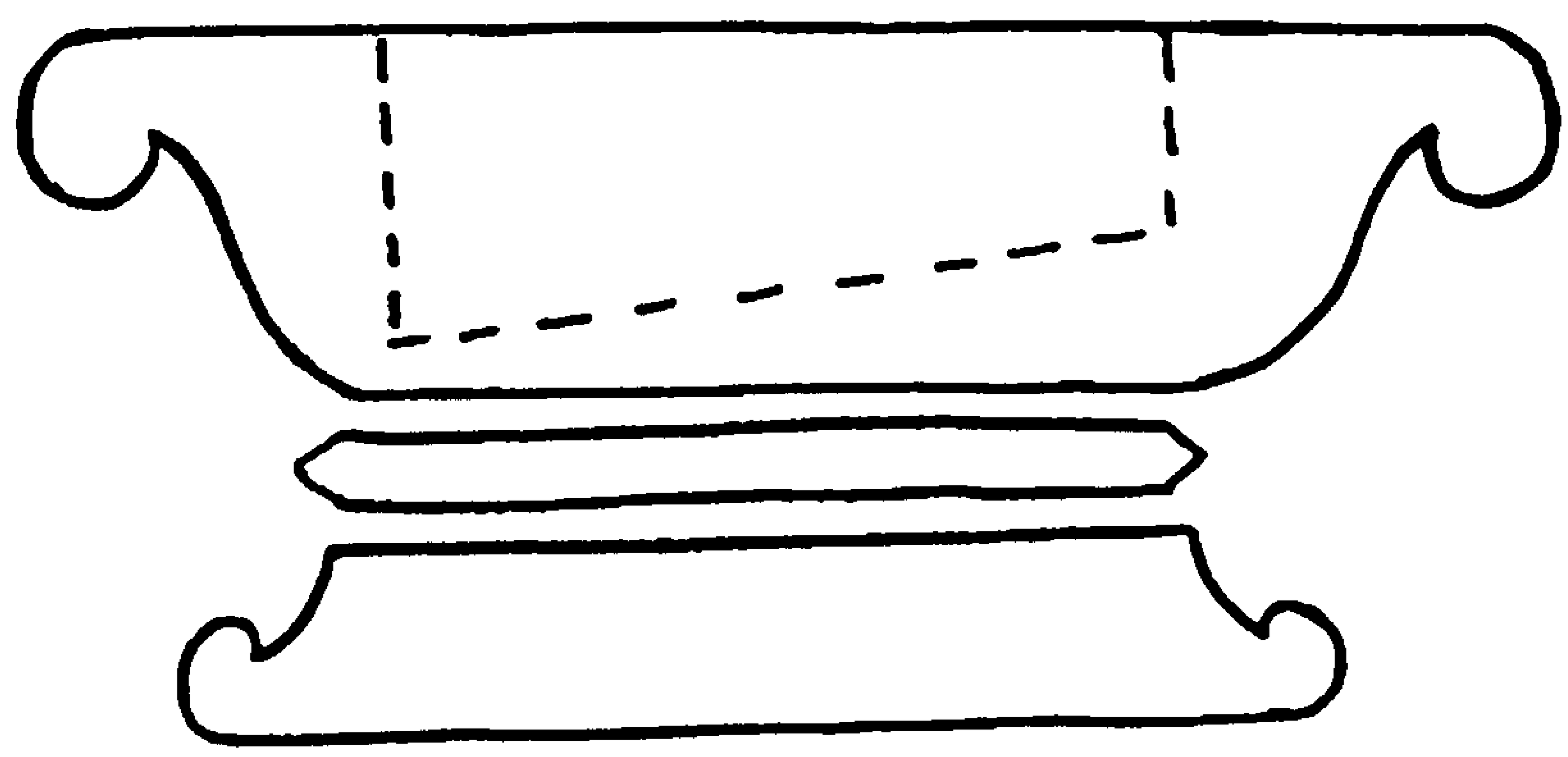


Fig. 87.

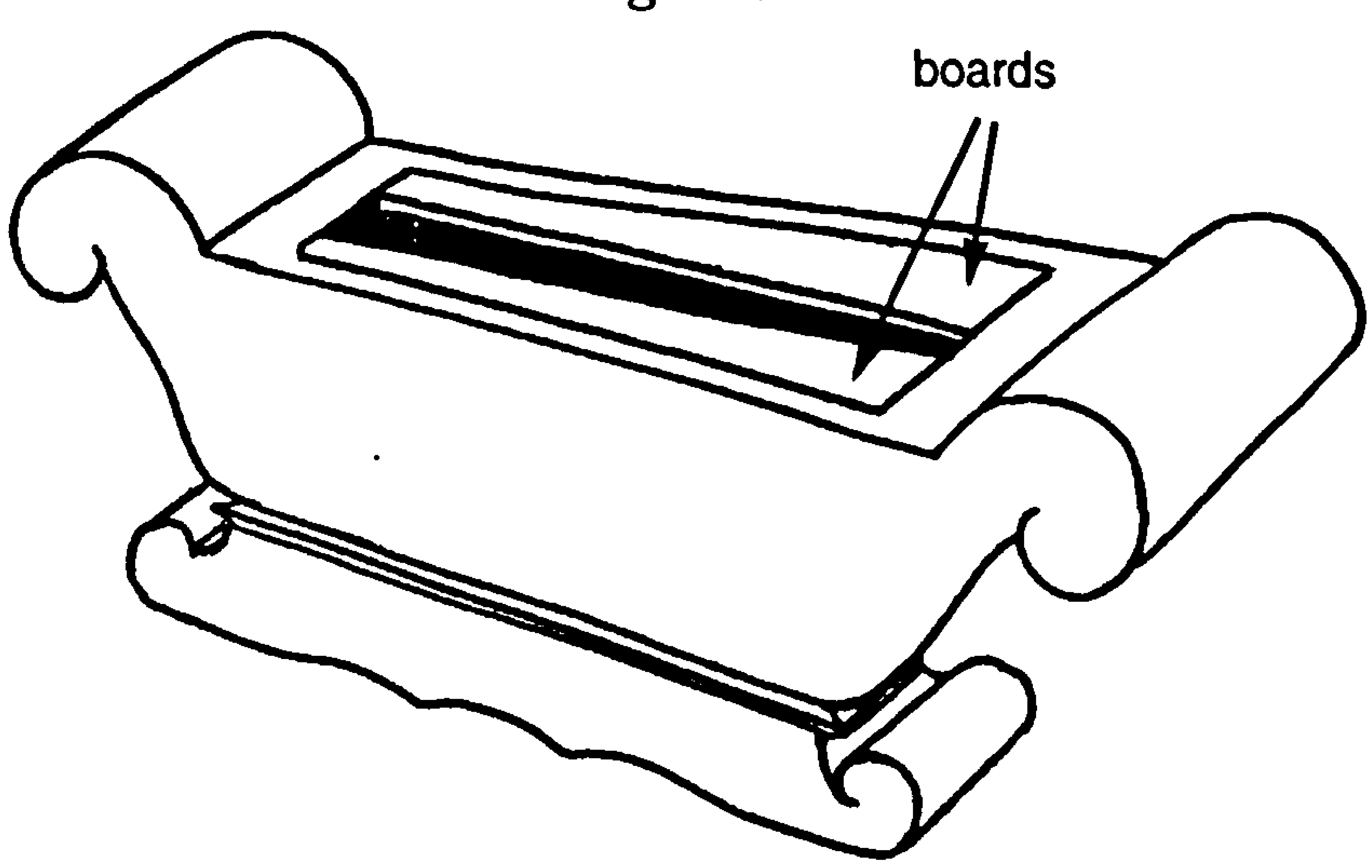


Fig. 88.

CHAPTER VI

FRAME BUILDING AND CARVING BY BAPAK DIRAN, IN SOLO, CENTRAL JAVA

DESIGN, MATERIALS AND WORK PRACTICE

Instrument design and ornamentation in South East Asia is highly decorative. The tuned percussion orchestras in Thailand, Burma, Cambodia and Laos all have richly carved and decorated frames. A Central Javanese court gamelan is ornately carved. The overall effect is powerful because of the size and number of instruments in a complete orchestra and the decoration of the individual instruments.

Instrument makers subcontract frame building and carving to specialist firms. Pak Diran runs a workshop in the south of Solo[1] and supplies both Pak Tentrem and Pak Mulyadi with instrument frames. The frames for the instruments I commissioned from Pak Mulyadi were made at Pak Diran's workshop during May and June 1989. Regular visits were made to Pak Diran's workshop to study carpentry and carving techniques.

Pak Diran and his son run the family business and employ fourteen people; eight carvers, two carpenters, two finishers, and two apprentices. The carpenters make the various parts of the frames (panels, rails etc.) and before jointing, pass these on to the carvers. After the carving is finished, the various parts of the frame are jointed and constructed.

The wooden cases and racks (*rancak*) are made almost exclusively from teak (*tectona grandis*), known as *jati* in Javanese.[2] Teak has been highly valued for centuries throughout south-east Asia for its natural durability and resistance to insect and fungal decay.

Teak is an excellent timber to work; its uniform grain enables it to be planed easily without tearing, although its high silica content does cause rapid blunting of tools. It is a superb material for carving, being soft enough to cut easily with sharp tools. The silica and natural oils in the timber enable teak to be intricately carved in all directions with little risk of splitting across the grain.

Unfortunately, teak has been over-harvested throughout Burma, Thailand, and Java, making it a scarce and highly valuable commodity. Although extensive plantations of teak have been made in Southern India, Thailand, and

Indonesia, most of these have not reached maturity, so much of the teak harvested still comes from naturally-grown trees.

There are many carving styles in Java, each representing a different area or royal court in the country. The main styles identified by D. Dalijo and Mulyadi [3] are:

a) Majahapit,
b) Pajajaran,
c) Cirebon,
d) Mataram,
e) Yogyakarta,
f) Jepara,
g) Surakarta.

Most of the carving done at Pak Diran's workshop is in either the Yogyakarta, or Surakarta (Solo) style. The characteristic feature of these two similar styles is the use of natural plant forms arranged on a spiral plan; Solonese style tends to use opening flower buds, whereas Yogyanese use large fully opened flowers. These Javanese styles are very similar to designs from the latter part of the European Gothic style, and differ from the other Javanese styles mentioned by their bold character.[4]

Fig. 89 Carving a Japanese-style dragon for a gong stand.

The carvers at Pak Diran's workshop will, however, work to any design. During my stay in Solo, work was being completed on a set of frames carved in a traditional Japanese style for a Japanese client (see fig. 89). The ability to replicate any style depends largely on the skill of the resident artist who draws the designs from which the carver works.

CARVING

The artist who works for Pak Diran is also the most skilled carver; most of the three-dimensional work, such as the dragon heads on the gong stand, are also carved by him. Relief carved panels are made at Pak Diran's workshop in the following way:

a) Drawing half of the design.
b) Rough setting in and grounding.
c) Making rubbings of the design.
d) Rough setting in and grounding the whole design.
e) Modelling.
f) Final setting in and grounding.

Drawing the design

One man usually draws the designs for all the carvers, although some of the more experienced carvers do this themselves. Since all the carvings are symmetrical, only half the design is drawn (see figs. 90 and 91); a rubbing of the design is made after setting in and grounding.

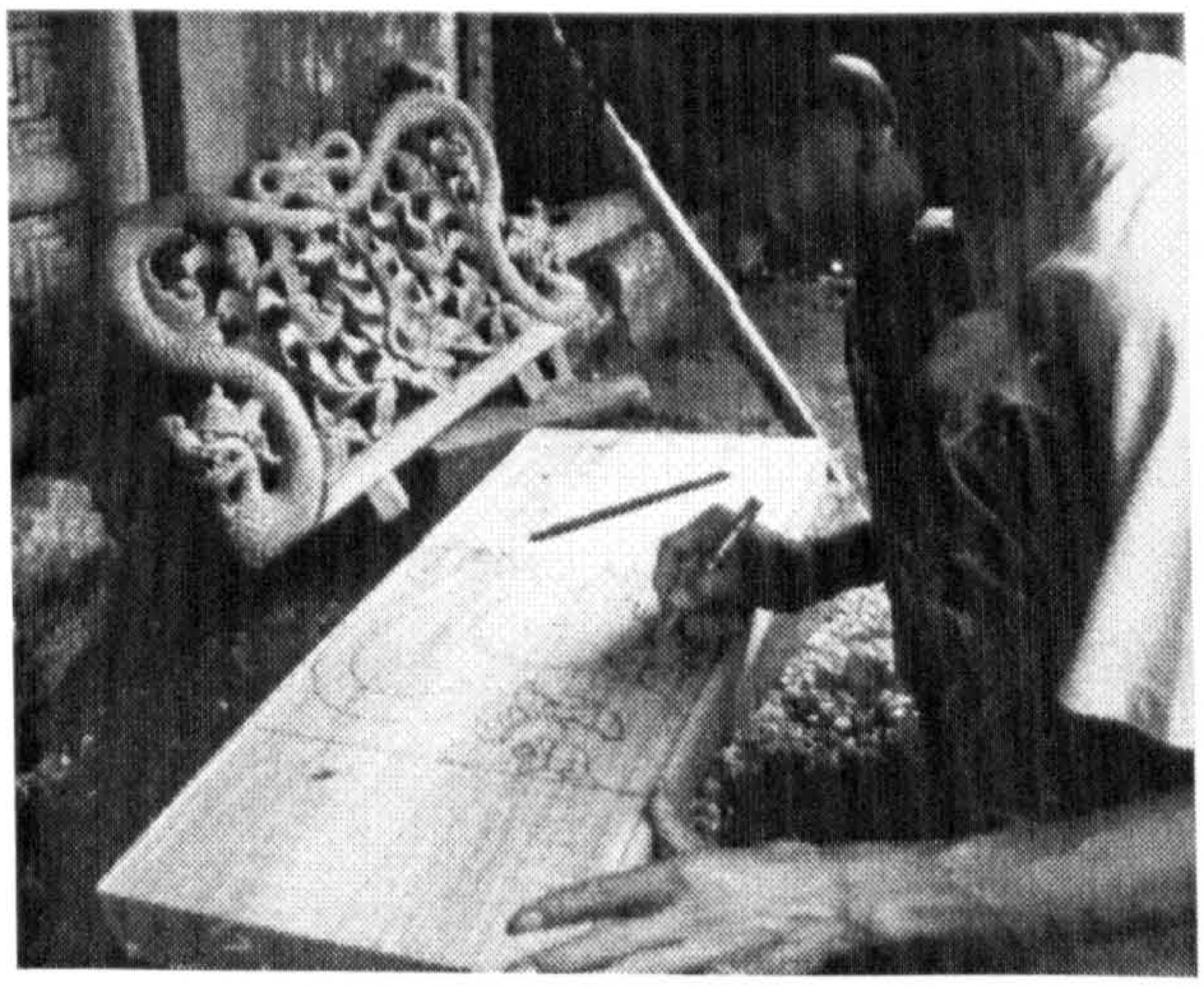


Fig. 90 Drawing the design.

Fig. 91 Frame end for bonang.

Rough setting in and grounding

The wood is cut away to form the base relief (grounding), but only to half the depth required, just enough to allow the design to be traced. Only the minimum grounding is done at this stage due to the risk of splitting and loosening the thinner elements of the design by the action of 'setting in'.[5] The design is 'set in' by making a series of vertical chisel cuts that follow the outline of the design.

A set of Javanese carving tools, (*tatah*) as used by carvers in Pak Diran's workshop, usually consists of thirty-four chisels. There are four different types of chisel (see fig. 92):

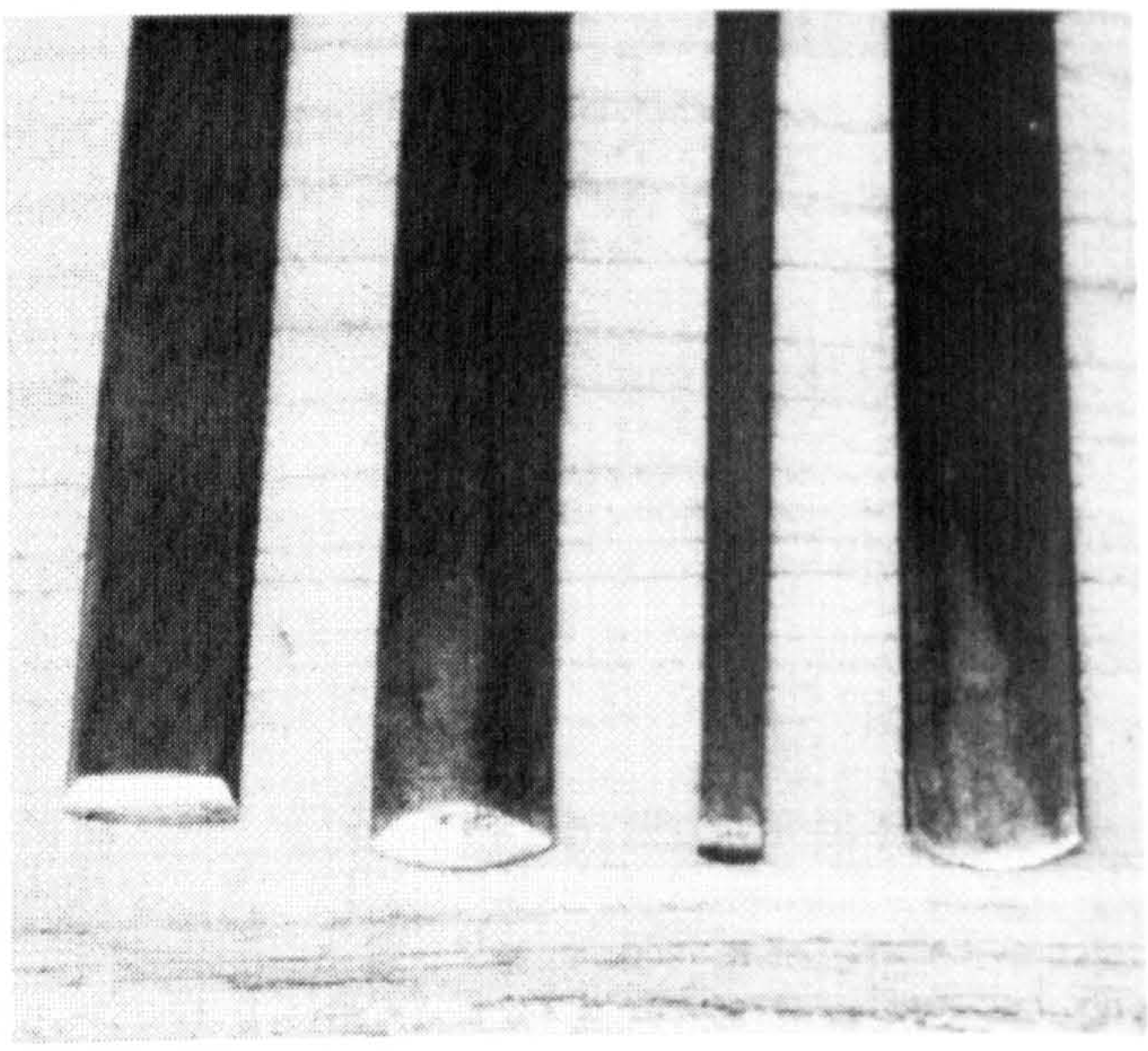


Fig. 92 Javanese *tatah*, numbered 1 to 4, from left to right.

1) *Penyilat* - a flat carving chisel; there are ten of these in a set.

2) *Penguku* - an internally bevelled gouge; there are twenty *penguku* in a set. Each gouge has a different size and sweep (curvature) to allow the spiral plan of the design to be accurately followed.

3) *Wanngkil* - a bent grounding chisel; there are two of these in a set.

4) *Pahat Col* - an externally bevelled gouge used for modelling; there are two of these in a set.

Javanese carving chisels are quite different from European chisels[6] ; the four characteristics that set them apart are:

a) Javanese tools are very thin, typically only two millimetres thick as opposed to four millimetres, which is standard for an English gouge.

b) Virtually all Javanese gouges are ground with an internal bevel, unlike the majority of European gouges which are ground with an external bevel.

c) Javanese chisels are given a very long grind, ie. the angle to which the chisel is ground is more acute (the grind looks short in fig. 92 because the chisel is only 2mm thick; ie. it would look twice as long if the chisel was the same thickness as a European 4mm tool).

d) The cutting-edge of Javanese gouges are always convex, as opposed to the 'ideally', square-ended European gouge.

Since the Javanese gouge is very thin, and given a long grind the lateral pressure exerted on the timber during the first blow of the chisel is much less than that exerted by a European chisel. This means that setting in can be done before any outlining or wasting away, without the risk of splitting the timber surface.

Once the design has been set in, the ground is removed with gouges, and bent grounding tools. Figure 93 shows half of a gambang side panel after having been roughly set in and grounded.

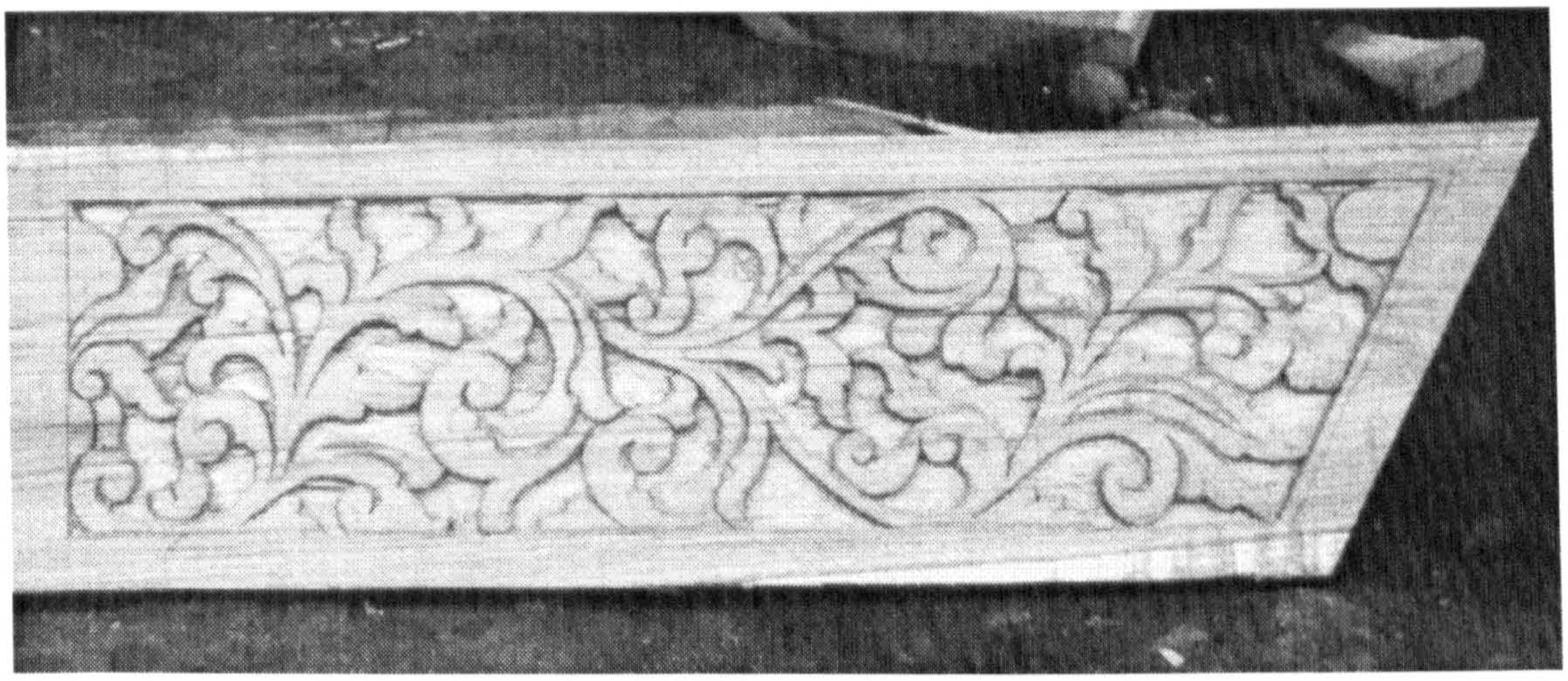


Fig. 93 Setting in and grounding.

Rubbing

The design is transferred to the other half of the panel by making a rubbing. A large piece of rice paper is securely positioned over the roughed out image. A sponge, dipped in a solution of paraffin and black pigment (charcoal dust), is rubbed over the paper thus creating an image (see fig. 94).

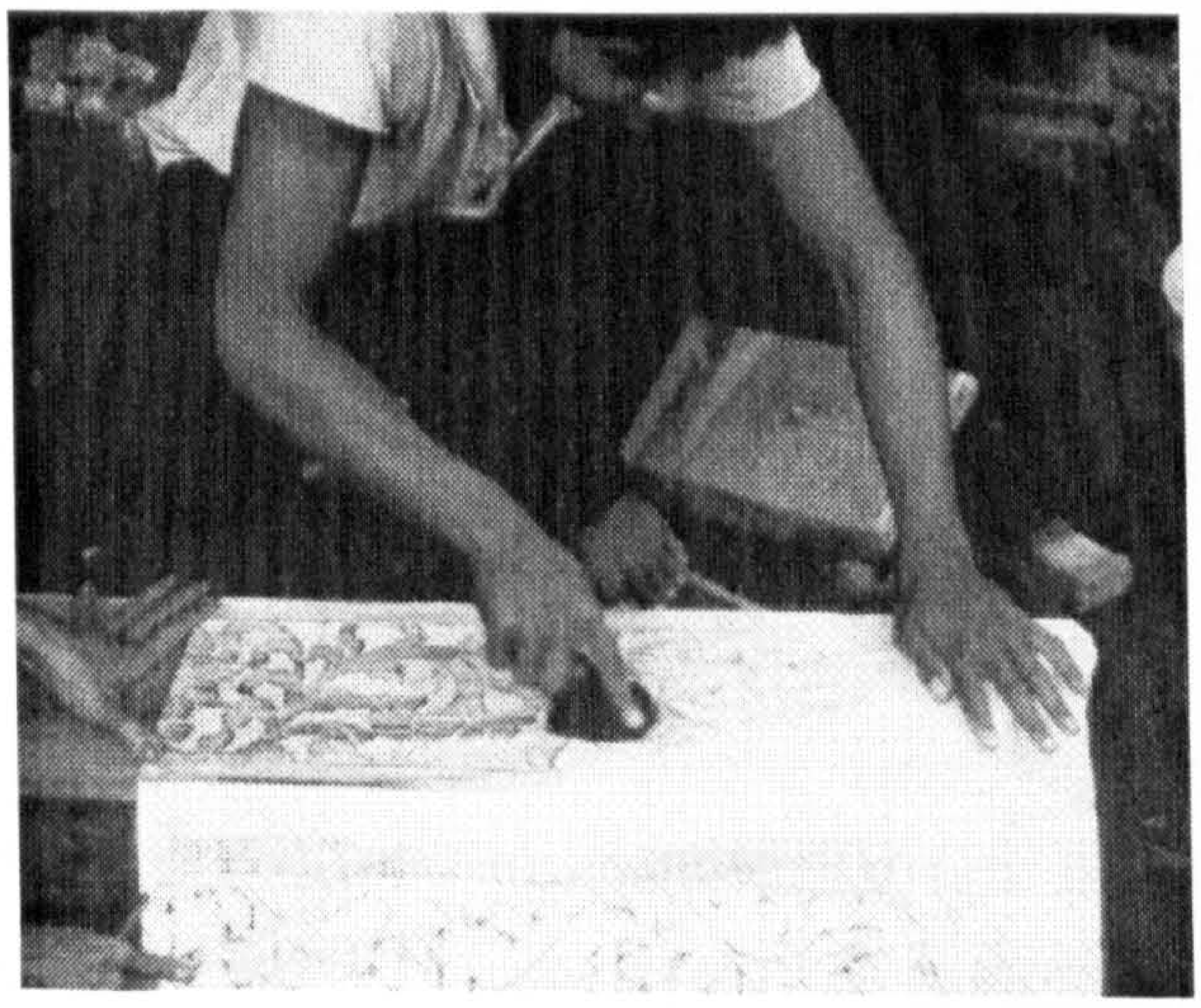


Fig. 94 Making a rubbing.

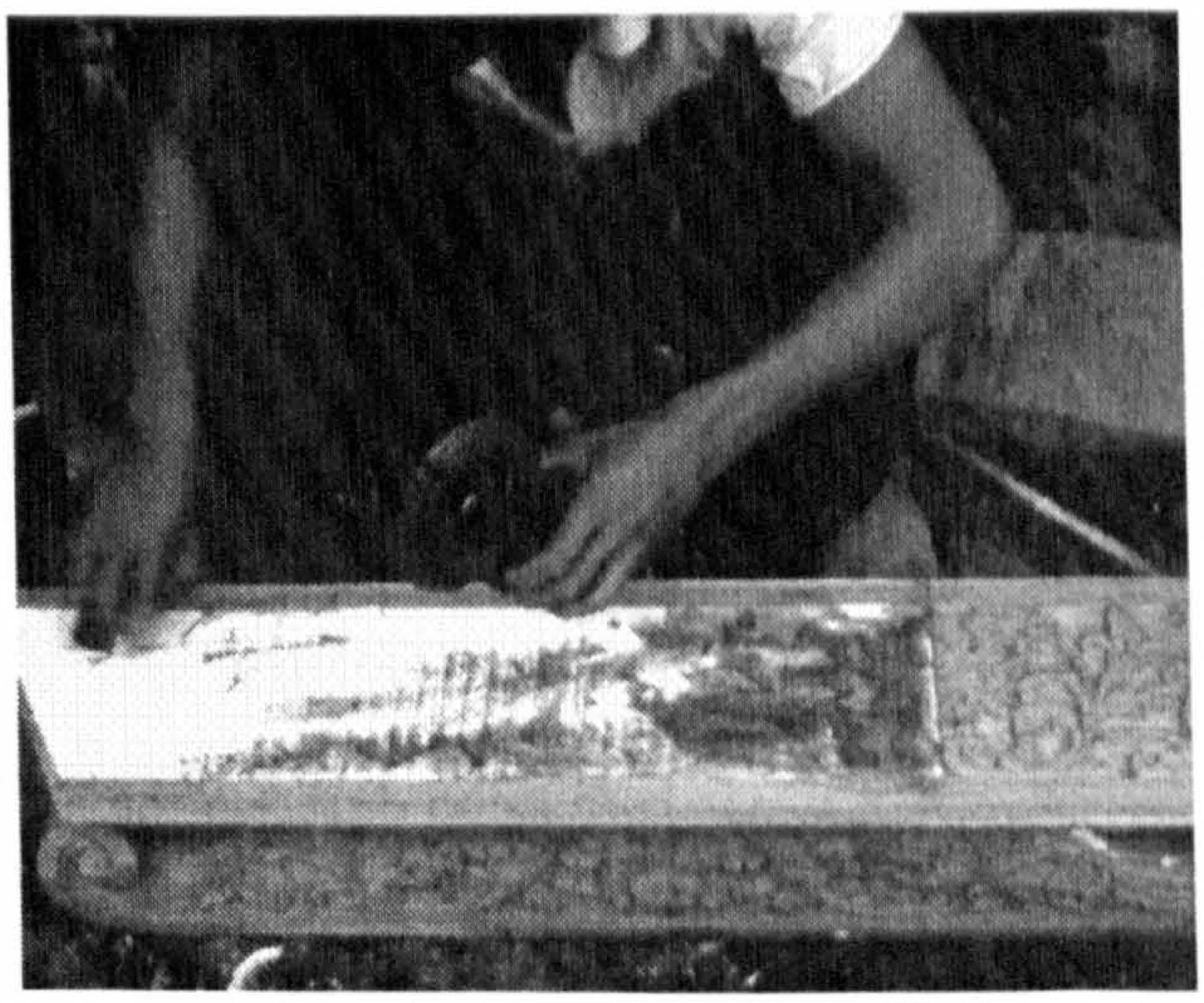


Fig. 95 Reversing the image.

Three such rubbings are made for the two panels of a gambang as featured in the photographs. The rubbings are stuck onto the teak panels with a paste of glutinous rice. To obtain the reverse image, the paper rubbing is stuck on upside-down, and then wiped with the paraffin soaked sponge, thus bringing the image through to the other side (see fig. 95).

Rough setting in and grounding the whole design

With the paper image stuck to the timber, the whole design can be set in and the ground partially removed (see figs. 96 and 97).

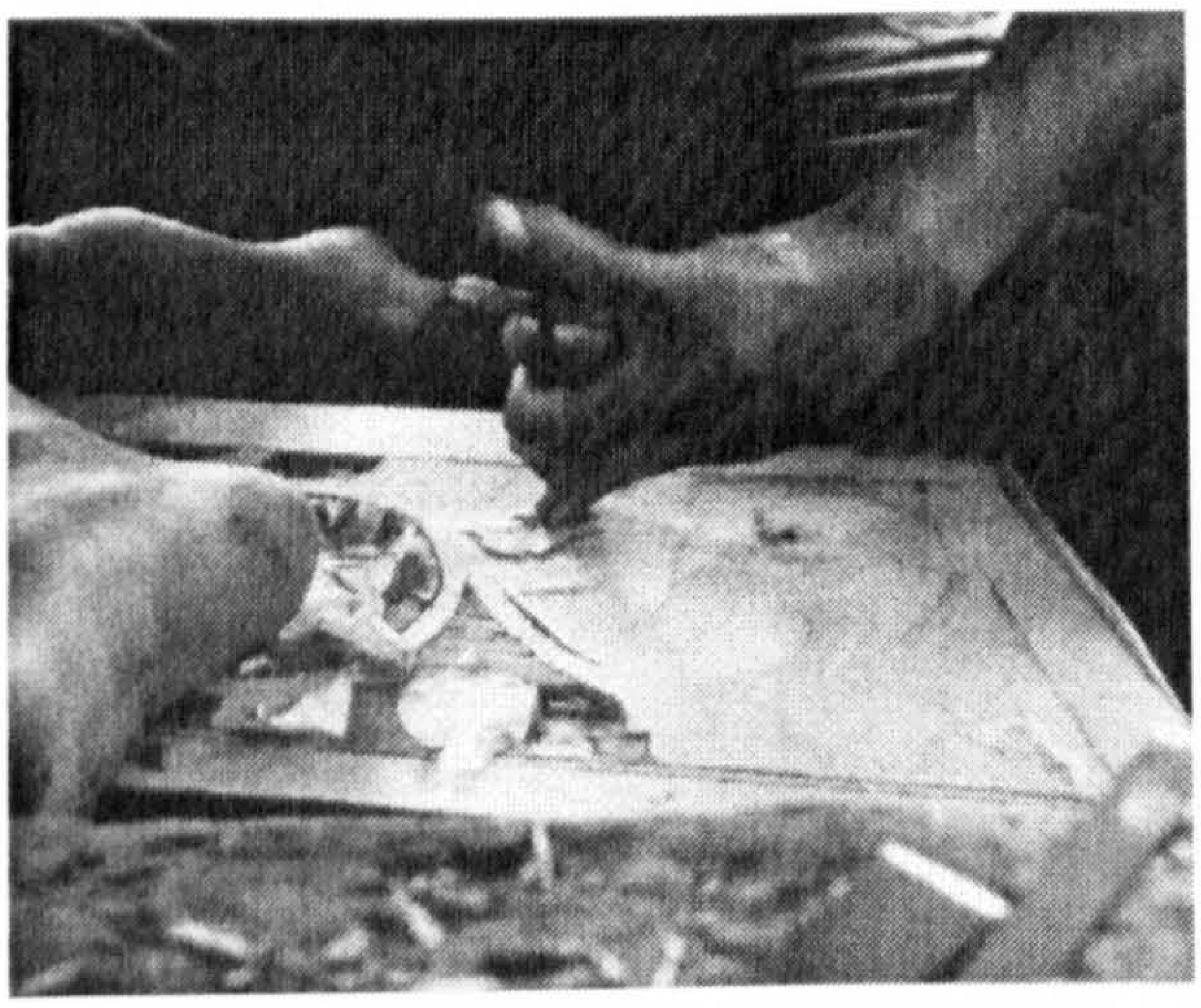


Fig. 96 Setting in.

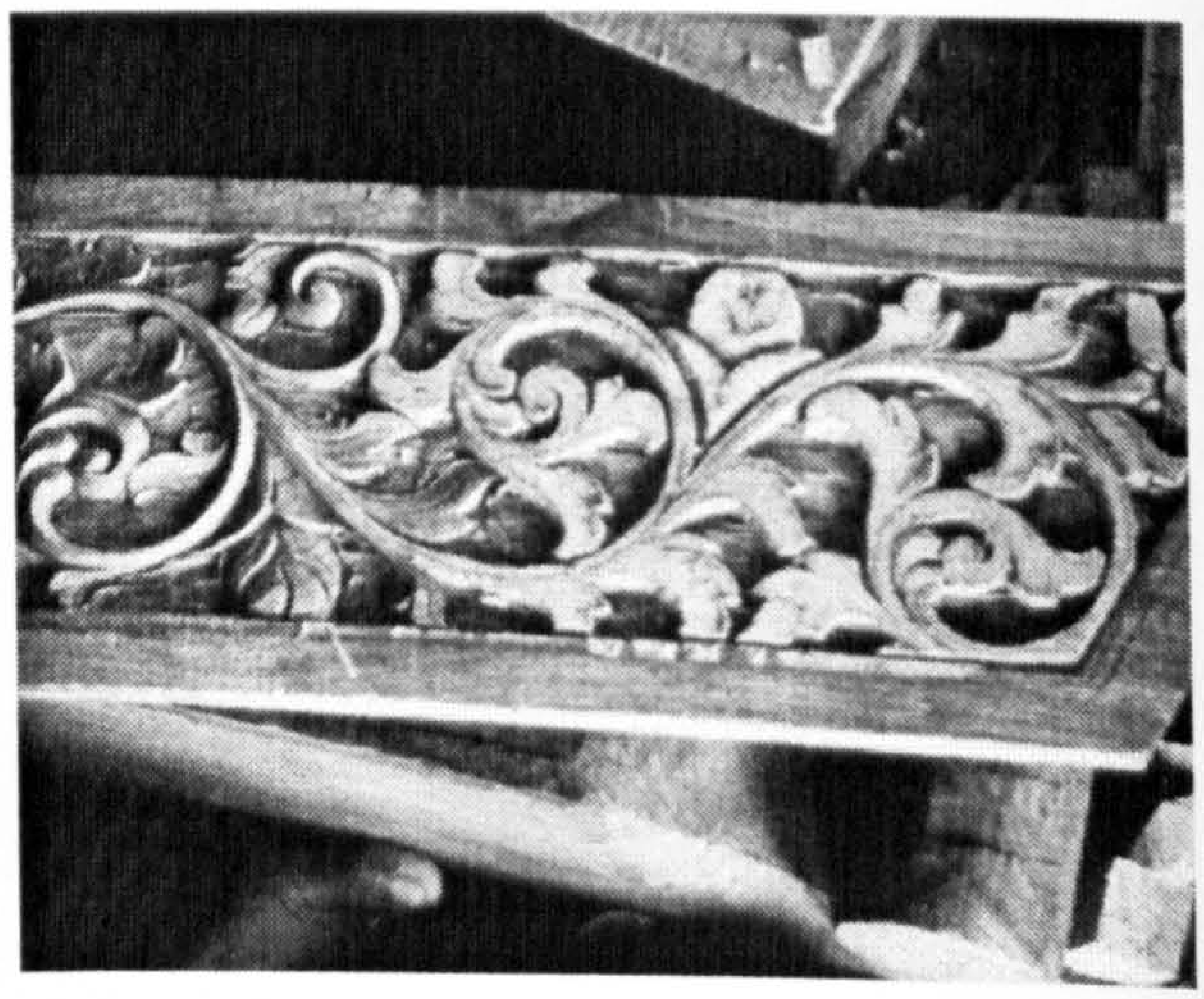


Fig. 97 Grounding.

Modelling

Modelling (in this case shaping the stems and contours of the leaves and flowers) is where the individual carver shows his artistic ability and understanding of form. At Pak Diran's workshop, there was a noticeable difference of quality between the apprentices' work and that of the experienced and artistic carvers. Pak Diran reported that most apprentice carvers learn their trade to a competent standard within one year. However, learning to carve accurately with speed takes much longer. Pak Diran also stated that a few apprentices lacked the necessary artistic ability, but this was normally apparent within the first six months after a basic ability to use and handle the tools had been gained.[7]

Javanese relief carvers tend to use their tools quite close to the perpendicular; the chisel cuts down into the timber at an angle, cutting the form of a stem for example, in a series of cuts, square-on to the material. Hence the need for all of the twenty gouges, with their different sizes and sweeps to follow the spiral curves.

The carvers work seated on low stools, with the workpiece off the ground, between their legs. The workpiece is not clamped down but merely held firm by the legs or feet. Because the tools are mostly used square on, there is little risk of the chisels slipping and causing injury.

The concave contours of the leaves are shaped with the two externally bevelled gouges, *pahat col*.[8] The modelling is shown in figure 97, left half.

Final setting in and grounding

Once the modelling has been completed it is necessary further to lower the level of the ground. This is done by setting in, following the outline of the design, and then using a grounding chisel to make the surface smooth and the edges keen. Figure 98 shows this process; the far right of the panel has been set in, while the rest of the panel has had the ground reduced to its final level.

Fig. 98 Final setting in and grounding.

Once all the carved panels of an instrument have been completed, the various parts are jointed and assembled by one of the two carpenters.

CHAPTER VII

CALUNG MAKING BY BAPAK TAMIARDJI IN GERDUREN, BANYUMAS, CENTRAL JAVA

Calung is the bamboo 'xylophone' ensemble from Central Java. The ensemble is most popular around the large town of Banyumas, where the folk roots have been taken and mixed with modern styles and instrumentation to produce pop music. This music is played on local radio stations, and cassette recordings are sold all over Java.

The *calung* is not strictly a xylophone since the sounding part, the bars, are not made of timber but bamboo. *Calung* and similar bamboo instruments differ from xylophones in that the bamboo bar operates both as the sounding part and the resonator. This is achieved by cutting the bamboo so that some of the length of the bar is still tubular, producing a resonator. The pitch of the air column and of the bamboo when struck are independent. It is therefore possible to tune both parts of the bar to the same pitch, so the tone produced when the bar is struck is strong and loud. This principle is used to make the *angklung* ensemble from western Java. Each individual *angklung* instrument is made up of two or three tuned bamboo bars, set loosely in a frame so that they sound when the frame is shaken.

Idiophones with bamboo bars similar to *calung* are very popular in Bali. The three main ensembles are *rindik*, *joged* and *jegog*.[1] *Rindik* and *joged* are very similar to *calung*, using bamboo bars [2] of similar dimension, whereas the *jegog* ensemble has truly gigantic instruments, with bars up to two metres in length and eighteen centimetres in diameter.

The fieldwork for this study of *calung* was done during May, 1989 in the village of Gerduren, which lies in the hills, north west of the Banyumas (see map 1, page 13).

THE INSTRUMENTS

I commissioned a set of instruments from the maker Tamiardji.[3] *Calung* is the name of both the group of instruments, and of the bamboo xylophone that leads the ensemble. A *calung* ensemble is normally made up of the following instruments:

a) *calung* (2 off),
b) kenong,
c) slenthem,
d) gong *bumbung,*
e) kendhang.

Calung

Two of these instruments are used in the ensemble: *calung pembukar*, and *calung penerus*. Although the two *calung* have different names, there is no difference between each instrument; both have fifteen bamboo bars tuned to the same slendro scale and encompass the same range. *Calung* are played using two padded disc beaters, with long, thin flexible cane handles. The *calung* usually play in parallel octaves. The two *calung* are played in interlocking style, each instrument playing two notes for each note of the balungan, so that the combined *calung* part plays four notes to every balungan beat.

Kenong

One kenong is used in the ensemble. The bamboo bars are much larger than those of the *calung*, and therefore produce more volume. The kenong is played with a single beater, which is much heavier than those used for the *calung*. Rubber, such as bicycle inner tube, is wrapped around the head. The kenong has only six bars.

Slenthem

The slenthem is similar to the kenong, but is tuned an octave lower. The slenthem is also played with one heavy beater. Like the slenthem in court gamelan, it plays the balungan. The range of the *calung* ensemble is shown below:

Calung	,,6 ,1 ,2 ,3 ,5 ,6 1 2 3 5 6 1' 2' 3' 5'
Kenong	,3 ,5 ,6 1 2 3
Slenthem	,,3 ,,5 ,,6 ,1 ,2 ,3
Gong *bumbung*	,,,3

Gong bumbung

The gong *bumbung* is a 'blown gong'. It consists of a length of large diameter bamboo, closed at one end, and a shorter length of smaller diameter bamboo, open at both ends. The smaller tube is held inside the larger piece of bamboo, so that roughly one third of the smaller one projects from the top of the large tube. The instrument is played by blowing into the small tube, using a lip reed technique, as used for playing the didjerido or large brass instruments.

Kendhang and ketipung

The kendhang used in the *calung* ensemble is similar in shape and size to the ciblon used in gamelan. The heads of the *calung* kendhang tend to be thinner than those of the ciblon; goat skin is used for the smaller head, and cow belly or deer for the larger. The drumming style is dynamic, characterised by the use of many slaps and other techniques such as changing the pitch of the drum by applying pressure on the skin with the heel of the foot.

The kendhang is always played in conjunction with the ketipung. This very small, high-pitched drum is hung vertically from the kendhang stand during performance. Goat skin is used for both heads.

CALUNG MAKING

The following information on *calung* making was given by Pak Tamiardji during my stay in Gerduren. I was shown eight different varieties of bamboo growing in and around Gerduren, each of these having its own particular use. About a thousand different species of bamboo are known, of some fifty genera.[4] They range from plants the size of field grass to giants of thirty-five metres, with a culm diameter of thirty centimetres. They grow from sea level tropics up to 4000 metres mountain slopes. Bamboo species vary widely in colour, shape, and size but all share one common characteristic; the woody culm, or stalk. A few grow almost solid with age, but most are hollow, divided by walled septa, or nodes. The bars of *calung* are made from a bamboo known locally as *wulong*, shown in figures 99 and 100 (*gigantochloa atter hassk*).[5] *Wulong* grows to a height of fifteen metres, with a diameter up to ten centimetres.

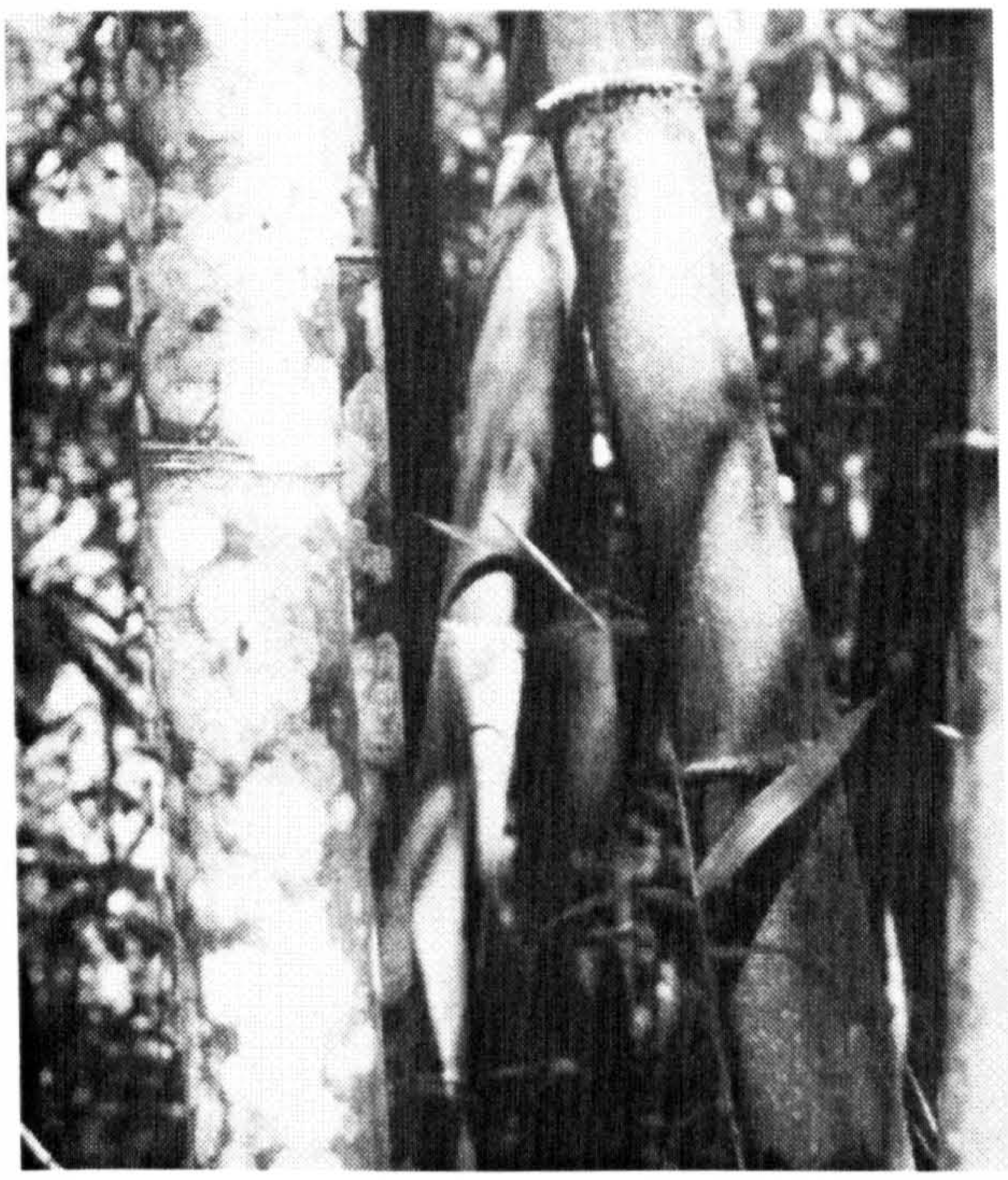


Fig. 99 *Bambu wulong.*

Fig. 100 *Bambu wulong.*

Bambu wulong is easily identified by the dark brown colour of the outer skin. It grows very straight, with large distances between the nodes. The nodes do not bulge out from the culm but lie almost flat. The wall of the bamboo is dense and heavy. When properly dried it remains stable with little risk of splitting.

Pak Tamiardji explained that the area around Gerduren provides the ideal growing conditions: relatively high altitude (which reduces temperature), and a good distance from a water source (river or lake). Both of these conditions slow the rate of growth, producing a denser material which gives a more sonorous tone, remaining more stable than a faster grown bamboo.

Bamboo of one and a half to two years growth is sought; the younger material being used for the thinner-walled bars of the *calung*, and the older bamboo for the heavier bars for the kenong and slenthem.[6] As the bamboo ages, the surface of the culm becomes covered in lichen; the culm in the left of figure 99 is two years old, and the younger culm in the right of the same photograph, without any lichen growth, is less than one year old.

The *bambu wulong* that Tamiardji cuts each year must be left to dry before it can be used to make *calung*. The culms are cut into short, manageable lengths and placed above the cooking fire in the kitchen. The culms are left here for one year, after which time they are thoroughly dry and covered in a black residue from the wood smoke. Figure 101 shows Pak Tamiardji sorting out the dry, blackened bamboo for different instruments. Pak Tamiardji said that bamboo which is put to dry outside should be left for at least two years, but it is always preferable to dry the culms above a cooking fire. The culms are then washed.

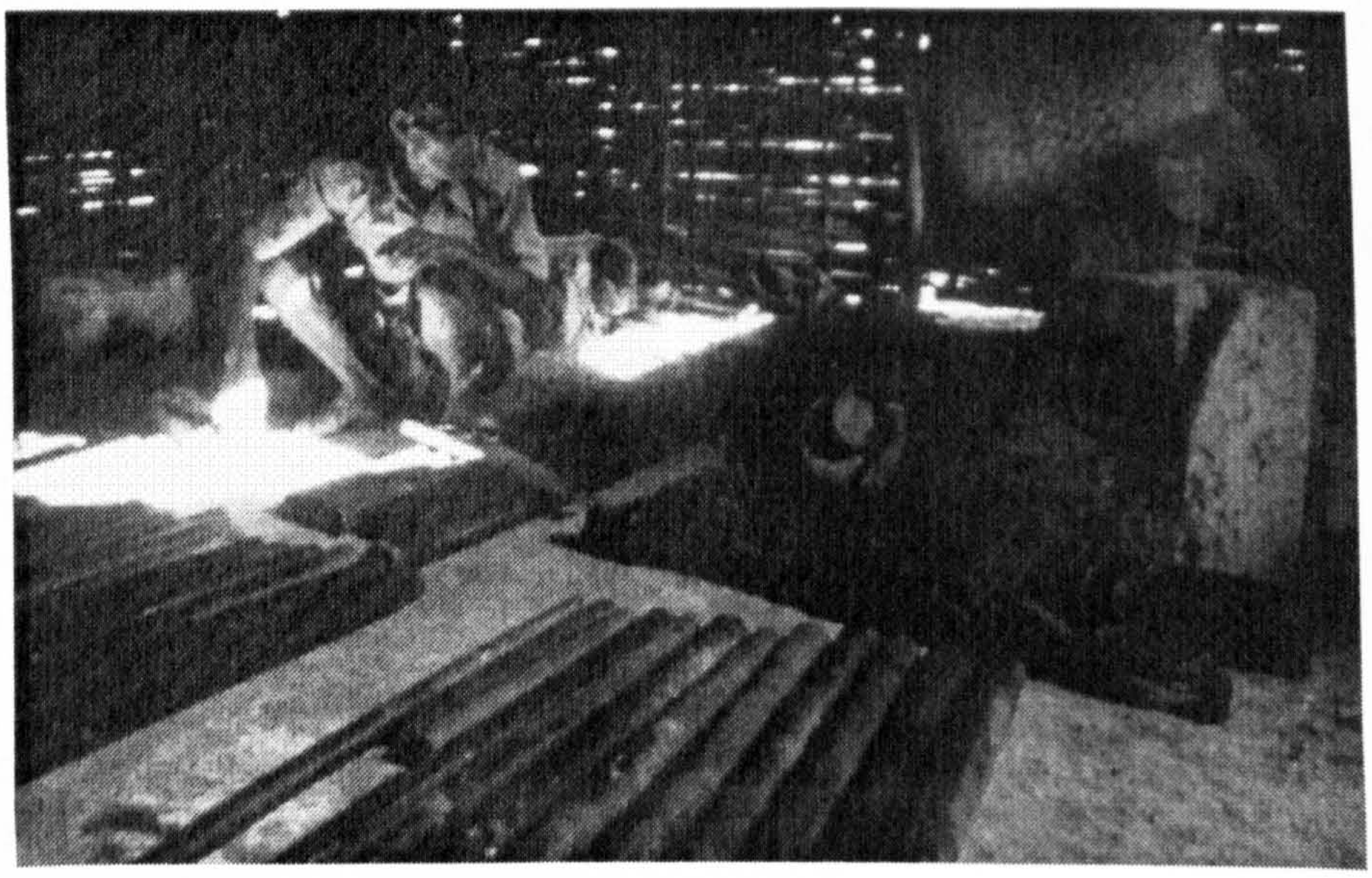


Fig. 101 Sorting the dry, blackened bamboo.

The ends of the selected lengths of bamboo are cut off just before the node, leaving a closed bottom to the air chamber. Pak Tamiardji refers to existing instruments for dimensions and tuning. As is common in the manufacture of most xylophones, the smallest and largest bars are cut to length first of all, taking measurements from the reference instrument. The roughly cut lengths of bamboo are laid out in order, and a straight-edge is used to mark the others.

Each bar is made in two stages starting with the lowest. The air chamber or resonator is formed and tuned first, and the tongue is tuned in sympathy. Having cut the bamboo to length, the first task is to make the cutaway that will form the sound chamber, and the tongue (see fig. 102).

The length of the resonator part of the bar (shown by A in the diagram) is taken from the reference instrument. A saw cut is made at this position, to a depth of no more than half the diameter of the bamboo.[7] The waste section can now be split away from the bamboo to produce the tongue as shown in figure 103. The measurement A on the new bar is made slightly longer so that the air chamber is flat of the intended pitch; it is not possible to lower the pitch once this cut has been made, apart from by partially closing the aperture which is undesirable.

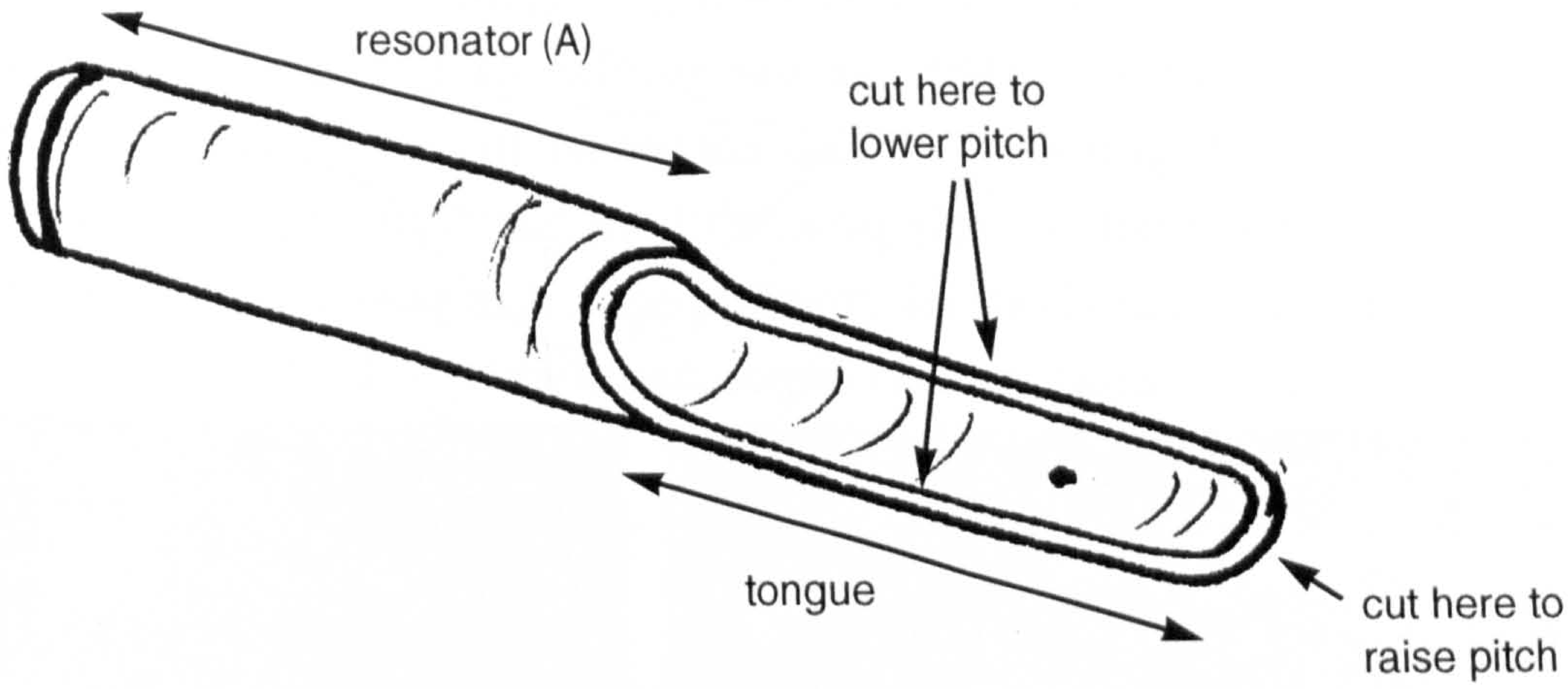


Fig. 102.

The pitch of the air chamber is tested by blowing across the opening, and at the same time hitting the reference bar as shown in figure 104.

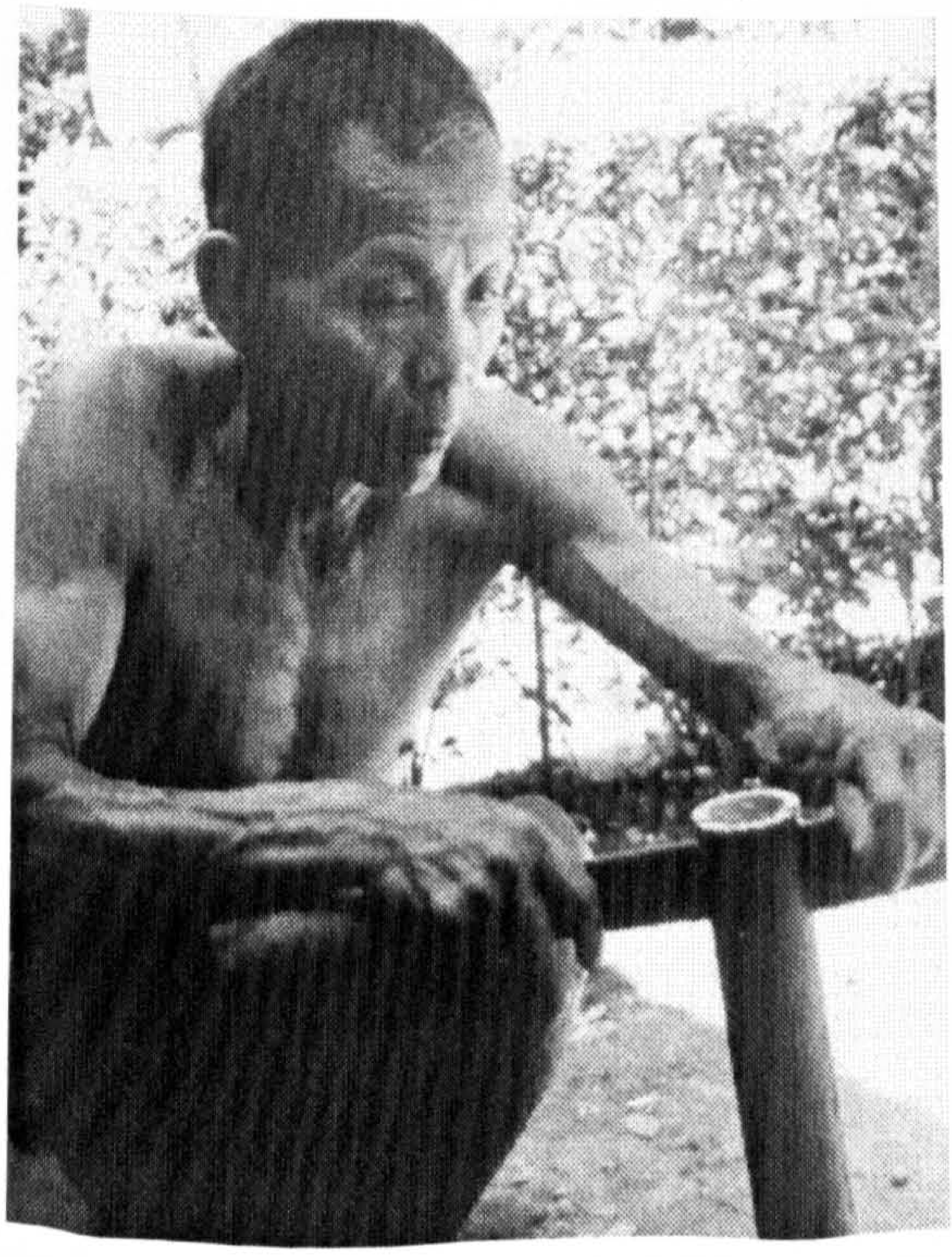


Fig. 103.

Fig. 104.

The two lowest-pitched bars of slenthem may have a node in the area of the air chamber, which must be broken through completely.[8] The resonator is tuned by cutting away the opening, little by little, until the desired pitch is reached. This is done using a very sharp, stout knife with a curved blade.

Having tuned the air chamber, it is now possible to tune the 'struck' part of the bamboo bar, ie. the tongue. The pitch is lowered by cutting away the sides of the tongue (see fig. 105), and raised by cutting the end of the tongue (see fig. 106). As the pitches of the air chamber and tongue come closer together, the tone increases in volume until, when they are perfectly matched, a clear powerful ringing tone is produced. In the lower pitched bars, like those of the slenthem, it is possible to hear a beating set up when the resonator and tongue are slightly out of tune.

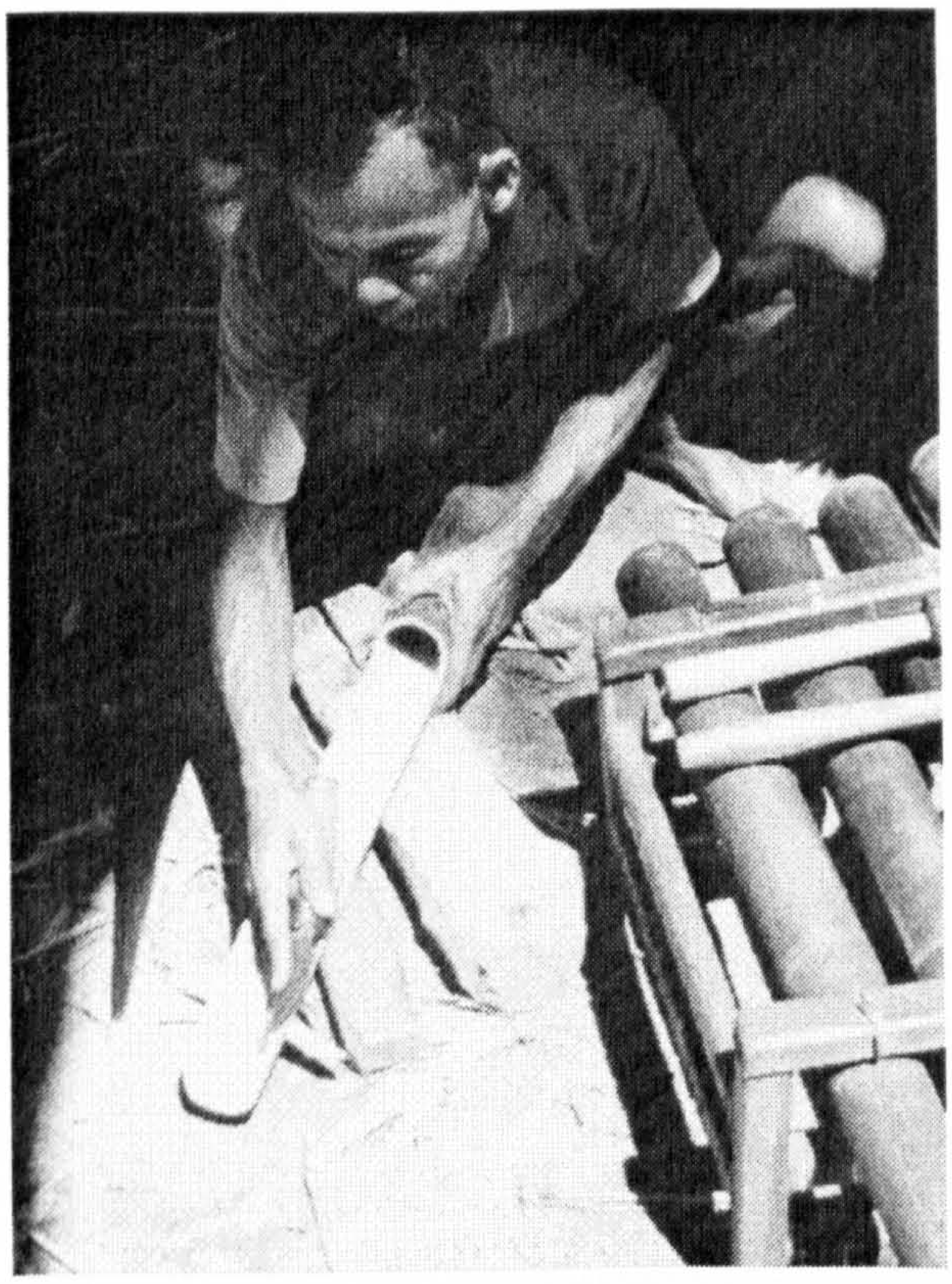


Fig. 105 Lowering the pitch by cutting the side of the tongue.

Fig. 106 Raising the pitch by cutting the end of the tongue.

The nodes (places of least vibration) are found by holding the bar by the tongue, between the thumb and forefinger, and moving this position until the note rings out freely. The nodes, like those for a xylophone bar, happen to be placed roughly one quarter of the length of the bar, from each end of the bar. A hole is cut at the node on the tongue, through which a string passes to support the bar in the frame. At the other end of the bar, the supporting string loops underneath it, and back onto the frame.

Two types of frame are in general use: the trapezoid type wooden frame as shown in the photographs, and curved bamboo frame as shown in figure 107.

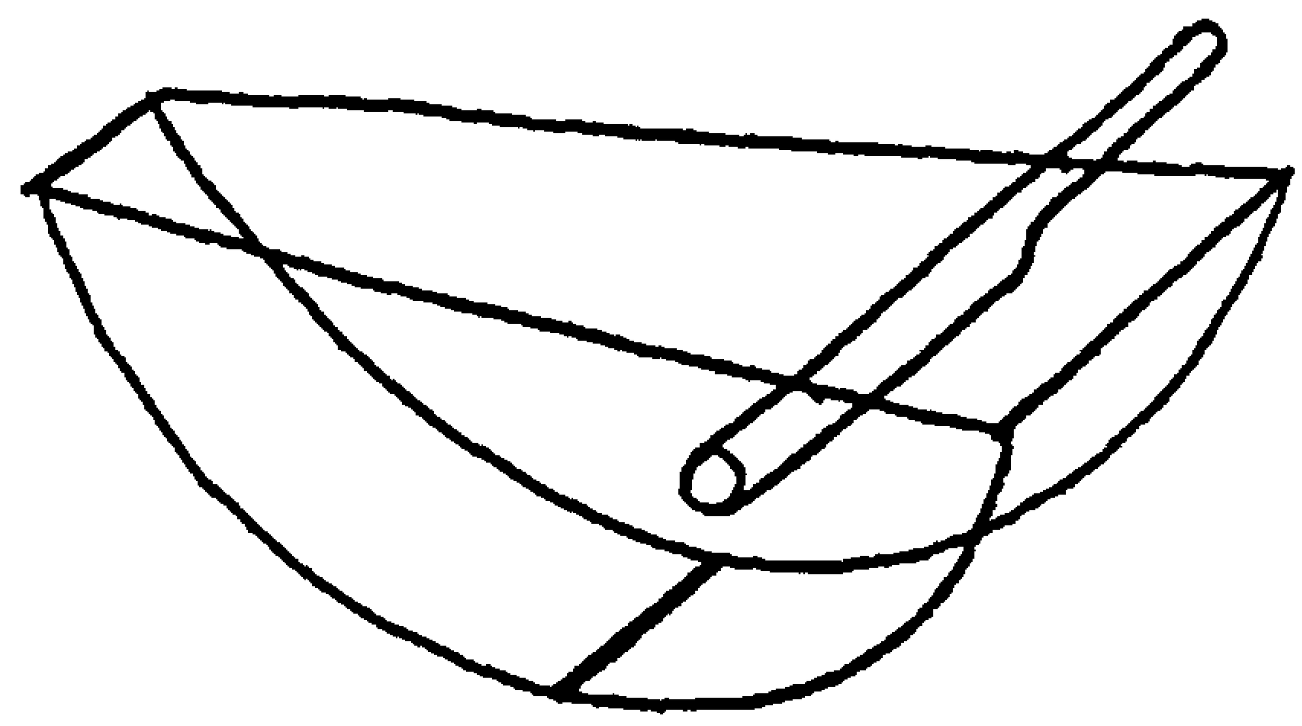


Fig. 107

Table 1 gives the dimensions of each bar and corresponding pitch in the *calung* set made by Pak Tamiardji in Gerduren.

Table 1 Dimensions (in millimetres) of *calung* bars.

Instrument	bar number	overall length	resonator length	diameter	wall thickness	pitch (Hertz)
	,,3	930	518	84	8	154.5
	,,5	910	470	82	8	187.8
slenthem	,,6	865	392	80	7	210.8
	,1	832	340	80	7	238.5
	,2	790	300	78	7	275.4
	,3	740	263	76	7	311.1
	,3	682	265	75	8	310.2
	,5	650	220	72	8	378.6
kenong	,6	610	185	72	7	423.8
	1	565	159	71	7	481.2
	2	515	138	65	7	552.8
	3	470	116	58	7	624.4
	,,6	804	393	67	6	214.4
	,1	770	352	66	6	238.5
	,2	720	305	64	6	275.1
	,3	665	262	61	5	309.7
	,5	617	225	60	5	377.6
	,6	567	190	55	5	425.8
	1	518	170	53	5	482.6
calung	2	477	152	49	4	555.7
	3	422	123	46	4	627.3
	5	395	105	46	4	757.3
	6	347	89	43	4	852.5
	1'	320	80	40	4	973.6
	2'	290	69	36	4	1128.1
	3'	256	62	34	4	1259.0
	5'	240	52	32	4	1523.3

The gong *bumbung*, as described earlier, consists of two lengths of bamboo. The large tube, closed at one end is 770 mm long, with a diameter of 95mm. The smaller tube, open at both ends is 513 mm long, with a diameter of 41 mm.

The pitch of the gong is largely determined by the length of the small tube. In order to achieve the low pitch required from this relatively short tube, this piece of bamboo is cut so that a node lies at its centre. This node is only partially broken through, enabling the tube to be tuned to a pitch much lower than would otherwise be possible, at approximately 77 Hertz. The intervals of Pak Tamiardji's calung are given in table 2.

Table 2.

key	Hertz	cents (above C)	interval (cents)
,,3	154.4	278	
,,5	187.8	626	348
,,6	210.8	826	200
'1	238.5	1040	214
'2	275.4	89	249
'3	310.2	295	206
'5	378.6	640	345
'6	423.8	835	195
1	481.2	1055	220
2	552.8	95	240
3	627.3	314	219
5	757.3	640	326
6	852.5	845	205
1'	973.6	1075	230
2'	1128.1	130	255
3'	1259.0	320	190
5'	1523.3	650	330

Calung are tuned to a slendro scale, and like in gamelan, each *calung* ensemble is likely to have its own particular slendro scale giving it its own identity. Table 2 shows the scale used by Pak Tamiardji. There are large intervals between notes 3 and 5, most of these being about 350 cents. An approximate scale could be taken from the kenong, starting at note ,3, this gives the following intervals: 345, 195, 220, 240, 211.

CHAPTER VIII

INSTRUMENT MAKING IN JAVA - CONCLUSION

The vitality of the arts, and culture in general, in Java is inseparable from Javanese life. Classical music is popular with the whole spectrum of society, from rickshaw drivers to royalty. Gamelan music is played at every social occasion.

The Indonesian government actively encourages culture in Java through the department of arts and culture. This department publishes studies on all aspects of culture from most regions in Indonesia. It has set up a number of music and dance colleges throughout country, taking over this cultural responsibility from the royal establishments.

The essence of Javanese culture is the music of the bronze court gamelan which has been exported world-wide (Europe, America, Australia and Japan). This study is intended to give an insight into the manufacture of the instruments that make the music. The art of forging gongs has been learnt over centuries, and by comparing the techniques used today with those used during the time of Jacobson's and van Hasselt's research in 1907, it can be seen that techniques and principles have hardly changed this century.

During the second world war and the following decade, the gamelan industry in Java suffered a serious decline through the lack of demand for large gongs and the subsequent loss (or partial loss) of the art of forging them. To what extent the recovery of the gamelan industry is due to foreign interest, as some people believe, is debatable. Nevertheless, many of the recent orders for bronze gamelan have been for export, and this relatively new area of demand has done much good for the industry in Solo.

The next threat to the bronze gamelan industry will probably evolve as Java goes through the next stage of economic development; industrialisation. The effects of this development are all too apparent in Thailand where two polarised societies exist; one working in the modern developed state with the financial rewards, and the other being little altered and unable to afford living expenses that have rocketed since industrialisation. Essentially, people in Thailand now find it very difficult to earn a living from labour-intensive work, such as traditional instrument making and craft trades like carving. During a stay in

Thailand I visited the last remaining bronze instrument foundry in Bangkok. The owner was despondent about the future of his trade; none of his sons had taken it up because of the poor financial rewards, whereas twenty years ago gongsmiths in Thailand had a high status in their society. Hopefully, the labour-intensive Javanese bronze gamelan industry will find a way of surviving the transition into industrialisation.

The ability of the iron gamelan-smiths to make good quality, sonorous instruments at a very affordable price has helped the growth of interest in gamelan, both in Java and Britain.

PART II

CHAPTER IX

THE MANUFACTURE OF LODAGAA AND SISAALA XYLOPHONES IN NORTH WEST GHANA

INTRODUCTION

Peoples possessing xylophones

The geographical distribution of xylophones in Ghana is restricted to the North West; in particular the Upper West Region and the neighbouring western part of the Northern Region. The LoDagaa group of peoples dominate the western part of this defined area, and the Sisaala people, the eastern part. For all these peoples the xylophone is the most important musical instrument, providing the music for all the ceremonies and, most significantly, for the funeral ceremony. Most of the old pagan festivals have disappeared as a result of the widespread adoption of Christianity in the west, and Islam in the east. The funeral ceremony amongst the LoDagaa has, however, survived virtually unchanged for at least one century.

Four distinct types of xylophone are used by the LoDagaa group:

a) *Lo gyil* or *gyilmɔ,*

b) *Dagaa gyil,*

c) *kogyil* or *gu,*

d) *bogyil.*

The Sisaala use just one type of xylophone known as *jengsi.*

Each of these instruments is distinguished by size, musical range, and tuning. The basic construction of a closed frame with calabashes suspended under the bars is common to all Ghanaian xylophones.

Sources of information

The principal ethnographic studies on LoDagaa culture were written by Jack Goody.[1] The first attempt at a comprehensive ethnographic study of the Voltaic region was carried out by Henri Labouret during the 1920s.[2]

Published material dealing with LoDagaa music is mostly limited to brief accounts in more general studies on African music, although A.A.Mensah's two articles 'Musicality and Musicianship in Northwest Ghana' and 'Further Notes on Ghana's Xylophone Traditions' [3] deal directly with the subject.

With regard to unpublished material, one study by Larry Godsey [4] and two by Mitchel Strumpf [5] deal directly with LoDagaa music. One study by Mary Seavoy specialises in Sisaala music.[6]

Research Methodology

Field work for this study was conducted between April and June 1991. The first week was spent studying at the Institute of African Studies, University of Ghana, Legon, Accra. I was given an introduction from Mr A Yirenkyi (at the I.A.S.) to Mr. Bondong, the director of the Arts Centre (Department of Art and Culture) in Wa, Upper West Region.

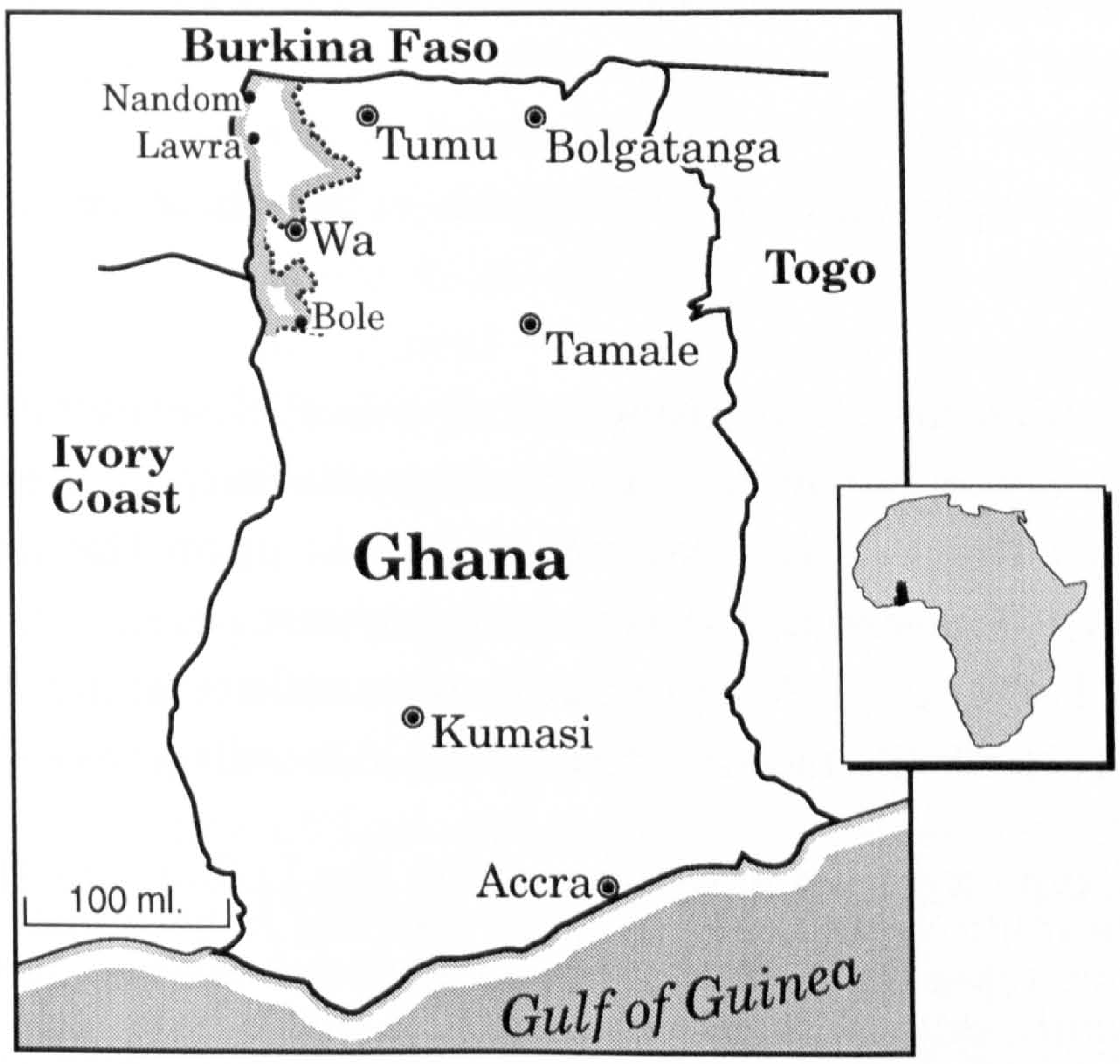
Mr. Bondong suggested that I should travel to the town of Lawra to study LoDagaa xylophone manufacture and to the town of Tumu to study Sisaala xylophones. In Lawra I was helped with my research by Mr. E. Dansie, the local representative for the Dept. of Art and Culture. He introduced me to Mr. Baaru, regarded as the best xylophone maker around Lawra. Most of the following information on LoDagaa xylophone manufacture was given by Baaru.

In Tumu I was given much help by Mr. C. Dikpe, local representative for the Dept. of Art and Culture. In Tumu it quickly became apparent that the Sisaala xylophone tradition was in a state of decline. There were no practising xylophone makers around Tumu so my research was largely based on interviews with old instrument makers, village elders and chiefs.

Subgroups of the LoDagaa

The term LoDagaa was devised by the anthropologist, Jack Goody [7] to refer to the culturally and linguistically related peoples of north-west Ghana, and the bordering areas in Ivory Coast and Burkina Faso (refer to map 2). LoDagaa territory straddles the Black Volta river, north to south from Boromo in Burkina Faso to Bole in Ghana (200 miles), and west to east from Kampti in Ivory coast to Kujopere in Ghana (100 miles).

The term LoDagaa, which is widely accepted by other scholars, was devised because there is no indigenous word which refers to these people as a whole. To outsiders trying to classify these people there is much confusion; "The Dagari of the French writers are the people referred to as Lobi by the English." Goody explains that they "are not divided into tribes, for no constituent group has consciousness of unity to give rise to a tribal name. Broadly speaking they acknowledge only place names, the names of settlements, which correspond to parishes of the Earth cult".[9] Different groups consistently use the terms Lo and Dagaa to refer to their neighbours, but may employ either term when relating to themselves depending on what aspect of culture they are referring to, ie. matriline, dance, property, death (all these overlap). Goody noted that the "main criterion pointed to is the relative stress given to matriliny and patriliny; the Lo in the west are matrilineal, while the Dagaa in the east are patrilineal."[10]



Map 2 LoDagaa territory.

The different groups, as noted by Goody, are listed below starting with the Lo oriented people in the west. The LoWilisi live in the extreme west and the Dagaba in the extreme east. Goody notes that "The Dagaba refer to all groups to the west of them as Lo, the LoWilisi refer to all groups to the east of them as Dagaa; and the intermediate groups refer to their neighbours in the same way".[11] The names chosen by Goody for individual groups "have some significance locally".[12]

Lowilisi and Birifor

The Lowilisi in the extreme west are the only people of the LoDagaa who speak a Lobi language, all the others speak dialects of the Mossi language. Although the two languages are mutually unintelligible, bilingualism is common resulting in intermarriage and the sharing of ceremonies and festivals. Both groups have a dual system of inheritance with the emphasis on the matriline, both use the same ensemble of instruments for the funeral ceremony, play the same funeral repertoire, and perform the same funeral dances.

The principal instrument is a fourteen-bar xylophone called *kogyil* by the Birifor, and *yolon mbo*[13] by the LoWilisi. This xylophone is distinct from all other LoDagaa instruments by having a carrying hoop and raised tips on the bar ends. This instrument is the only LoDagaa funeral xylophone to be played singly; all the others play in pairs.

LoDagaba

Goody subdivides this group into the LoPiel (lit. white Lo) and the LoSaala (lit. black Lo), both of which "possess fully-fledged dual descent systems, but there is increasing emphasis upon the obligations of patriclanship. The matriclan is less important among the LoPiel than among the LoSaala".[14] The LoSaala live mainly around the town of Lawra, while the LoPiel live to their north. According to Godsey [15] the:

> *kogyil*-type xylophone recurs among the LoSaala as the *lo gu*, but the main sequence of funeral dancing is accompanied by a different type: the *gyilmɔ*. It is roughly 1-1/3 times larger than the *kogyil*, and as a result its overall pitch level is lower. The interval series of the *gyilmɔ* is also different: although both instruments are pentatonic, the *gyilmɔ*'s tuning is hemitonic whereas the *kogyil*'s is anhemitonic. Finally, whereas the *kogyil* is never played in pairs, this is the usual way of playing the *gyilmɔ*.

Strumpf,[16] however says that the LoSaala and the LoWiili use the *Lo gyil* for the entire funeral ceremony; this corroborates with my own research.

The LoPiel use the *Dagaa gyil* for the entire funeral ceremony, although according to Strumpf [17] and Goody [18] the LoPiel in former days used the *Lo gyil* for the short announcing section of the ceremony, though this practice has died out.

LoWiili

The LoWiili live to the south of the town Lawra. The LoWiili "recognise descent groups based on both lines but property of all kinds is inherited patrilineally and consequently matriclans play a comparatively subsidiary role".[19] For this reason they may be considered more Dagaa orientated than the LoSaala.

According to Goody the LoWiili used the *Lo gyil* for the announcing section of the funeral and once this is completed it is replaced with the *Dagaa gyil*.[20] However, Strumpf in his more recent research notes that the LoWiili use the *Lo gyil* for the entire ceremony.[21] It should be noted that most of Goody's very thorough research on the LoDagaa was concentrated on the LoWiili.

Dagaba and DagaaWiili

The Dagaba are set apart from all other LoDagaa sub-groups since they are emphatically patrilineal.[22] Goody states that the DagaaWiili "only have patrilineal descent groups but in certain ways, such as the prohibition on a son inheriting his father's wives, they are distinct from the Dagaba proper".[23]

According to Goody, the only xylophone both these groups possess is the *Dagaa gyil* (significantly referred to as simply *gyil*).

The different authors' discrepancies of which group uses which xylophone is indicative of Lodagaa culture; Goody notes "There are no distinct "cultures", but rather a slow merging as of linguistic dialects".[24] This "merging" is even apparent in the groups Goody devised, and it is common to find different clans from the same group using different instruments. This may give some reason behind the conflicting results of various researchers work, although most commonly the discrepancies arise from certain ceremonies' (and the associated instruments') growth or decline in popularity over time.

Historic and geographic background of the LoDagaa.

The LoDagaa form part of the Voltaic speaking group of peoples that are spread from the Ivory Coast in the west to Togo in the east, and from the Mali/Burkina Faso border in the north to Bole in Ghana. Although little is known of the ancient history and migrations of the LoDagaa, it is generally believed that they arrived in north-west Ghana at the beginning of the nineteenth century [25] following migrations from the Ivory Coast. The LoDagaa north of Wa traditionally live in dispersed settlements which offered no protection against attack. The early Arab travellers of the middle ages were concerned with the impressive Niger towns and the trade routes to the north, and not with the country to the south.[26]

Mandingo slave traders, whose empire was forced south and eastwards as a result of their defeat by the French, did make regular raids into the country around the Black Volta. Goody [27] writes "The inhabitants on the right bank of the Volta suffered considerably from Samori forces, while the Lawra district was visited by Babatu and by other raiders".

The British colonial system appointed chiefs in the Lawra district, but as Goody writes: "there was a real sense in which their authority was delegated by their subjects".[28] The LoDagaa are historically a very mobile group and often migrate relatively short distances when they feel the land is exhausted.

LODAGAA XYLOPHONES

The sub-groups of the LoDagaa who live around the town of Lawra generally use three different types of xylophone:

a) *Dagaa gyil* - 17 bars,

b) *Lo gyil* - 14 bars,

c) *gu* - 14 bars.

The *Dagaa gyil* is the largest of the three instruments, and is tuned to a roughly equitonal pentatonic scale. The lowest bar on the instrument is left untuned and has no calabash resonator. This bar is used to play rhythmic patterns during certain stages in the funeral. The *Dagaa gyil* is always played in pairs.

The *Lo gyil* is the xylophone in most common use at funerals in and around Lawra. Although the bars are arranged on a pentatonic basis with four bars between octaves, every fifth bar is regarded as a 'bad' one. These are not played during musical pieces, although they are played in introductions where the musician plays runs up and down the instrument. The *Lo gyil* is always played in pairs during the funeral ceremony.

The small, fourteen bar *gu* is a borrowed instrument from Lowilisi (Lobi) and Birifor peoples and is used only for dance and recreation amongst the people around Lawra. The *gu* is tuned to a pentatonic scale similar to the *Dagaa gyil*. This instrument is known as *kogyil* amongst the Birifor and is never played in pairs unlike the other LoDagaa funeral xylophones.

The information in the following study is based on demonstrations by, and interviews with two xylophone makers, Baaru and John Bobri during May 1991. Baaru, who lives in Lawra generally used the term Dagaba for internal reference, since his clan places more emphasis on the patriline. Now this does not conform to Jack Goody's system, but when talking about certain aspects of culture such as music, Baaru would refer to himself as LoDagaba. Goody subdivides this group into LoSaala and LoPiel, the former he uses to distinguish the people "living within a mile or two of Lawra itself".[29] According to Godsey [30], the LoSaala use the term *gyilmɔ* for their funeral xylophone and the Lowiili use the term *Lo gyil kpee* ("large Lo xylophone") for the same instrument. I found that *Lo gyil* was the common term for this instrument amongst who I assume to be the LoSaala. Godsey appears to confirm this to be true by stating that the LoSaala are the only people, other than the Birifor and LoWilisi, who use the small fourteen-keyed xylophone known to them as *gu*. Due to this confusion I will use the term LoDagaba which Baaru used internally when referring to music.

Bobri lives four miles to the north of Lawra, and used the term "Lobi" for internal reference since the emphasis on inherited wealth is matrilineal. With regard to music however, the main instrument his clan used for the funeral ceremony was the *Dagaa gyil*.

The following study is based on the *Lo gyil* (see fig. 108). The construction for all the LoDagaa xylophones is very similar differing only in size and tuning systems.

Construction

The making of a *Lo gyil* cannot be studied purely on a technical level but must take into account the spiritual aspect which is constantly borne in mind by the maker. His methods of construction are dictated by generations of tradition. The *Lo gyil* is regarded with much respect; without it the funeral ceremony cannot take place and therefore the dead person cannot pass through to a peaceful after life. The making of a *Lo gyil* is considered spiritually dangerous and the necessary precautions must be taken along the way to pacify the gods and ensure good health to the maker.

Fig. 108 Baaru with his children and *Lo gyil*.

The buyer makes an order, and must provide the maker with a hen, a guinea fowl, and 500 cowrie shells. The maker takes the hen to the xylophone shrine (*gyil-tilo*), sacrifices it and informs the gods that he intends to make a new instrument. In addition to this sacrifice, the maker performs a ceremony every year at the beginning of the dry season to thank the gods for his 'given' talent and to ask for continuing guidance and protection for the following year during the pursuance of his craft.

Since the predominant occupation in the area is farming, instrument making tends to be carried out in the dry season when there is little work to be done on the farm. The dry season is traditionally a time to relax, spend time with the family and to work on traditional crafts such as weaving to gain a little money. The making of all LoDagaa xylophones is a lengthy process. The gathering of materials that will be used can take as long as the actual making process. To build one xylophone the maker will utilise at least four different species of timber, one cow hide, the skin of one small bush antelope, at least seventeen calabash, one hundred metres of twine, fifty spiders egg sacs, a quantity of raw rubber and a number of medicinal preparations. During the wet season Baaru spends some of his spare time making one or two instruments but during the dry season he makes them in batches gathering all the materials to make about four instruments at a time.

Procuring and drying the timber used for the bars

The first task is to procure the timber needed to make the bars. The LoDagaba, along with most other Sudanic societies, use exclusively *pterocarpus erinaceu* for this purpose. It is known locally as *ligaa*, *nigaa*, or *boniga* and is commonly known as Senegal or African Rosewood. The *ligaa* tree is believed by the LoDagaba to be very dangerous or "full of evil". Ideally a dead tree is used in order to minimise seasoning time. The tree should be straight enough to yield bars up to 80cm in length and wide enough so that between two and four bars may be split from one log.

Once a suitable tree has been found, pacification rites are performed. These vary in detail from clan to clan but invariably follow the form either of a gift set in the ground at the base of the tree or a 'medicine' painted on the tree. Before felling the tree, Baaru places a coin in the ground at the base of the tree. He learnt this from his father (also a xylophone maker) who taught him that it was necessary to 'buy' the tree from the spirits in order to pacify the gods. He also added that his grandfather had used cowries. Bobri paints a vertical line of 'medicine' on the trunk of the *ligaa* tree. This medicine is made by burning various timbers, barks and 'herbs' which are then mixed with some of the locally brewed millet beer (*pito*) to form a paste. Bobri told me he could not divulge which particular species these were since the medicine would be ineffective "if everyone knew them". His father had taken him into the bush and shown him how to make the medicine explaining that it was used to "drive the evil from the tree" and to "prevent it from cutting you". He told me of one occasion when the medicine had not worked, when "there had been too much evil in the tree" and he had fallen ill; "all my limbs ached, I couldn't get up". He had to get another medicine from a respected herbalist.

Once these duties have been performed the tree may be felled. The tree is cut into 80cm sections, split and then taken back home. If it is not possible to find a dead tree the maker must go through a much longer process of drying the timber. A gift is made or the medicine applied and then fire is set into the roots at the base of the tree and left until the tree actually falls, usually within two or three days. An alternative method is to chip away the roots and leave it until it dies (four to six months) and then fell it. With all these methods the most important consideration is that the tree is actually dead before it is cut down.

Back at the compound the maker sets to work on cutting the bars to length using his own instrument for reference. This instrument has usually been in his family for at least one generation, and is considered a standard for all aspects of construction and musical quality. Baaru uses his father's instrument as a model; although it is over fifty years old, it still plays beautifully. The cut bars are then roughly shaped with an adze before the final drying or 'smoking' process begins. Baaru digs a shallow pit into which he places the bars and then covers them with a 5cm layer of sand. A fire is made on the sand and left burning for two days so that the heat penetrates through to the bars and dries them without the risk of burning the timber. If a dead, partly dry tree is not used then the timber must be dried over a pit fire for up to three weeks. This is carried out with the timber in merely split form, before any shaping. A deep pit is dug and filled with slow-burning, dry cow dung. The slabs of wood are suspended about 30 cm above the fire and are constantly turned so that they dry evenly. After this the bars are roughly shaped with the adze and then further dried using the sand method.

Frame construction

While the bars are being dried the maker begins construction of the frame. The frame is usually made from the *lim* tree (*diospyros mespiliformis*). This is a close-grained, white wood that is reasonably strong and flexible enough to be bent to form the curved support pieces for the bars. Goody [31] notes that this timber is closely associated with the earth shrine and a *lim* stake driven into the ground is used to invoke the power of the earth. Baaru suggested that if *lim* is not available it is possible to use other timbers with successful results and did not state any spiritual significance in the use of *lim*. Figure 109 shows the construction of the frame.

The only specialised tools the maker uses are a set of hole-boring irons. These are heated to red hot and then driven through the timber. The two ends are made first. The four vertical posts are carved, leaving the central portion thicker than the ends so that the horizontal pieces will rest against the shoulders. The horizontal cross-pieces for the ends are carved, the top one shorter than the lower one, and a hole burnt through each end, through which the vertical posts will pass. The frame is made wider at the bottom, thus making it easier to fit in the calabash. Once the two ends have been made, four lengths of timber are cut which will form the rails of the frame. The top two, which are to be curved, are bent into position over a tree and left over-night. A hole is then burnt through each end of the rails which the vertical post will pass through. The frame is assembled by first, locating the cross-pieces over the posts and then, putting the rails over the posts, linking the ends and sandwiching the cross-pieces with the rails.

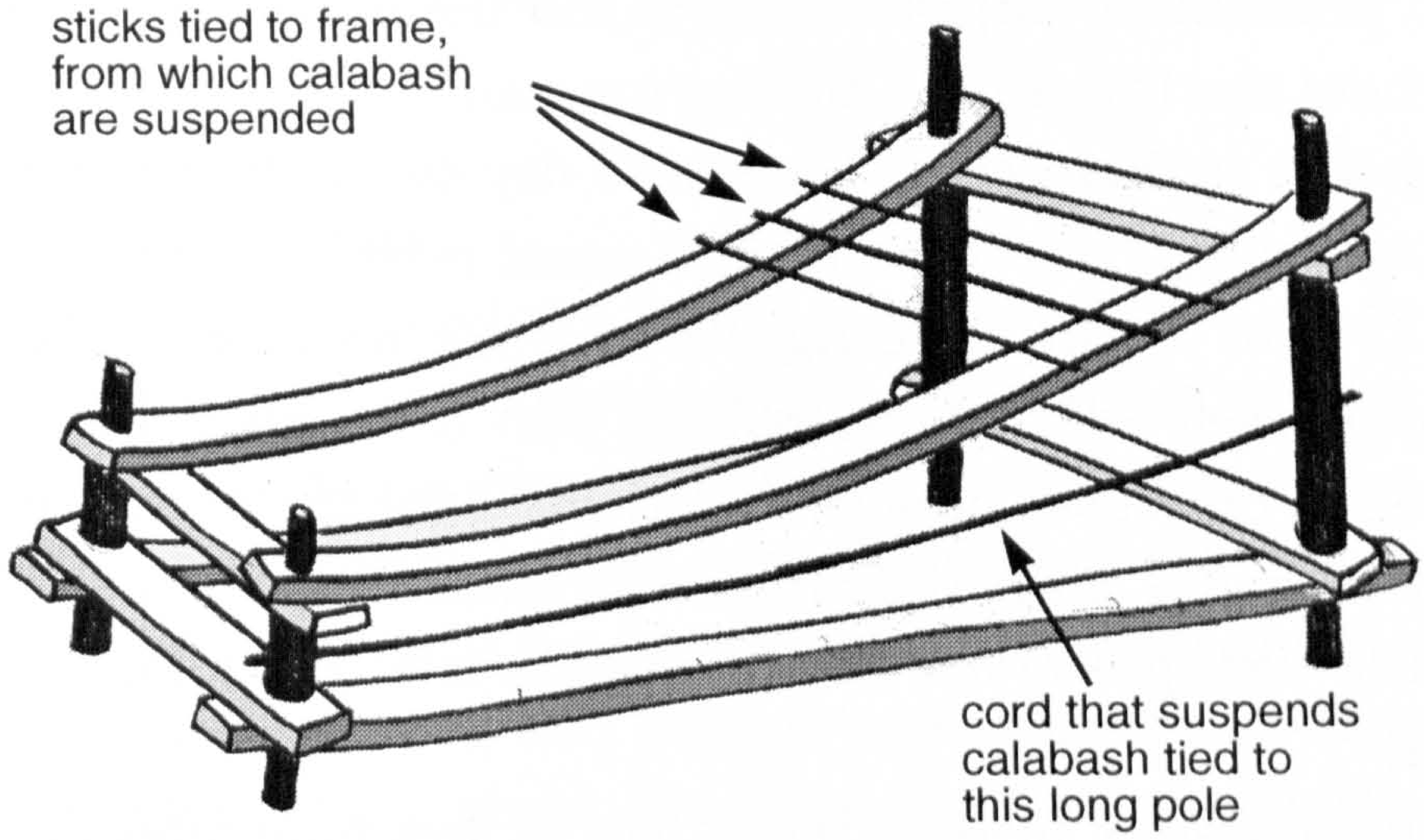


Fig. 109.

The frame is then lashed together with wet rawhide (cow or some equally thick skin) in the following manner: a long strip of raw hide is tied to the centre of the vertical post, passed over the top rail, and then under the bottom rail on both sides of the post, so that the rawhide pulls the frame together (see fig. 110).

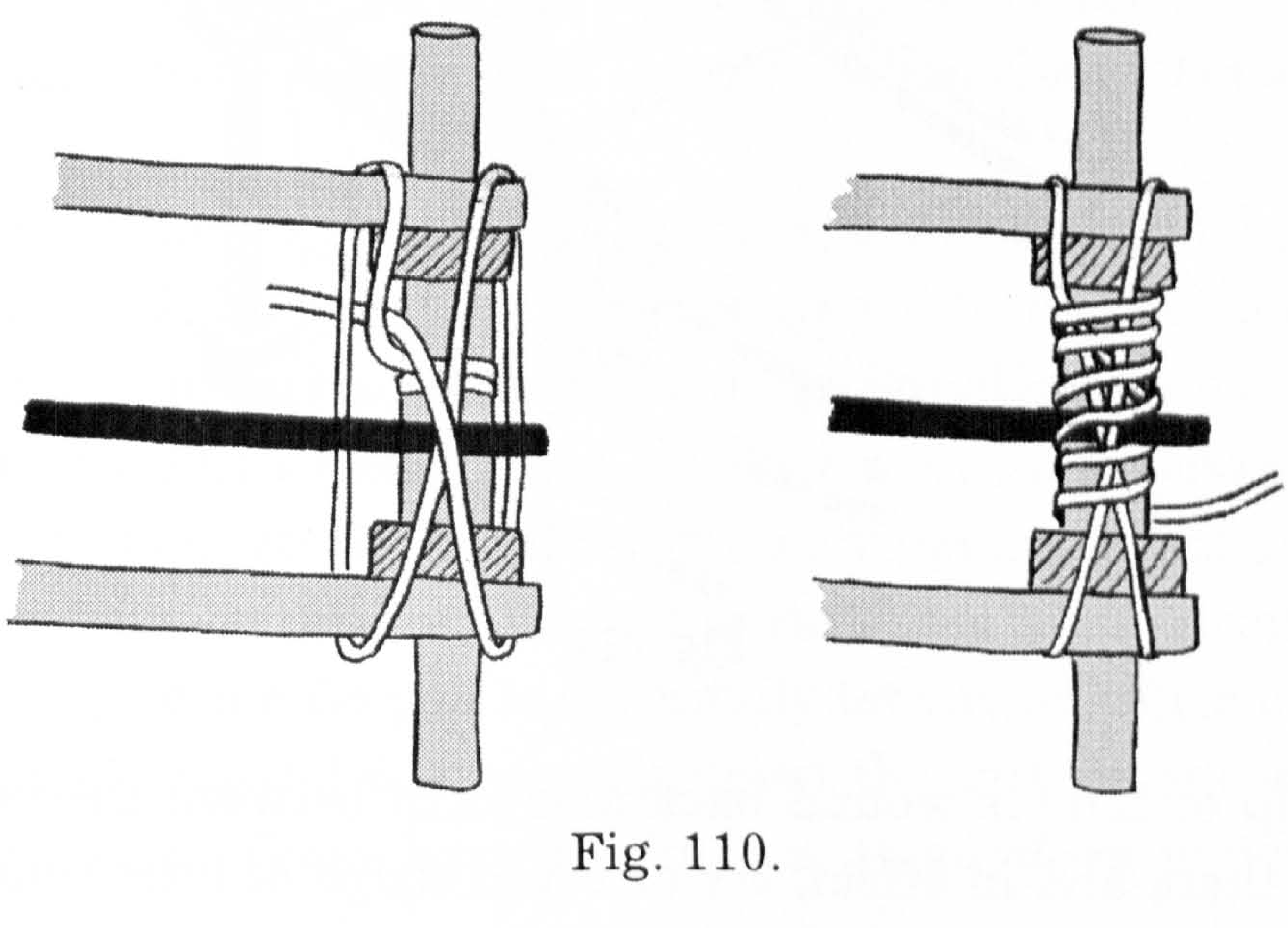


Fig. 110.

The rest of the hide is wound round the upright from bottom to top so that the vertical ligatures are squeezed towards the post, thus increasing their tension and pulling all the joints together. During the lashing together of the frame the two long sticks which the calabash will be tied to must be lashed to the uprights. To maintain the curvature of the top rails they are lashed with rawhide to the bottom rails at the middle of the frame. The round bottom rails are much stouter than the thinned top rails, and it is possible to adjust and equalise the curvature of the two upper rails without the lower rails moving too much.

The frame is then left in the sun to dry out so that the hide contracts, further tightening the structure. The usual reason for an instrument being spoiled is due to the hide ligatures working loose. The lashing can therefore be seen as the most critical part of making the frame. For this reason Baaru only uses fully seasoned wood for the frame; wet timber will in time shrink and cause the rawhide to come loose. It is also important to use fresh or well preserved rawhide which is of good quality and uniform thickness.

The next step is to tie a long strip of wet hide laterally between the tops of the uprights that will form a cushioned support for the keys and prevent any extraneous noise being produced by the keys hitting the bare wood of the frame.

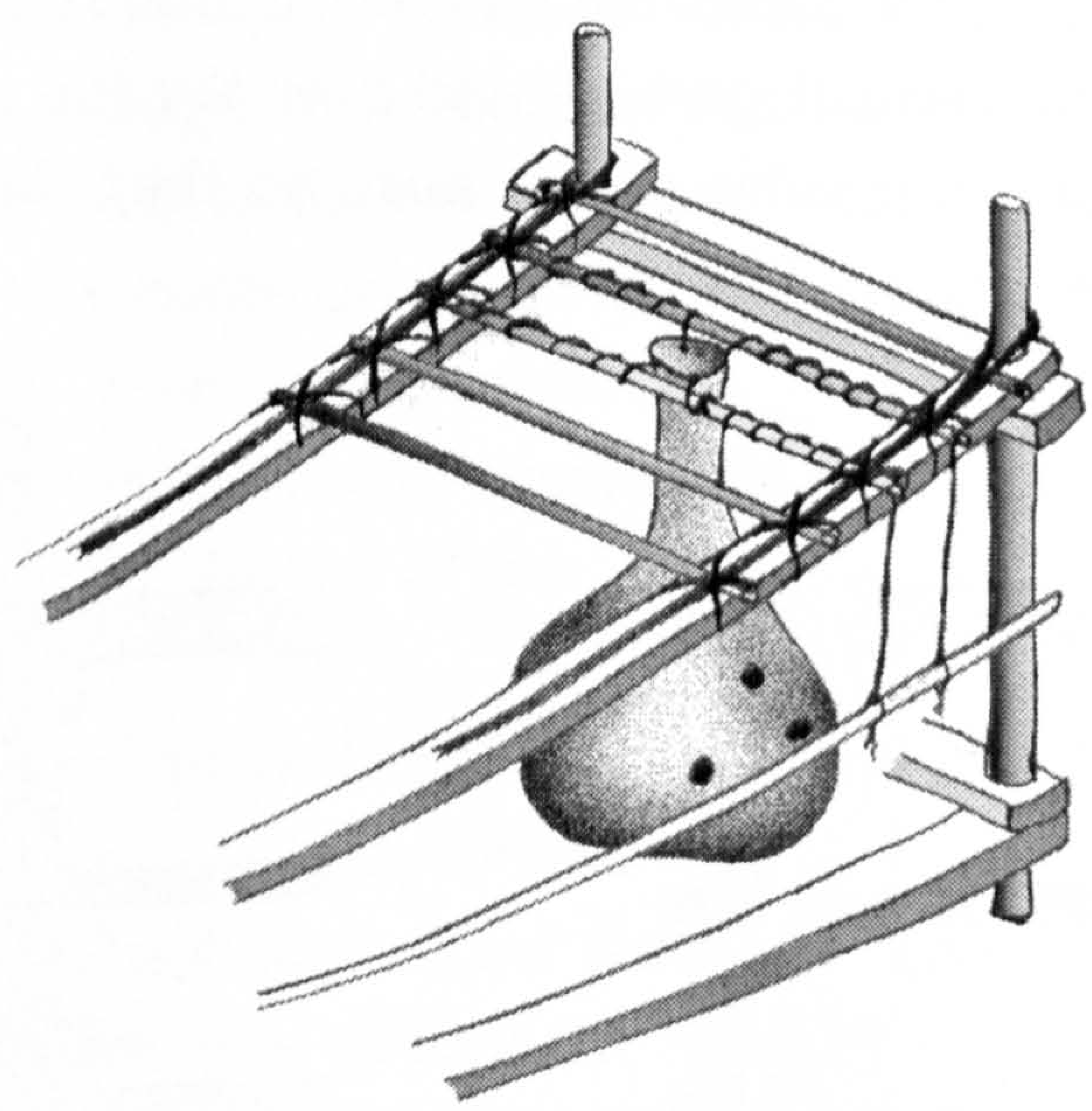


Fig 111.

The strip of hide is wound back and forth between the two pairs of uprights so there are, in effect, six or seven strips of hide running above each top rail. The slack is taken up between these thongs so that they are not resting on the rails and then another strip of wet hide is wound loosely around all the six lateral lengths to make one thick support.

The thin sticks, which the calabash are suspended from, are tied into position across the two support rails. These sticks are passed between the support rails and the leather cushioning. They are positioned so that they will lie directly between each bar once the bars are in place. The cushioning is now tied to the rails, and the sticks to the support rails as shown in figure 111.

Shaping and tuning the bars

The smoked slabs of wood are tested to ensure that they don't buzz; small splits often account for extraneous noise and any like this are replaced. At this stage the bars are only roughly shaped; they are cut to length and the correct width with an adze using the reference instrument as a model. The top surfaces of the bars are made smooth and flat with an adze. This is a time-consuming and tedious task since the wood is liable to tear due to the interlocking grain. Thin shavings are removed by cutting diagonally across the grain with the adze very sharp. The top surfaces of the bars are then scraped with a knife to produce a very smooth finish.

All the bars are then roughly tuned by reducing the thickness without, at this stage, carving an arch. The new bars are laid across two rolled up mats when tuning. The lowest pitched bar is tuned first, cutting an arch on the underside between the nodes (lowering the pitch), while checking it against the reference instrument. When the bar is close to the desired pitch, the fine tuning is done by removing timber closer to the nodes (the change in pitch by removing mass is lessened the closer this area is to the nodes).

The rest of the bars are tuned, working towards the highest. Intervals are checked and short musical phrases played to ensure the notes "mix well". Once all the bars have been tuned, ten minutes or so is spent playing the new instrument which is then checked with the referent instrument. The bars are then left for a week before stringing so that small rises in pitch that usually occur when the timber stabilises can be dealt with.

The tuning of the *Lo gyil* is essentially tetratonic, since bars 5 and 10 are not played, apart from running down the instrument where all the pitches are used. These bars are known as *gambira* which translates literally as 'jump over'. Although there is no standard tuning or pitch for the *Lo gyil*, most of the instruments found amongst the LoDagaba use the same interval structure with the starting pitch (lowest) usually not varying more than 100 cents. This appears to result from the fact that one instrument maker's clientele come from a wide geographic area so that different makers are aware of each others' instruments and a norm is established or maintained. The nature of the LoDagaa craft of instrument making, its quite rigid adherence to custom and teaching, gives the impression that the xylophone culture in this region has changed little from the time of the original migration of the LoDagaa clans to their present location.

The LoDagaba have recently started playing the Birifor xylophone, *kogyil*, which the LoDagaba call *gu*. The *gu* has been absorbed into the culture, but with some difficulty; Baaru told me that his father (also a maker and player) tried to discourage the use of the Birifor xylophone because he feared the ensuing lack of interest in their own music/culture. This has not happened and Baaru's children play both types of instrument with equal enthusiasm and skill.

Table 3 gives the tuning of Baaru's *lo gyil.*

Table 3 Tuning of Baaru's *lo gyil.*

key	Hertz	cents (above C)	interval (cents)
1	79.2	332	
			242
2	91.2	574	
			115
3	97.4	689	
			323
4	117.4	1012	
			316
5	140.9	128	
			194
6	157.6	322	
			258
7	182.9	580	
			141
8	198.3	721	
			279
9	233.1	1000	
			345
10	284.5	145	
			190
11	317.5	335	
			233
12	363.2	568	
			118
13	388.8	686	
			299
14	462.1	985	

It should be noted that bars 5 and 10 are regarded as 'bad' and therefore the scale has only four intervals. Thus the following series of intervals (in cents) is arrived at (the intervals between notes 4 and 6, and 9 and 10 are shown in bold) starting from the lowest pitch:

242, 115, 323, **510**, 258, 141, 279, **535**, 233, 118, 299.

After final tuning, the bars are strung together with hide. The ideal material is buck or small antelope skin. Baaru normally tries to buy the hides direct from the hunters to ensure that they are fresh. As these animals are becoming increasingly harder to find domestic goat skin is sometimes used, but this is said to be less suitable since it tends to break rather easily. The edges of the hide are first cut off with a knife to produce an oval skin. This is then cut into one long, narrow strip by cutting a spiral, working from the outside to the centre.

The hair is removed by soaking the hide in water and then putting it in a black clay pot which is placed upside down in the sun for one day. This has the effect of loosening the hair which can then be easily removed. The hide, which is still in its raw state, must now be softened to prevent the lacing from buzzing and to make it flexible so that it may be pulled tight. The softening is achieved by soaking the lacing in shea butter and working it into the hide by passing the long strip back and forth between thumb and forefinger. The method of lacing is shown in the figure 112.

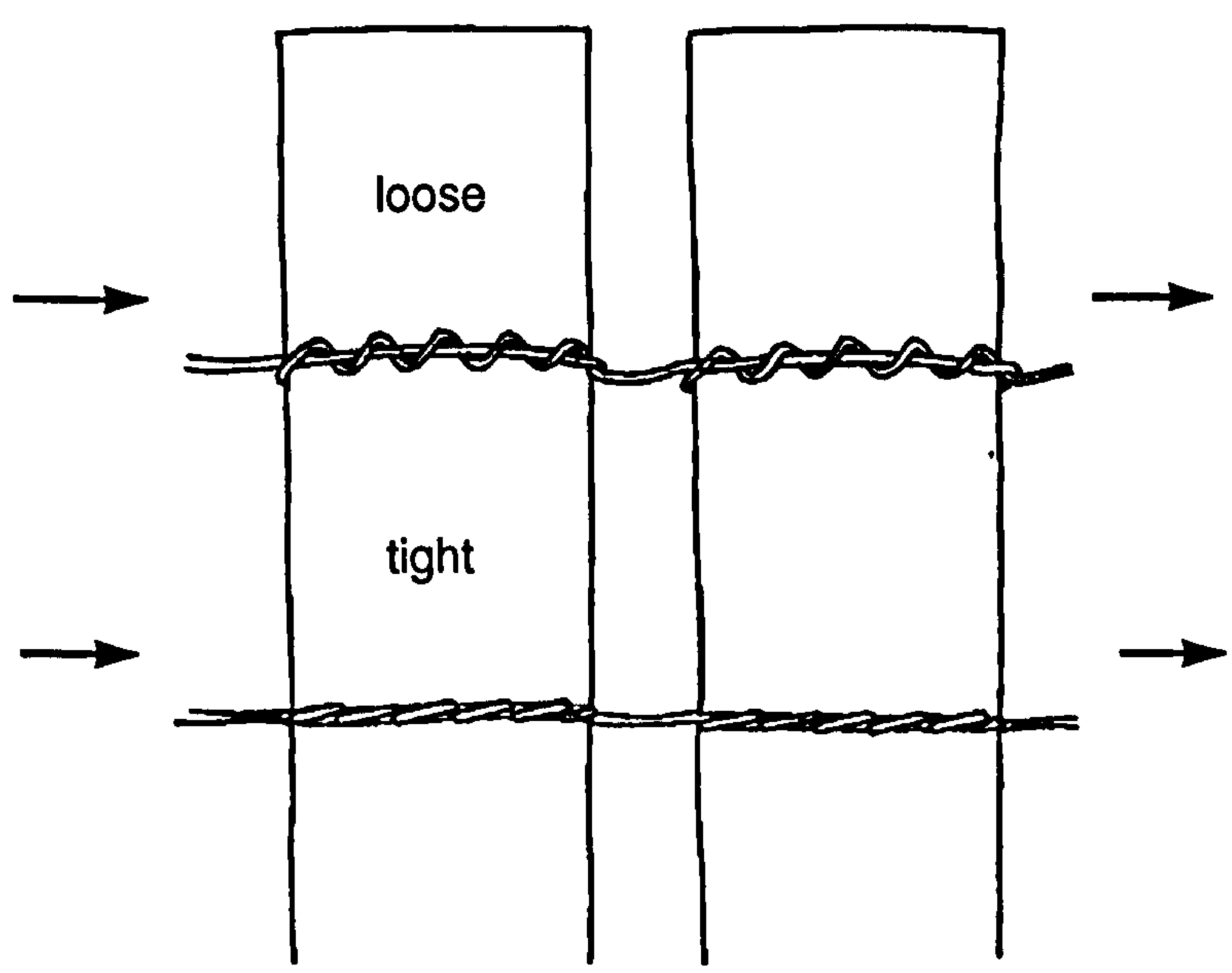


Fig. 112

Selecting and tuning of resonators.

Each bar of the *Lo gyil* has its own sympathetically tuned calabash (gourd) resonator. Calabash are the hard-skinned, melon-like fruit of several plant species belonging to the *cucurbitaceae* family. The variety commonly grown in Ghana is called *Lagenaria vulgaris* or 'bottle gourd'. They are used for food and drink containers, *pito* cups, spoons, and xylophone resonators. The calabash are annuals which are sown at the beginning of the rainy season. The fruits ripen between three and six months after planting. They require heavy rainfall during the early stages of growth and then high temperature and sunshine during and after harvesting. The white, seedy pulp is inedible. For household use, fresh green calabash are prepared by leaving in the sun until the contents dry and shrivel. They are then cut, cleaned and washed. The method of preparing calabash for use as xylophone resonators differs because they cannot be cut in half in order to scrape out the stubborn dried pulp. Instead, the fruit are prepared by cutting off the top and removing, as far as is possible, the seedy pulp. The calabash are then filled with water and left to soak for about a week by which time all the pulp has rotted and can be easily removed. They are then left out in the sun to dry and harden.

The large calabash are tested by hitting the gourd on the ground to hear the pitch. The smaller ones are held at their necks, close to the ear, and tapped on the bottom with a finger. It is also possible to blow across the mouth to hear the pitch and this method is used for the very small calabash where it is difficult to hear a tapped pitch.

The calabash are tuned by either cutting down the neck (or making the aperture larger) to raise the pitch, or by making the aperture smaller by applying a mixture of clay and dung around the opening to lower the pitch. It is easier to cut the neck down, so a calabash is chosen whose pitch is slightly flat of the bar. Bottle gourds with very narrow necks are avoided because of the reduced volume they produce (volume is related to the size of the aperture; the smaller the aperture, the lower the volume).

Once all the calabash are tuned, three holes are burnt on one face of the large gourds and normally just two on the five smallest calabash. On Baaru's instruments these holes vary in size from 25mm on the largest calabash, to about 16mm on the smallest . A thin membrane is stuck over each hole with tree gum to produce the mirliton or buzzer. This sound, which is characteristic of the majority of African xylophones, is produced when the air inside the resonator is excited forcing the membrane to vibrate. The usual material used for the membranes are spiders egg casings; these are collected from the walls and ceilings of the insides of buildings. The material used for the membranes varies throughout Africa; the more common ones include bat wing, peritoneum of cattle, diaphragms of small rodents or lizards, pig stomachs etc. The choice of material is not guided by availability only, but rather by the tone characteristic of the membrane; the very thin animal diaphragms used on xylophones in central Africa produce a looser sounding buzz, whereas the thicker spiders' egg sacs used in Ghana give a more mellow sound. The tone of the instrument is also dependent on the size of the mirliton. In Lawra and the surrounding area the mirlitons are unusually large, producing a metallic, almost electric powerfulness to the sound. In the area north of Lawra, around Nandom, a less harsh sound is preferred, achieved by making smaller mirlitons.

Four small holes are burnt into the top of the neck of the calabash by which they are tied to the support-sticks. Due to the size of the calabash they are arranged in a staggered fashion so as to fit into the frame. The calabash are positioned in the frame with the mirlitons facing out so that they can be easily repaired.

The laced bars can now be laid on the frame and stretched between the four upright posts. The instrument is then played and the sound of each bar checked. At this stage it is sometimes necessary to fine tune some of the calabash so as to achieve an equal response for every bar.

Making the beaters

The beaters used on the LoDagaba *Lo gyil* are unusually large and heavy. They normally measure 30cm long, with a diameter of about 25mm, and a hefty 35mm ball of latex. The extra weight of these beaters enables the musician to play with more power during large ceremonies. The combined effect of the heavy beaters and the very large diameter mirlitons makes the *Lo gyil* one of the most powerful xylophones in Africa. The latex head is intentionally made relatively soft so that it will easily excite the fundamental even in the lowest pitched bars. The tone of the *Lo gyil* relies heavily on the use of the correct type of beater; try the small, hard beaters used on the *bala* in Mali and the lowest four notes of the *Lo gyil* will hardly sound. A slightly softer beater is normally used in the left hand to play the low pitches.

The rubber vine (*landolphia owariensis*) is very scarce in northern Ghana. Its normal habitat is dense forest, and since most of northern Ghana is covered in scrub and sparse forest it has little opportunity to flourish.

Moreover, those few pockets of dense vegetation that contain the vine are normally claimed by a local family who 'farm' it, selling it wound on sticks at the weekly markets in the area. As such it is a valuable commodity in northern Ghana and latex beaters are sometimes reserved only for use during performance. The more readily available rubber beaters made from tractor or lorry tyres are normally given to children to use.

This scarcity of the latex has meant the local people have learnt how to harvest it, store and then make it reworkable by a process of boiling it in water. In Central African Republic where the rubber vine grows abundantly in the dense forests, instrument makers first make the sticks and take them into the forest. The bark of the vine is cut and left for half an hour until the latex seeps out and coagulates. The beater sticks are then rolled directly onto the vine and the coagulated latex to form a rough ball. This method, although uncomplicated and quick, does have the disadvantages that small pieces of bark and wood get mixed up in the latex, and that it is almost impossible to make even, well-shaped beaters.

In Ghana the latex sold in the markets is wound on 45cm sticks to a thickness of about 3mm. The rubber is cut off the stick in one long spiral. At this stage the rubber will break if stretched and is consequently unusable in this state. To make it soft and malleable it is boiled in water for five minutes, after which time it is easily stretched enabling the small pieces of wood and bark to be picked out. It is then neatly wound onto the beater stick. The tighter the latex is wound onto the stick, the harder the beater.

From maker to buyer

In recent years Baaru has started making xylophones for 'export' to the capital, Accra. From here a few are bought by tourists, but the majority are bought by LoDagaa living away from home in the south. These instruments are made in batches of up to five during the dry season when there is little farm work to be done. Following an order for these 'export' instruments Baaru still adheres to the traditions of sacrificing a hen before starting work, and all the ensuing pacification rites performed during the making process. The traditional method of handing over the instrument to the buyer is, however, simplified. Baaru 'sweeps' the bars of the xylophones with a guinea fowl, and then sacrifices it.

This 'sweeping' is believed to cleanse the instrument and prevent evil spirits re-entering the timber. Payment for these xylophones is purely in monetary terms as opposed to the traditional bartering system, supplemented with a small sum of cash. During 1991 Baaru was selling at the following prices:

Lo gyil 2000 cedis,

gu 1600 cedis,

Small tourist xylophone 700 cedis, (£1 = 100 cedis).

The traditional method of handing over a *Lo gyil* to be used as a funeral instrument in the region is much more involved. On completion, the xylophone is cleansed as described above with the guinea fowl that was handed over when the instrument was ordered. The bird is then sacrificed and some feathers are stuck with its blood onto the bottom of the largest calabash. Further feathers are stuck onto the calabash of bars 3 and 4. Bars 1, 3, and 4 are singled out by Baaru in this way because they are believed to be important. Bar 1, known as *kokpee* (father) has the most powerful voice and is said to look over all the others. Bar 3, *kaadoa* (male guinea fowl) and bar 4, *kyiera* (major bar) are regarded as musically very important, playing most of the key phrases during the funeral ceremony. Having pacified the gods and spirits in this way, a further ceremony takes place on the road halfway between the maker's and buyer's homes. The buyer provides a large pot of the locally brewed millet beer (*pito*), together with food for a feast for between six to ten people.

Prayers are made to the gods for the protection of the new owner from the *Lo gyil*. A white chicken is then offered and its neck broken, leaving it to wander until it drops. If the bird dies facing the sky it is believed the instrument is not fully purified and the fowl must be discarded and definitely not be eaten. Another chicken is offered with further prayers. Before the instrument is played the musician, who may or may not be the new owner, eats some *teezed* (the local staple diet, maize flour meal) from the underside of an old xylophone bar.

The xylophone can now be played and the feast begins, which carries on through the evening. The following morning the buyer gives the money and all the agreed farm produce (millet, corn etc.) over to the maker. The maker will then sell any produce surplus to his own requirements. It used to be common to pay in part for the *Lo gyil* with livestock (sheep), but this practice is now fairly rare. The handing over and purification ceremonies follow the tradition taught to Baaru by his father and grandfather. Different makers and clans follow similar ceremonies differing slightly in detail but aimed toward the same end, that of appeasing the gods and spirits.

Bobri follows a slightly different ceremony. The buyer brings ears of millet and corn, along with a large pot of millet beer to a meeting place halfway between his, and the maker's homes. The xylophone is then carried by the group assembled to the home of the buyer who has prepared a feast. The buyer gives the maker 150 cowrie shells, which the maker puts into the largest calabash of the xylophone. The instrument is turned upside-down, and a circle of ash is made around the instrument. Some millet flour is then taken, mixed with water and thrown over the xylophone. A guinea fowl and a hen are then used to sweep the instrument clean, during which time prayers are made to pacify the gods and protect anyone who may play the instrument. The birds are then both killed and feathers stuck with the blood onto the calabash of bars 1, 3, 6, 8, 11, & 13. It was explained to me that the reason behind making the circle of ash was to contain any 'bad' spirits within the instrument, and then to purify these by throwing the flour and water over the instrument and then sweeping it with the birds. This process is used to purify the whole instrument, but Bobri identified certain bars that had the potential to hold, or attract harmful spirits more so than others. With these he felt it necessary to attach the feathers to ward off any evil.

It is interesting to note that the bars singled out for extra purification/protection differ between the two makers studied here. The names they give to the bars also differ slightly as shown in table 4.

A few notes on the translation are necessary; 'big knee' is a literal translation, an alternative would be 'spoilt knee' indicating damage through injury or disease. Baaru referred to octaves as 'answer to ...', whereas Bobri to referred to octaves as 'small ....'. This is quite logical since the LoDagaa think of pitch in terms of size, ie. big and small, corresponding to the western low and high. Bar 4, *kyiera*, was translated during the interview with Baaru as the major bar and its octave as minor (ie. small major). However, Bobri thought of this as 'caller'.

Table 4 Note names, Baaru and Bobri

Bar (1 = low)	Baaru		Bobri	
1	*Koppee*	Father	*Gyilzu*	Head
2	*Nyuu*	Neck	*Nyuu*	Neck
3	*Kaadoa*	Male guinea fowl	*Kaadoa*	Male g' fowl
4	*Kyiera*	Major bar	*Kyiera*	Caller
5	*Gambira*	Jump over	*Gambira*	Jump over
6	*Sogra*	Answer to 1	*Dunkpulankpu*	Big knee
7	*Kongbebir*	Leppers toe	*Kongbebir*	Leppers toe
8	*Dunkpulankpu*	Big knee	*Kaadale*	Small g' fowl
9	*Kyierle*	Minor bar	*Kyiele*	Small caller
10	*Gambile*	Minor jump over	*Gambile*	Small j' over
11	*Sogle*	Ans. to 1 & 6	*Dunkpulankpule*	Small b' knee
12	*Kongbebile*	Ans. to 7	*Kongbebile*	Small l' toe
13	*Dunkpulankpule*	Ans. to 8	*Kaadale*	Small g' fowl
14	*Kpikpiyoro*	Last one	*Kyiele*	Small caller

If we look again at the 'dangerous' bars as identified by Baaru; 1, 3, & 4, and those identified by Bobri; 1, 3, 6, 8, 11, & 13 (ie. bars 1 and 3 and their octaves) it appears that bar 4, as singled out by Baaru, is the only one where they differ. The reasons behind this discrepancy appear to be bound up in individual clan teachings.

The Spiritual Dimension.

Traditionally, LoDagaa xylophones were surrounded by mysticism and ceremony. Today, many of the pagan beliefs are dying out as the church gains popularity. However there are still many LoDagaba, especially around Lawra, who hold traditional beliefs and continue their funeral observations in the age old way. It does appear that idol worshipping is less common but the belief in the existence of spirits or 'fairies', both good and bad, is widely held. Few people claim to have seen spirits, most people who have experienced them explain it as feeling a presence around them.

Baaru told me the following story concerning the origins of the *Lo gyil*: "A hunter, whilst out in the bush, came across a clearing with a group of 'fairies' attending a funeral. At the funeral the hunter was enchanted by the beautiful sound of an instrument he had never heard before, and though in great fear of being found in his hiding place, he stayed so he could hear more. After listening for a long time the hunter tried to creep away but was heard by the 'fairies' who chased and caught him. He was kept by them for three years during which time he was taught how to make and play the *Lo gyil*. When the hunter came back to his village with the xylophone no one would believe his story until he started playing the music he had learnt and enchanted all the villagers, like he himself had been". This is a very well known story around Lawra; I also heard it from Bobri and others during discussions with musicians in Lawra.

Today it appears that the only spiritual protection attached to xylophones are the feathers of the guinea fowl which is sacrificed upon completion of the instrument. Older instruments often have effigies or charms attached as well as the feathers. Baaru has a *Lo gyil* made by his father over fifty years ago. This instrument has an unusually powerful voice which Baaru puts down not only to its quality, but also the spiritual strength offered by the charms attached to it. These charms consist of a bronze figure tied to the frame near the lowest bar representing a 'fairy' (see fig. 113), a bush animal horn tied underneath the bars (see fig. 113), a piece of fur from a bush animal stuck onto the calabash of bar 1, and a number of cowrie shells sewn onto the calabash of bar 3. In addition to these there is a secret charm inside the calabash of bar 4, the nature of which was not disclosed to me. The practice of inserting secret charms into the LoDagaa funeral drum, *kuor*, is quite common. The *kuor* is a single-headed drum made from a large calabash.

The skin, traditionally monitor lizard, but more commonly goat or antelope, is glued and nailed onto the calabash. It was suggested to Strumpf[32] that the contents were stones from a crocodile's stomach. For each year of its life the crocodile swallows a stone, and these stones are believed by the LoDagaa to give the drum "more sound" and protect it from breaking. Strumpf [33] further noted:

> The monitor lizard skin is very strong, yet there is great fear that if it should break while being played at a funeral, great danger may come to the player. If the *kuor* skin breaks, the player must quickly collect that which is inside the gourd, turn the gourd upside down, quietly leave the funeral area and try to secure a 'medicine' prepared by the maker of the *kuor*, that the player must eat to be protected. The objects retrieved from the inside of the broken drum are returned to the *kuor* maker and another *kuor* will replace the broken one in order to continue its part in the funeral.

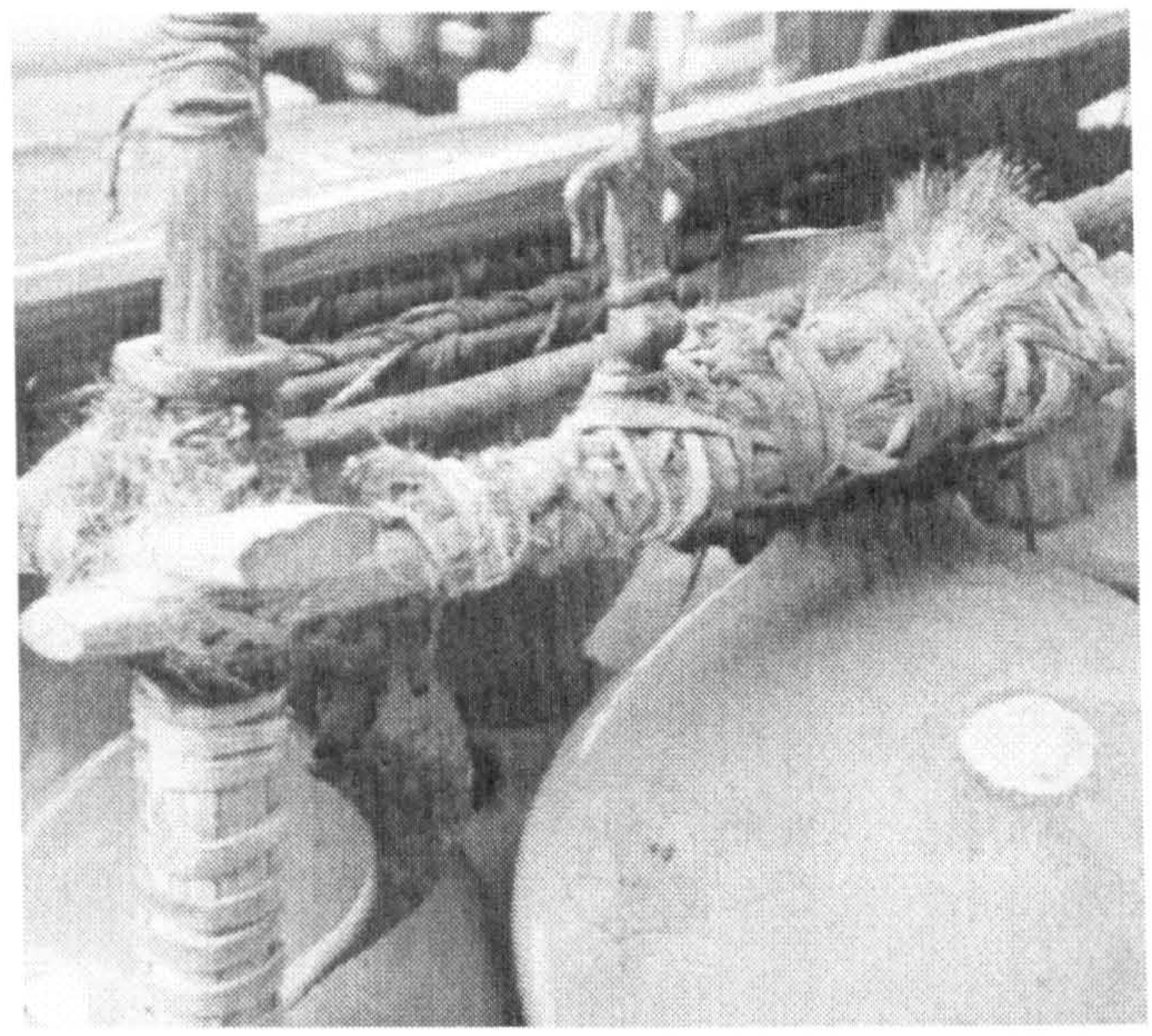


Fig. 113 Spiritual protection on Baaru's *Lo gyil*, note the bronze figure on the end of the instrument and the horn tied underneath the bars.

No additional protection is given to the *Lo gyil* before it is played at a funeral, but the musician often seeks protection himself. This is not generally from spirits, but from other jealous, competing musicians at the funeral who may cast spells on the players in order to steal their skill as a xylophonist. A good player is recognised by the left hand; an average player will use maybe three notes in the left hand to play a piece, where a skilled musician will fill in using the whole instrument. It is therefore the left hand that requires protection, which is gained by eating a medicine (sometimes from the underside of an old xylophone bar) using the left hand, something never usually done.

Once the funeral has finished (usually three days, although funerals are generally shorter in the busy farming season) the pair of xylophones are returned to the owner, along with a cock for payment. Before the instruments are put away the owner will ceremoniously 'sweep' them with the cock to cleanse them. If the cock survives this ordeal (I'm told it normally does!) the owner may keep the bird, otherwise it must be thrown away.

There is a great respect shown towards the *Lo gyil* and if certain taboos regarding it are broken it is believed the negligent person is in great danger. These taboos include:

a) no food is to be passed over the *Lo gyil*,

b) no one is to step over the *Lo gyil*,

c) nothing is allowed to rest on the bars.

A household possessing xylophones will often acquire a specific 'medicine' to protect the family should one of these taboos be inadvertently broken. The *gyil* is always stored leaning against a wall with the smallest bar resting on the ground so as to prevent children breaking the taboo.

Should a xylophone need the bars removing to carry out repairs, then the instrument must be purified again by sacrificing a hen.

The Learning Process

The professional musician does not exist in LoDagaa society. Unlike the hereditary caste of musicians in Mali, known as *jali*, who make music a professional occupation, the LoDagaa musician is foremost a farmer. Although the accomplished *gyil* player is a well respected member of society, there is no structure within the society that allows him to earn a living purely from music making. Although an older member of a LoDagaa family often passes down musical skills to his relations, there is no formal restriction of family, caste, or clan on anyone learning the *Lo gyil* as in Mali.

The LoDagaa believe that all accomplished xylophone players were born with a degree of ability. It is believed that a baby born with clenched fists (resembling the manner in which the beaters are held) is destined to be a fine xylophone player. This is looked for in a family of xylophone makers/players and the child is given attention towards this end by introducing the child at a young age to the instrument. Baaru told me he was born with fists clenched in this way and started learning at the age of four or five years. This learning is usually quite passive in nature; the father sits on a stool in front of the instrument and plays with the child standing between his legs just watching and listening. It is then left up to the child to show interest. The high incidence of blind xylophone players in the region is believed by the LoDagaa to be caused by parents forcing the baby to unclench its fists at birth.

Most players say they learnt from watching the hands of another player. If a learner does not show promise relatively early on, he is simply left alone, uncorrected and unsupported. If it is believed that the child is gifted his father and elder brothers/uncles will spend time with him after returning from the day's work. By the age of eleven or twelve the student may perform at his first funeral. He will normally wait until late on in the evening, after many of the guests have left. During this first performance the child's father will stay at his side to protect him. The first money earnt at a funeral by the child is usually taken by the parents to provide medicine to guard against evil.

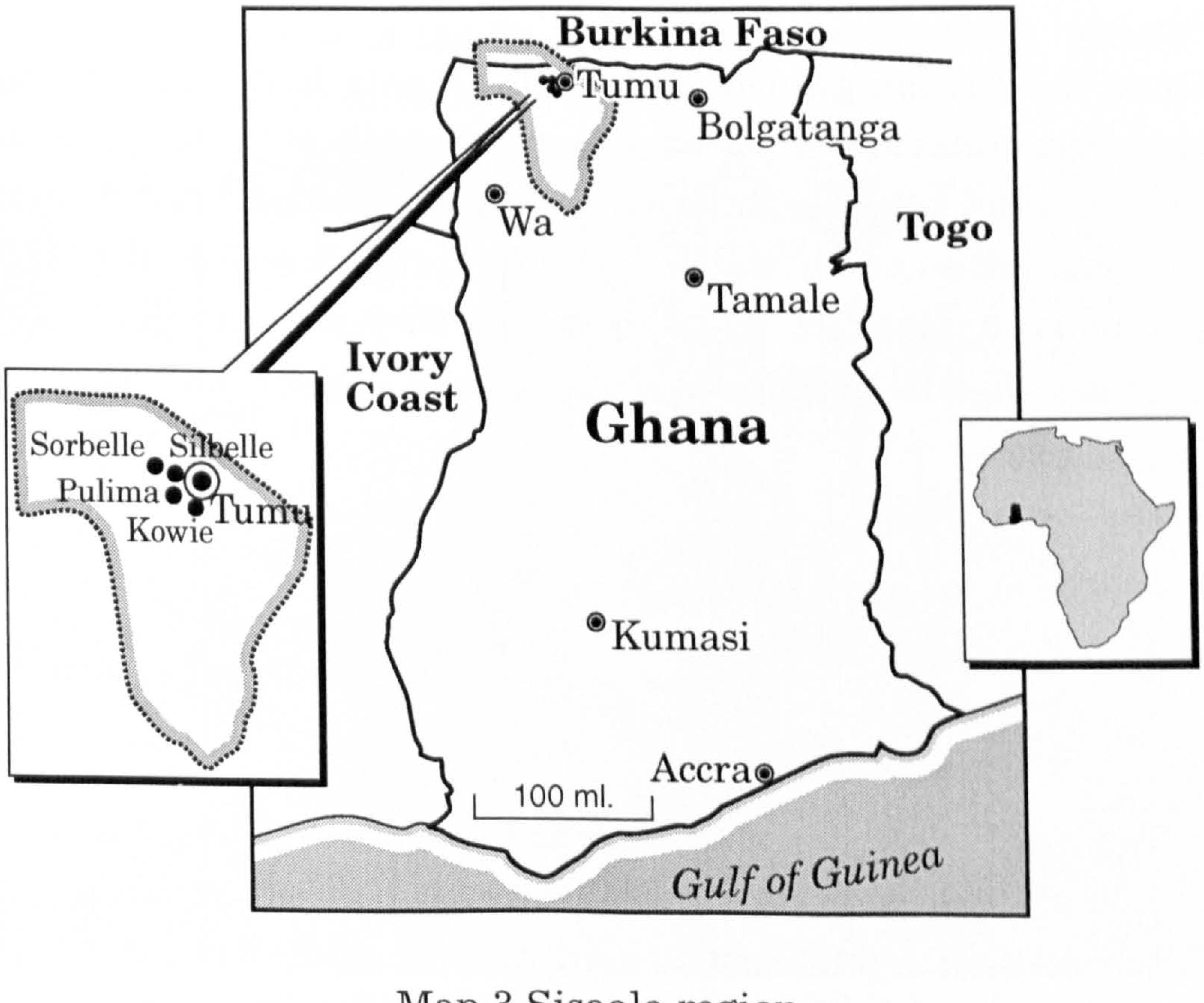
A child who shows interest and ability but who does not come from a family of xylophone players, may be encouraged to spend time at the home of a xylophonist. Children will also construct their own 'trench' xylophone using an old set of bars resting on bundles of grass over a trench dug in the ground.

A xylophone maker will normally learn his skills by watching and helping his father. Xylophone making almost always runs through the family generation by generation.

SISAALA XYLOPHONES

Historic and geographic background

The Sisaala live primarily in the Tumu district with a small pocket extending north into Burkina Faso. The region is bound on the north and east by the Sisili river and on the west by the Kulpawn river (see map 3, Sisaala region).



Map 3 Sisaala region.

Mendonsa [34] notes that the environment in this region is very harsh, such that it "deterred habitation until perhaps the seventeenth century". The harshness that Mendonsa talks of is not only the dry, hot climate and poor soil, but also the prevalence of river blindness in the area. From the middle ages the Sisaala region lay between major trading states of the Mossi and Dagomba. However, the Sisaala were little affected by this since "traders would have avoided the unhealthy conditions there".[35]

Before the colonial era the Sisaala lived in scattered independent villages, linked only by loose ties of clanship and marriage. As a result of this they were easy prey to the highly organised slavers and were almost continually raided. Mendonsa [36] quotes a report by Lt. H.J.C. Leland, written after first passing through the Sisaala region in 1898:

> The inhabitants are as a whole very industrious and were very friendly to me, but owing to constant wars, first of all with Babatu [a slaver] and latterly with the French, they are at present in a very unsettled state; most of their towns and villages are in a very dilapidated and broken down condition, and they are showing no signs of building them up again. I did not pass through a single village that did not show signs of having been pillaged. There are hardly any cattle or sheep left in the country, and nearly all of the horses have been taken by Amahria [a slaver].

Once the British gained control of Sisaala land they attempted to impose a hierarchical system of area chiefs with one overall leader. This was unsuccessful because the colonial administrators did not understand the structure of the Sisaala pagan society. Instead of making the indigenous ritual leaders the area chiefs, they sought people of wealth who fitted in with the European idea of power and leadership. Mendonsa[37] writes:

> Often the *tinteen-tiing* (ritual leader) of an area was suspicious of this new powerful influence and did not come forth to claim legitimate leadership of his people. Sometimes he sent a messenger to deal with the British, who promptly made the messenger a chief.

At first, the British imposed system created two power bases, with the Sisaala people still following their traditional rulers, regarding the new chiefs as political upstarts who had no real authority over them. The British persevered with this unpopular system and by the 1930s their chiefs had become more accepted by the Sisaala.

Today the Ghanaian government still supports the system of chiefship set up by the British but not every village has a chief and even when they do, matters of social deviance are always dealt with by the spiritual leader. Chiefs deal with government matters such as taxes. Mendonsa [38] notes that "Chiefship seems to be dying out now, especially at village level".

SISAALA XYLOPHONES

The field work was carried out in the villages of Kowie, Pulima, Silbelle, and Sorbelle around the town of Tumu in the Upper West Region of Ghana (see map 3). All of these villages still retain the traditional Sisaala culture, unlike many villages in the area which have converted to Islam. Invaluable help was given during my stay by Charles Deri Dikpe, the local government representative for the arts, and Alfred Gomina from the village of Pulima, himself a xylophone player, who translated during interviews.

The *jengsi* is an unusually large instrument with seventeen bars normally measuring at least six feet in length (see fig. 114). The main features that distinguish the *jengsi* from LoDagaa xylophones are its size, tuning, sharp curvature of the bars, and the woven basket "shield" that protects the large calabashes at the bass end.

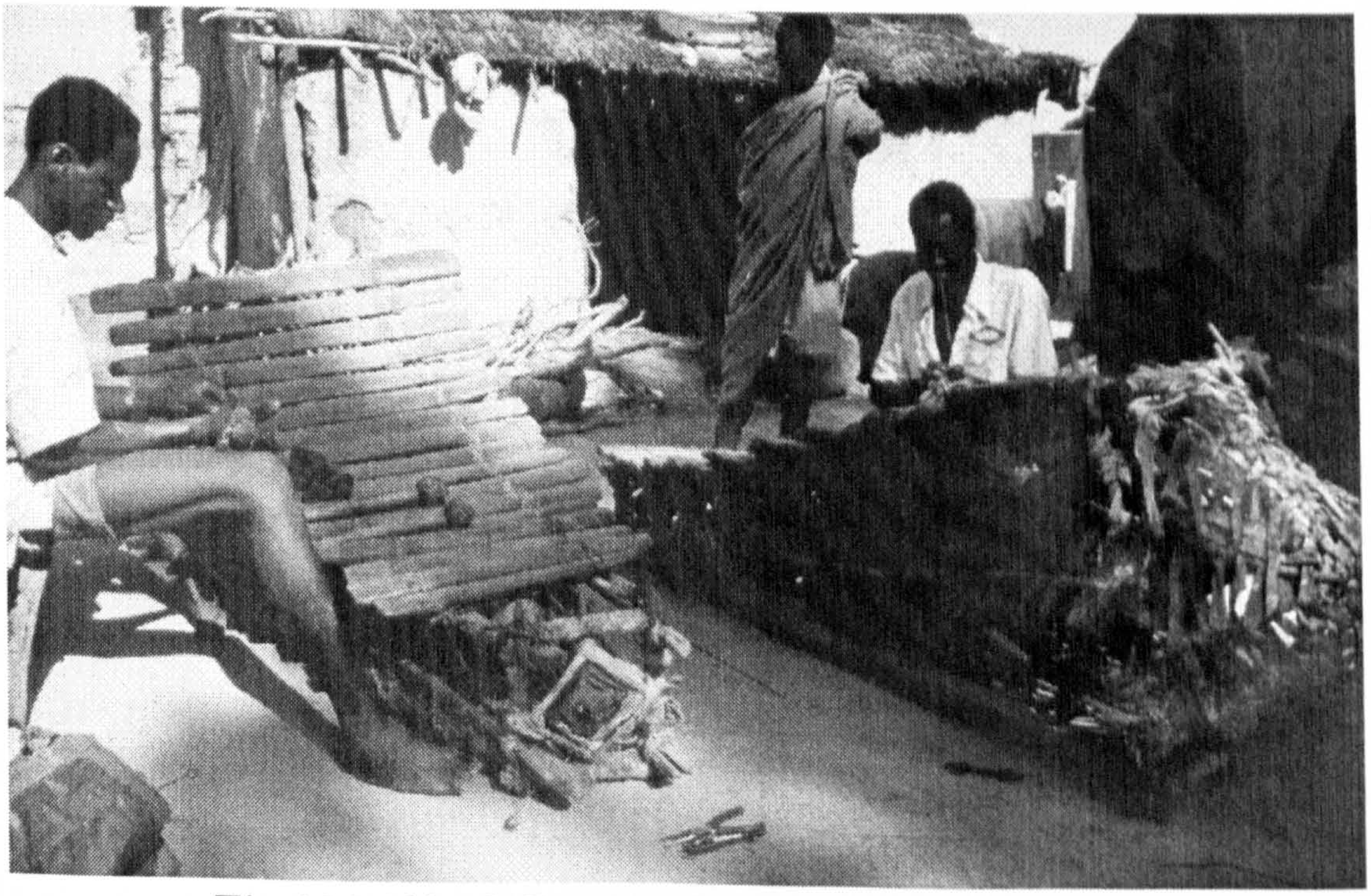


Fig.114 Alfred Gomina (right) with his brother.

As with the LoDagaa people , the Sisaala *jengsi's* most important function is to accompany the funeral ceremony. In Sisaala society only certain families can possess the *jengsi*; this being a privileged position handed down through generations of makers and musicians. All of the instruments in the above villages were in a very poor state of repair; most of the calabash resonators being either broken or the mirlitons having come unstuck leaving holes in the calabash thus rendering them useless as resonators. During the time of Mary Seavoy's research,[39] the most respected *jengsi* maker was Dingwia in Kowie. When I visited Kowie, Dingwia was very old, blind and partially deaf, so the interview was done with his sons and grandsons. Dingwia had made the last instrument in the village over ten years ago with the aid of his sons. Since then it appears that little repair work has been done. This lack of care and maintenance for the *jengsi* is the same in all the villages around Tumu. The reasons given by the local people for this situation were numerous and sometimes conflicting. Some informants said new instruments were no longer being made because the materials are now difficult to obtain and too costly. In Kowie it was said that they "had no right to make *jengsi* while Dingwia was still alive".

Since I found no evidence of any *jengsi* making having occurred within the last ten years the following account of the construction and the customs involved is taken from a number of discussions and interviews with local village elders, musicians, and instrument makers from the villages Kowie, Pulima, Silbelle, and Sorbelle (see appendix 2 for full list of contributors). The general details of construction of the *jengsi* and the *Lo gyil* are very similar, so more attention is given to those aspects that differ.

Construction

Jengsi are almost always bought on consignment, the buyer reserving the instrument by offering a hen and a small amount of money. Ownership of a *jengsi* is normally restricted to a family of musicians, but generally the instrument is regarded as being owned by the community, for the use of the community. This crucial difference from LoDagaa attitudes means that *jengsi* are not made by the Sisaala for commercial reasons, thus limiting the supply. However, some informants expressed the opinion that if an outsider comes to buy an instrument, the interest shown by making that enquiry is sufficient reason for the maker to agree the request.[40] In this case a monetary deal will be worked out, but this view is held only by a few. Batches of funeral *jengsi* are never made to take to market for sale as LoDagaa instrument makers tend to do in the dry season.

Instrument making is carried out during the dry season when there is no farm work to be done, however the gathering of materials (a lengthy process) may be started in the wet season. Once the maker has been given the hen he takes it to the room in the compound that contains the earth shrine; this room contains nothing else. Every visit to the shrine must be followed by a sacrifice. Whilst at the shrine the maker informs the spirits of his intention to make a *jengsi*, and then takes the hen to the bush to find a suitable '*teme*' or '*butuma*' tree (*erythrophleum suaveolens*) from which the bars will be made. Some makers sacrifice the hen in the bush,[41] while others perform the sacrifice at the shrine, believing they would then be "directed to a tree with good spirits, never bad."[42] Sisaala makers tend to believe that this is a general sacrifice to the 'farm' or bush, rather than specific to one tree.

Procuring and drying timber for the bars

The makers try to find dead trees in order to save time and effort on seasoning. Large, mature trees are required for the bars since the timber contains more dense heartwood than the smaller specimens. Finding such trees today is very difficult since the growing demand for firewood and building timber has considerably depleted the naturally sparse bush stock. This situation is claimed by many to be a reason for the decline in *jengsi* making in this area.[43] The Sisaala, like the LoDagaa, will only fell trees during the dry season when the tree (and the spirits) are dormant. Failure to adhere to this rule is believed to bring certain illness, or even death.

Some informants believed it necessary to perform an additional safety measure prior to felling the tree.[44] A straight line of medicine (*jengluri* - *luri*=medicine) is painted on the tree. This *jengluri* consists of various herbs mixed with ash to form a black paste. The next day the maker returns to the tree; if the *jengluri* has disappeared, or been 'absorbed' by the tree, it is believed to be unsafe to use.

A fire is made around the base of the tree and left burning until the tree falls; this can take up to four days. The log is then cut into sections according to the various bar lengths. These sections are then split along the length of the log with up to four wedges so as to prevent the interlocking grain splitting the log unevenly and wasting timber. The wood is roughly shaped into bars whilst in the bush. A few extra bars are cut in case some develop cracks during the smoking process.

Once back at the compound the timber needs to be dried or seasoned by a smoking process known as *chebe.* A hole is dug in the ground into which dry cow dung and 'medicine' (herbs) are put. The dung is lit and left smouldering whilst the roughly-shaped bars are placed over the hole. The fire is kept smouldering for between one and three days, the maker periodically checking and turning the bars to prevent them catching light. All the makers claimed the reasons behind the smoking were two-fold; both to dry the timber and to drive out the bad spirits, enabling the wood to "sound sweet".

Frame construction

During the smoking process the maker begins to construct the frame. The basic structure of the *jengsi* frame is similar to the *Lo gyil*; the *jengsi* being larger, with a more pronounced slope for the bars, and the addition of the characteristic basket shield (*jeng-chiking*), see figure 114.

The distinctive pronounced curvature of the frame allows the player to reach the bass end of the long instrument. The musician does not sit in the middle of the instrument, but slightly to the lower (high-pitched) end so that the first six bars lie comfortably under his right hand. These bars lie roughly parallel to the ground, and the bars start to slope at around the seventh one so that the largest bar is 70cm or more off the ground, facilitating the positioning of the large calabash at the high (bass) end.

The frame is usually made from the *lim* tree (*diospyros mespiliformis*) or the *vege* tree (*mitragnya cuermis*); both these timbers being close-grained whitewood of low to medium density with good bending characteristics. The most striking characteristic of the *jengsi* is its truly massive size (see fig.115). Pitch ranges of *jengsi* vary, but generally only by one tone (200 cents). Typically the range lies between B 2 (61.7 Hertz) and D 5 (587.3 Hertz). Consequently the sizes of the low-pitched bars and calabash resonators are very large and require a frame of equal stature to suit. The *jengsi* measured in Pulima had the lowest-pitched bar measuring 95 cm by 10 cm, and a corresponding calabash 66 cm in height and 46 cm diameter.

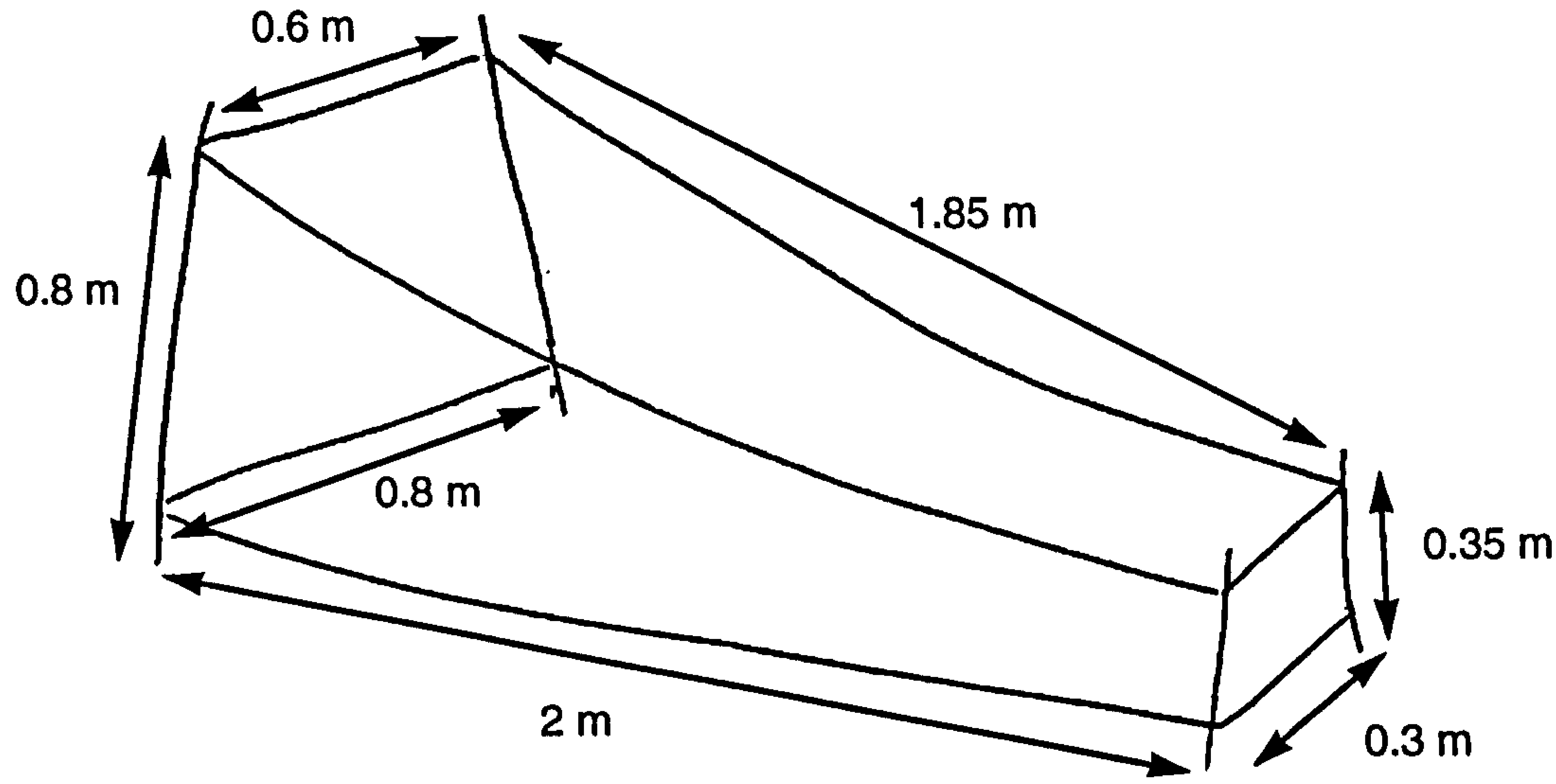


Fig. 115 Frame dimensions.

The process of making the frame is so similar to that of the *Lo gyil* that it is not described here. After completing the wooden framework the basket shield (*jeng-chiking*) is made. This *jeng-chiking* protects the large calabash from damage. Makers also suggested that without it the instrument would lack beauty. The shield is made in the fashion of a spider's web, by bending slender branches of the *cheeng* tree to form the domed radii of the web. Starting with a button in the centre, rawhide strips are woven in and out of the ribs to form a densely-sewn spiral dome. Once dried out this shield work is very strong. At the other end of the frame rawhide is woven in the form of a diamond, this being purely decorative. Having completed the frame the next task is to tune the bars.

Tuning

The tuning of the bars is regarded as the most difficult and critical task in the making process. Before it can begin, all the bars have to be shaped; cutting to length and width, and smoothing the edges and playing surface. The smoked bars are sorted out according to size and laid out on the ground. The lengths of the largest and smallest bars are marked and a straight edge used to mark the others in between. The bars are then cut to length using an adze or saw, if available.

The bars are smoothed using just an adze, a time consuming and skilled job. Coping with the interlocking grain can mean changing the direction of cut several times along the length of one bar: it is impossible to avoid tearing the grain, so a further process of scraping the tops of the bars with a sharp adze or knife is necessary to achieve the smooth surface found on so many *jengsi*. The maker will usually get help with such jobs from his family.

Most makers tuned with reference to another instrument, as do the LoDagaa, though a few claimed to tune purely by ear.[45] The bars of the referent instrument are untied and laid on the ground across two rolled up mats or bundles of grass, as are the bars to be tuned. All makers tune the highest pitch (*kila*) first, and continue down to the lowest pitch. This practice identifies *kila* as the leader of all the bars, whereas the LoDagaba regard the lowest pitch as the 'father' or 'head' and consequently tune this one first. This difference could be due to the difficulty of starting a scale on such a low pitch as found on the *jengsi*; LoDagaba instruments rarely go below D# 2 (77.75 Hertz), where as the *jengsi* descends 400 cents further to B 1 (61.7 Hertz). The lowest pitch, 17 is only roughly tuned and has no resonator. This bar is only ever played with the hard end of the beater to produce a purely rhythmic accompaniment, and as such it is known as the *zangbal*, or dry bar.

Table 5 shows the tunings of xylophones in Pulima, Silbelle, and Sorbelle. It should be noted that these tunings were taken from old, neglected instruments that were in a bad state of repair. The instruments had gone out of tune, though it is generally true that all the bars of a xylophone rise in pitch more or less uniformly with the ageing process. Certain 'rogue' bars may alter in pitch excessively, but this tendency is unusual in an originally well-made instrument. On a newly made xylophone, the low frequency bars will rise in pitch relatively quickly since these are thin and dry out faster thereby losing mass, whilst the higher-pitched bars, which may be two or three times thicker, dry out more slowly but for a longer period. It is therefore difficult to analyse these tunings and come up with a reliable pattern.

In broad terms the tuning is pentatonic, with two or three intervals corresponding to those of an equitonal pentatonic scale at 240 cents, one interval around 300 cents, and one of a tone (200 cents) or slightly less. The octaves are not exact; makers stated that this was not the intention, preferring a "more alive" sound. The highest pitch (*kila*) is tuned first and normally lies within the range C 5 to D 5. The maker continues to tune down the bars, sounding the two instruments together to assess the amount of carving required. Makers stated that they would check their work by playing set phrases or patterns on the two instruments.

Table 5 Tunings of three *jengsi.*

Pulima			Silbelle			Sorbelle		
Hertz	cents (above C)	interval (cents)	Hertz	cents (above C)	interval (cents)	Hertz	cents (above C)	interval (cents)
60.0	1050		71.2	146		65.3	1196	
		334			94			63
72.7	184		75.1	240		67.7	59	
		53			240			230
75.0	237		86.3	480		77.7	289	
		248			240			190
86.6	485		99.1	720		86.3	479	
		357			250			320
106.4	842		114.5	970		103.8	799	
		170			215			226
117.4	1012		129.7	1185		118.2	1025	
		252			165			229
135.7	64		142.7	150		135.0	54	
		246			352			306
156.5	310		174.8	502		161.1	360	
		240			243			248
179.7	550		201.2	745		185.7	608	
		200			171			167
201.7	750		222.0	916		204.7	775	
		207			244			200
227.4	957		255.7	1160		229.7	975	
		146			210			300
247.4	1103		288.6	170		273.2	75	
		312			310			245
296.2	215		345.2	480		314.7	320	
		302			170			160
352.7	517		380.8	650		345.2	480	
		156			265			380
385.9	673		443.8	915		430.0	860	
		224			277			240
439.2	897		520.8	1192		493.9	110	
		308			160			170
524.8	5		571.3	152		544.8	70	

Once the maker is satisfied with his tuning, the calabash are selected. The Sisaala use the same bottle-neck calabash as do the LoDagaba (*lagenaria vulgaris*), and employ the same method of getting rid of the soft pulp by scraping out as much as is possible, and then filling them with water, leaving them in the sun to rot the pulp for four or five days. Ideally they are flat of the corresponding bar so that the resonator can be cut down, raising its pitch. Due to the very low frequency of the bass bars this is not always possible, so the the pitch of the calabash has to be lowered by decreasing the aperture with a mixture of cow dung and ash. This is less than ideal, since with age, the dung dries, cracks and comes loose. I saw one instrument in Accra which had calabash tuned in this way using cement! The next step is to make the holes in the resonators which are covered with a membrane to form the mirlitons. The Sisaala prefer these holes to be quite small; 12mm to 18mm. This gives a much sweeter sound than the large ones used on the LoDagaba *Lo gyil*. The Sisaala, like the LoDagaba, use spider's egg sacs for their membrane material, these being stuck on with tree gum.

Unlike the *Lo gyil*, whose bars are laced together off the frame and then secured with separate leather thongs (facilitating its removal), the *jengsi* bars are laced and tied to the frame with the same piece of rawhide so that to remove the bars, every one must be unlaced. The reasons given for this are tradition (it has always been done like this) and that the bars of the *jengsi* are so large and heavy, the lacing would be prone to breaking if the tension of all the bars were to be exerted on one strand of rawhide (as with the *Lo-gyil*). Figure 116 shows the method of lacing. The Sisaala use the same method for making the lacing as the LoDagaba: softening bush antelope or goat rawhide strips with shea butter.

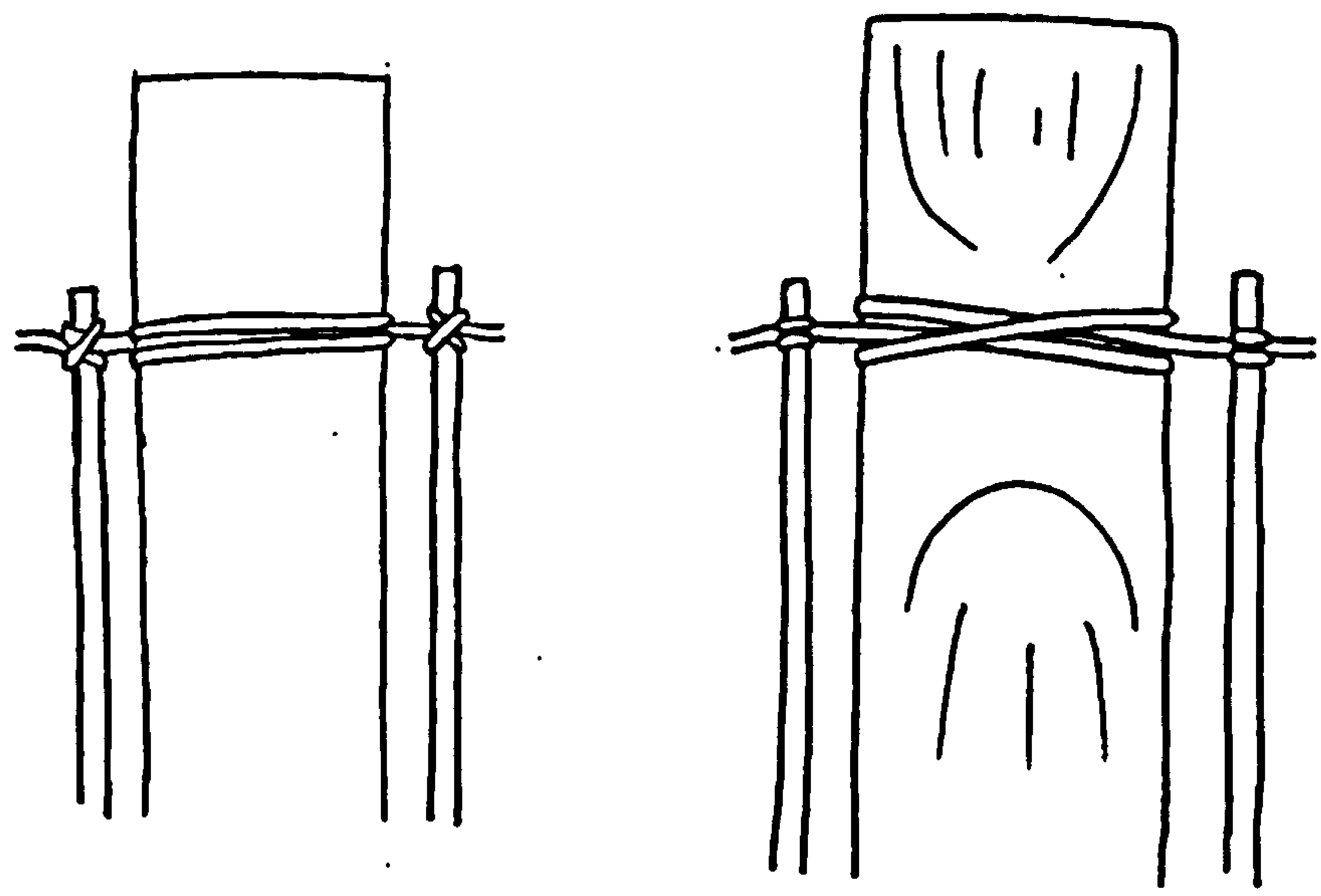


Fig. 116 Lacing method, left half from above, right from below.

Having completed the instrument the maker pours cold water over the earth shrine, offering prayers and informing the spirits of the work done. Finally, he asks that the *jengsi* may now be delivered in safety.

From maker to buyer

Makers from different clans have customs varying slightly in detail concerning the delivery of a new *jengsi*, though they all follow the same general pattern. The new instrument is carried by the maker's wife (on her head!) to the house of the buyer.[46] Some makers said they would meet halfway, where the instrument would be played and millet beer drunk, and then continue on to the buyer's house.[47] A guinea fowl is provided by the buyer for the wife as a goodwill payment for carrying the *jengsi*. A hen is also slaughtered for the maker. On arriving at the buyer's house, the maker claims the first thing he sits on - a stool or mat is specially provided by the buyer for this purpose.

The buyer slaughters a sheep for a feast, and provides a large pot of millet beer. It is customary for the maker to claim the skin, the head, organs and a leg which are taken home with him on leaving.[48] The feasting and ensuing music and dancing usually lasts one day and the maker's party return home with their gifts. The old makers said that this feasting used to last for anything up to three days. Gifts of kola nuts are provided for the elders back at the maker's village.

Payment for the *jengsi* varies and depends on the ability to pay and the relationship between the maker and buyer. A local buyer from the same village will often help the maker by felling the tree, providing materials, and doing any menial tasks during the making process. Since this instrument will be used by the whole village, the only payment necessary is kola. However, if the *jengsi* is destined for another village, the payment used normally to consist of animals; anything from goats, sheep, or even a cow. Some old makers gave a figure of 30,000 cowries as being the last payment they received.[49]

The spiritual dimension

The making and use of the *jengsi* used to be surrounded by ceremony, but today with the advent of imported religion and westernisation many of the pagan beliefs are dying out. However, many of the elders in the villages visited still held on to the old ways, and castigated the young for their irreverence, citing this as the reason for the ills of their present society.

Trees are traditionally regarded by the Sisaala with respect, and they will consequently make prayers, apologies and even sacrifices before felling. When receiving an order for an instrument, all the makers stressed the need to pacify the forest spirits by making a sacrifice to the earth shrine. Some makers, in addition to this, thought it necessary to paint a line of medicine onto the tree prior to felling in order to assess whether the tree is safe to use. Makers stated that this medicine is also painted on a dead tree since the spirits can live on in the tree's soul. Mary Seavoy [50] noted, "thus a black cross may also be applied to the first and last keys of new instruments". I was told that this is only done nowadays if the buyer wishes it.

Sisaala makers, like their LoDagaba counterparts, stressed the importance of using a medicine during the smoking of the bars. During discussions makers recognised the importance of drying the timber through the smoking process, but always subordinated this against the effect the medicine had of purifying the timber by pacifying the spirits. Each maker has his own recipe for *jeng-luri* handed down through generations of instrument builders. Medicinal recipes are kept secret, but generally take the form of some bush 'herbs' and/or roots mixed with ash to form a black paste. It is interesting to note that both the LoDagaba and Sisaala use 'black' medicines in connection with xylophone making. Colours have specific spiritual meanings: black is associated with any serious matter, whilst red signifies danger. Consequently when the body of the dead person is on show during a funeral the body must not be dressed in anything red.

Certain general taboos regarding the use of the *jengsi* exist among all Sisaala clans; in addition to these, individual clans have developed their own taboos. Breaking these taboos is believed to cause illness or bring ill-fortune to the perpetrator. The general taboos include:

a) women cannot play the *jengsi,*

b) the *jengsi* cannot be played left-handed,

c) the instrument must not be played in the house: this is especially dangerous at night,

d) the *jengsi* may be played under a baobab tree, but must not come into contact with the tree.

In the village of Pulima the elders told me that the women who carry the xylophones to the funeral site must not have sex until after the instruments have been brought back to the house. In Sorbelle, the custodian of the village instruments must not bath for a period of ten days after sending out the instruments. In Kowie, if an instrument leaves the village to be played elsewhere, the leaves of the *dawa-dawa* fruit tree are inserted into the basket-work of the instrument. It is believed by the musicians that failing to do this will enable spirits to play the instrument along the way, resulting in their own inability to play. LoDagaba musicians also hold this fear of losing their ability to play, but through the witching effect of other jealous musicians rather than by roaming spirits.

Traditionally a maker always repaired his own instruments. However, when a maker repairs an instrument not made by him, he will purify the instrument so it is safe for him to work on. Seavoy [51] relates a story regarding the more unscrupulous efforts makers can go to safeguard future repair work for themselves:

> One enterprising carver intentionally used one key of entirely different wood so that the xylophone would in time require repair. Sacrificing a black hen over this key assured his spiritual retribution against anyone else trying to retune his errant key; consequences were guaranteed to be fatal. But nowadays, unable to repair all his xylophones, he no longer makes such 'black xylophones' (*jeng-bise*).

The Sisaala do not, from my research, appear to have any stories relating to the origins of their xylophones, though they are aware of the LoDagaba myth concerning the forest fairies.

The learning process

The situation the Sisaala musician finds himself in is very similar to his LoDagaba counterpart; he is foremost a farmer and no structure exists whereby he can make a living purely from music. During the time of Seavoy's research (1970-1972) she found a structured system identifying different stages of learning that a musician (*jeng-goke* : xylophone player) goes through: pre-learner, learner, young *goke*, head *goke*, and ancestor *goke*.[52] These various stages were never mentioned to me during discussions on the matter, but it should be remembered that the Sisaala xylophone tradition was still very strong twenty years ago when her research was carried out.

The musician's training is a life long process, usually starting at a very early age. Like the LoDagaba, the Sisaala's attitude to learning from the start is guided by performance, so the idea of practice does not exist. A learner will "watch the hands" of a *jeng-goke*, and when he feels confident will play, in performance, what he has 'seen'. This performance may well only be to other children gathered around, but the notion that he plays for others is always central. The recreational repertoire, which is performed by a solo instrument, is learnt first, leaving the often more complicated interlocking patterns of the two *jengsi* used in the funeral repertoire until later.

Since the rubber vine is not found in this area, the latex beaters are kept by the head of the household only for special performance. Children therefore often play with corn cobs, whilst learners make their own using tractor tyres for the rubber head.

Instrument making always runs in families, the skill being passed down generation to generation. An instrument maker will normally have one or two members of his family working with him as apprentices. The apprentices learn the frame-making first and then progress to the weaving of the basket shield, considered one of the most difficult tasks. The most skilled job, that of tuning the bars, is always left to the maker. Apprentices are socially constrained from making their own instruments until their mentor dies; Dingwia in Kowie was no longer capable of making due to his bad sight and age but his sons said they had "no right to make *jengsi* while he was still alive".

DISCUSSION ON THE PRESENT STATE OF LODAGAA AND SISAALA CULTURE

During my stay in Northern Ghana it was very apparent that the Sisaala culture was struggling to survive, whilst on the other hand the LoDagaba culture was thriving. Taking into account the similarities of the two cultures, and their resilience to overcome oppression experienced in the last 150 years, it is difficult to understand why the Sisaala culture should be falling apart. On the surface the answer appears simple: the introduction of Islam into Sisaala land. Many informants laid the blame here, seeing converted villages discarding their old culture. Villages tend to convert as a whole unit rather than on a gradual individualistic basis. A school teacher, Mr. Robert Nuakama from Tumu, told me of the overnight conversion in Lipilme where all the instruments, shrines and cultural artefacts were burned. Seavoy [53] noted this during her research in the 1970s:

> It appears that the traditional Sisaala social order and religious practice with its pantheistic structure cannot coexist with the strict monotheistic base of Islam. A convert does not simply adopt a new belief system, but must reject a whole socio-religious way of life that is the essence of tradition.

This has been taken on so wholeheartedly that now some villages are renouncing their language, so that the young know nothing of Sisaala. The villages of Pulima, Sorbelle, Silbelle, and Kowie where I did most of my fieldwork, still retain traditional values but enthusiasm for tradition and culture, especially amongst the young, is at a low ebb.

The overall impression is that interest has not been sustained by the young in the culture due to new interests such as modern education and the attraction of town life. Yet still, why do the older generation not maintain their culture as vigorously as they used to? One can only surmise it is borne out of a lack of respect, firstly from the many Sisaala villages that have turned to Islam and despise the old pagan ways, and secondly from the younger generation who have lost interest in the traditional way of life. The following quote from Felwia Nabila, spiritual leader (*tinteen-tiina*) in Sorbelle, is representative of the feeling of many of the older generation: "..our tradition is dying, taboos are no longer respected, this used to be a strong disciplinary society, but now, as a result of foreign religion doing away with the old customs of our grandfathers, the discipline has gone. This leads to the problem of youth today." The "problem of youth" that Felwia Nabila was talking about is the lack of respect the young have for their elders wishes: ie. their role in the traditional family unit, marriage, and leaving the rural areas. Children from the villages will often go to school in the local town, and stay there during the week since it is too far to travel on a daily basis. This situation, combined with the fact that teachers are often non-Sisaala, helps to alienate the children from their own culture.

In each of the Sisaala villages I visited, a performance would be given at the end of the discussions. This would always bring all of the women in the village to the music to start dancing, from the young to the very old. The feeling of happiness this induced amongst everyone was easy to see. Although the traditional form of *jengsi* is losing popularity amongst the young, new smaller instruments are being made to play recreational music.

When comparing the current state of the LoDagaba culture to that of the Sisaala it appears strange that the former is thriving whilst the latter is in rapid decline. Broadly speaking the two cultures have had to endure similar difficulties during colonialisation. Indeed, at the time of independence (1957), both cultures were very much intact. The last twenty to thirty years have seen new threats emerge to such cultures:

those of westernisation and mass communication. Westernisation threatens traditional cultures, introducing an attractive alternative to the young from the very hard life of subsistence farming. Drawn by the glamour of city life and materialism, the youth often leave rural areas only to find that for many of them life is in fact harder, where sleeping rough is the norm and disease endemic. This lifestyle is most prevalent at the town or city bus garage, where children and youths work as porters and street hawkers. Mass communication (ie. transport system, radio etc.) is the means by which westernisation is spread, but communication can also be used to combat the detrimental effect westernisation can have on traditional culture. A successful way of combating these problems is by governments actively encouraging indigenous cultures, using mass communication such as television and radio to increase national awareness, which in turn gives self respect for a people's own culture.

Ghanaian governments have achieved this with the LoDagaa culture: it is common to hear their music and see their dance on national radio and television. The LoDagaa form an important part of the Ghanaian National Dance Troupe which has gained international respect travelling all over Africa and Europe. It appears to be this sense of pride that has captured and retained the interest amongst the younger LoDagaa generation in their tradition and culture. Every year, government-sponsored music and dance contests are held in the LoDagaa region, but this does not happen amongst the Sisaala. It is certainly not because the Sisaala have nothing to offer, but because the Sisaala have no representative voice to help establish such events.

There is no single easy solution to the problems faced by the Sisaala: better roads are needed to open up the area, local industry needs to be promoted to encourage Sisaala youth to realise a future in the area, but above all, better education is needed so that their voice is represented in government at all levels, both locally and nationally. The local government representative for the Department of Arts, Charles Dikpe, is a non-Sisaala-speaking LoDagaba, placed in the job by a civil servant in the region's capital, Wa. Mr. Dikpe is very conscientious and enthusiastic about his work, and I received immense help from him, making my research possible. However, he is constantly struggling against the lack of government support; his only transport is a bicycle shared with another department, he has no camera or recording equipment making his job virtually impossible.

CHAPTER X

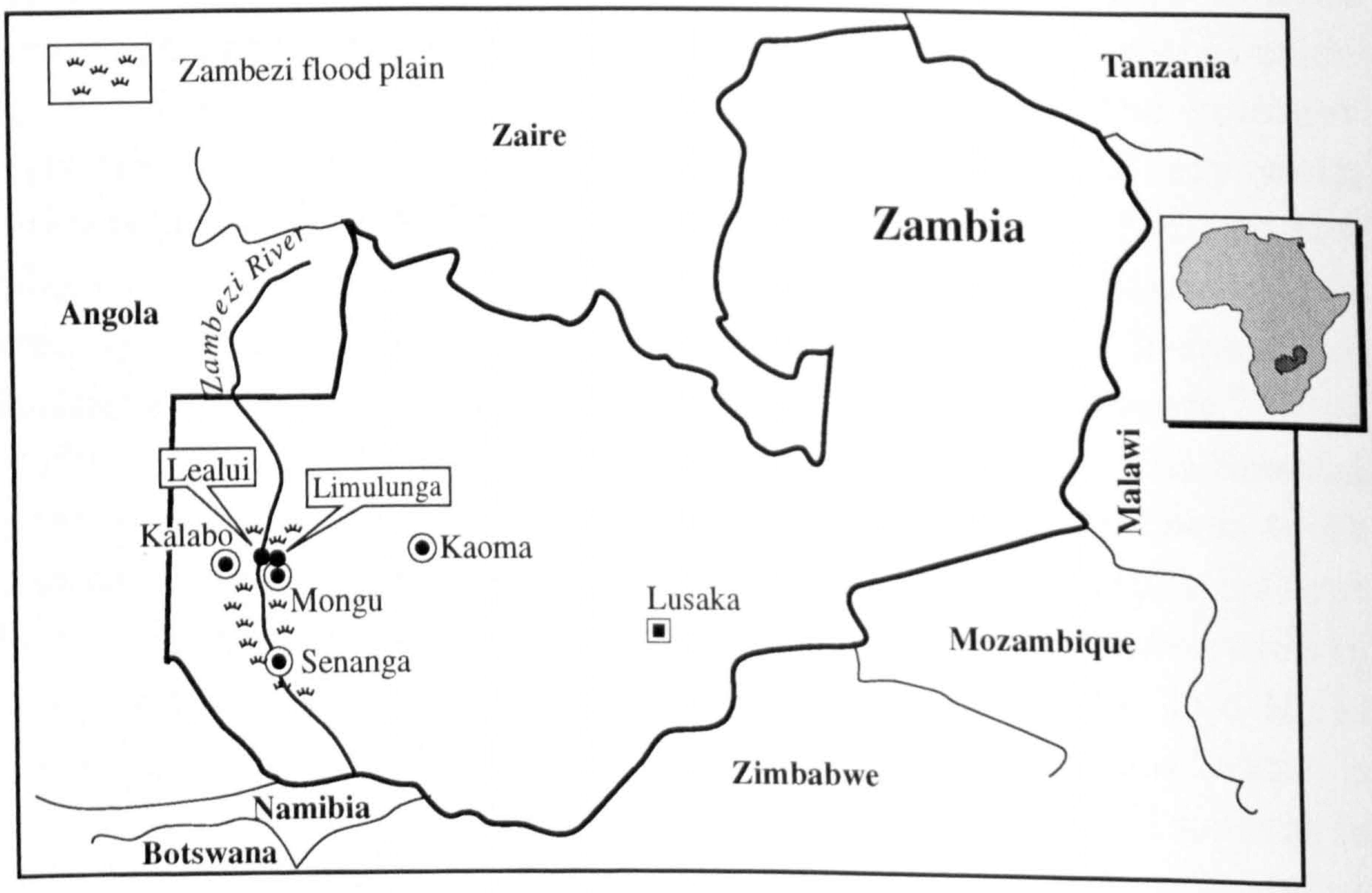
THE MANUFACTURE OF LOZI AND NKOYA XYLOPHONES IN WESTERN ZAMBIA

INTRODUCTION

The distribution of xylophones in Zambia

The strongest xylophone traditions in Zambia are found amongst the Lozi and Nkoya peoples in the Western Province (see map 4). Four basic types of xylophone exist:

a) *silimba saLozi* - Lozi royal,
b) *silimba* - Lozi commoner,
c) *silimba siNkoya* - Nkoya royal,
d) *silimba* - Nkoya commoner.



Map 4 Western Zambia.

Sources of information

Lozi history has been well researched, mainly relying on a very strong oral tradition which traces lines of descent back at least three centuries. The first history of the Lozi was written by Adolphe Jalla [1] at the end of the last century. Jalla was an early missionary who was requested by the Lozi king Lewanika I to write the nation's history. Although it contains a vast amount of valid historical information, it is politically biased. This bias comes from Lozi royalty, eager to reinstate their traditional status of sovereignty after the recent defeat of the Kololo forces who had ruled the Lozi for a period during the the latter part of the nineteenth century.

The more recently researched Lozi history by Mutumba Mainga [2] is less biased and very detailed. The history of the Nkoya people is far less well documented and to a large extent one has to rely on indirect accounts which mention the Nkoya secondarily to the subject of study. Most of the Nkoya history contained in this study comes from a report written in 1945 for the Rhodes Livingstone Institute.[3] Unfortunately, I could not get access to a recently written book on the subject.[4]

On the subject of Lozi and Nkoya music a recent PhD. thesis was written by Ernest Brown.[5] A.M.Jones [6] wrote a paper for the Rhodes Livingstone Institute on Zambian music in 1948 which includes some interesting notes by Max Gluckman on the social background of Barotse (Lozi) music. There is very little information on instrument manufacture in Zambia, although Atta Mensah [7] wrote a brief article on Lozi xylophone making.

Research methodology

The field work for this study was conducted between October and December 1991. I had planned to spend just one month in Zambia and then travel across land into south west Zaire to study the *madimba* xylophone of the Pende people. It had taken six months to get the relevant paper-work for a Zairian research visa, but two days before I left England the army rebelled (they had not been paid for three months). Once I was in Zambia the situation in Zaire deteriorated to the extent that it would have been foolhardy to attempt the trip. Three months were therefore spent in Zambia.

The first week was spent at the University of Zambia, Lusaka. Mr. Nkunika, acting director of the Centre for the Arts, suggested I should travel to Mongu in Western Province to study Lozi and Nkoya xylophones. Mr. Nkunika gave me a letter of introduction to Mr. F. L. Mukwita (the Resident Tutor, University of Zambia, Mongu). Mr. Mukwita suggested I should stay at the Nayuma Museum in the royal village of Limulunga, the seat of the Lozi king (Litunga, literally, the earth). Mr. Mukwita wrote a letter to the Litunga, and through this introduction I had two meetings with the king[8] to discuss the history and manufacture of the royal instruments.

I brought a bicycle with me from England with the idea of using it to travel to villages around Mongu. The bicycle turned out to be almost completely useless because the very soft Kalahari sands that cover Lozi territory make cycling impossible. However, I was fortunate in being able to travel with the Nayuma Museum vehicle on local craft buying trips. I was also able to travel to outlying villages with a Danish Volunteer physiotherapist. During these trips I was able to study Lozi folk xylophones.

The end of the field trip was spent further east at Kaoma, home to the Nkoya people. A short time was spent there studying Nkoya folk xylophones.

Historic and geographic background

Lozi

Western Zambia consists of sandy forests (Kalahari sands) criss-crossed with rivers and streams. At the centre of the region is the Zambezi flood plain which is between ten and thirty miles wide and one hundred miles long. The Lozi set up their kingdom in this enormous, fertile rift valley. (see map 4). Mainga [9] suggests that:

> the old Lozi, or Luyana, were part of a general Luba migration into north-western Zambia, and that they arrived about the same time as the other Luba groups to the north...It also seems reasonable to suppose that the people who introduced Lunda rule to the Upper Zambezi among the Mbwela (Nkoya) and the Lwena were part of the same group that went to Bulozi (the Zambezi flood plain) and founded the Lozi dynasty.

Lozi history basically consists of five epochs:

a) The setting up and expansion of the Luyana (original or old Lozi) kingdom (1700s (?) to about 1840).

b) The Makololo conquest and domination of the flood plain (about 1840 to 1864).

c) The regaining of the Lozi kingdom and the fight to rebuild Luyana institutions including the kingship (1864 to 1900).

d) European conquest of Angola, Zambia, and Zaire (1890 to 1900)

e) Independence (1957).

The first Lozi kingdom was founded in Kalabo, which is now in the northern part of Lozi territory. Mboo is recognised as the first Lozi king, although at this stage the kingdom was very small. It was not until the reign of the fourth king, Ngalama, that the whole of the Lozi flood plain was brought under the control of one king. This involved the defeat of two breakaway groups, one under the leadership of Mange in the present Mongu-Lealui region, and the other under Mwanambinyi (Mboo's brother) in the present Senanga district.[10] In order to make the takeover more palatable to political factions the southern kingship was retained. Eventually the Lozi rulers in the north decided that the southern ruler should always be a woman since Lozi tradition forbids any woman from assuming the kingship in the north. This tradition has continued to the present day with the Litunga la Mbeola (Lozi queen) maintaining a palace in Senanga.

The Lozi now had the united power to control a wider area outside of the flood plain. The plains people and the forest peoples were economically interdependent, trading, among other things, milk, fish and cattle for timber, bark and honey. The Lozi extended their control to the forest areas surrounding the plain, thus securing their economic independence as well as being able to extract regular tributes both in terms of produce and labour for such projects as canal building.

Living permanently on the plain brought a sense of cohesion and identity to the Lozi whereas their neighbours in the surrounding forests "comprised small decentralised groups which presented little resistance to the Lozi".[11] The Lozi believe that "all members of the royal family have divine ancestry through their descent from Mbuyu, daughter of god".[12] However, the Lozi still borrowed institutions from the people they conquered. Mainga [13] notes that the *maoma* drums (which are regarded as the second most important ensemble) were "not introduced into Lozi kingship until the reign of Ngalama (K4) who is said to have captured them from Mwanambinyi, who in turn captured them from the

Mbukushu at Katimamulilo".

In about 1840 the Lozi kingdom was defeated by a large Makololo (or Kololo) army led by Sibitwane. Although the Makololo didn't know it at the time, they had chosen an opportune moment to attack since the Lozi kingdom was in a state of civil war following a succession crisis. In 1823 the Makololo had been driven from their homeland in the present Orange Free State "as a result of the Military and political revolutions which shook South African tribes in the early nineteenth century".[14] During the Makololo domination of the Bulozi (Lozi homeland, the flood plain) until their defeat in 1864, they lived in constant fear of the Matabele who regularly made raids into southern Bulozi. Slavery was introduced into Bulozi by Sibitwane in an attempt to acquire guns with which to repel the Matebele.

The Makololo, although only in control for about twenty five years, changed many Lozi institutions, and managed to introduce their own language to the Lozi which is still in use today. The original Luyana (old Lozi) language is now only understood by a few members of the Lozi elite. In 1864 the Lozi regained sovereignty of Bulozi almost completely annihilating the entire Kololo population. By the time of their defeat, the Makololo had suffered massive losses through malaria which they had no resistance to since it was not prevalent in their homeland.

During the late part of the nineteenth century the Lozi king, Lewanika I, tried to restore the kingship to its former glory but this never really succeeded. Before long, the British gained control and stopped further Lozi expansion. During the colonial era much of the power of the Lozi king was taken away and many Lozis were forced to work in the mines in the Copper Belt and on the commercial farms in southern Africa. The Lozi chiefs were kept in power by the colonial administrators, but only as figure heads.

During the colonial era, Lozi territory was made a British Protectorate, but with no real financial power, many of the state institutions dwindled. However, Lozi chiefs and their children were educated by the British in Europe, and now the Lozi form a large proportion of the educated and skilled workforce in Zambia.

During the colonial era western Zambia fell into economic isolation with the British declining to invest in the infrastructure. The first sealed road from Lusaka to Mongu was not made until the 1970s; this was made possible with Chinese investment. Western Zambia is still a relatively poor region in Zambia with no real industry apart from the state-run cashew processing plant in Mongu.

All Lozis previously lived on the Zambezi flood plain, but nowadays most people live on the high escarpment surrounding it, though they still rely economically on the plain.

Nkoya

The history of the Nkoya is more sketchy than that of the Lozi. From the earliest written history of the Lozi by Jalla,[15] the Nkoya are written about as subordinate neighbours to the Lozi. This political bias has resulted in vastly differing accounts of Nkoya history. Clay [16] writes that "according to the present Mwenemutondo (Kanyasha) the Mankoya (Nkoya) had no dealings with the Malozi (Lozi) before about 1860", whereas Jalla writes that they were conquered much earlier than that. Kanyasha related to Clay that the Nkoya were defeated in the time of their chief Mwenemutondo Lushiko, by "Mbololo and his Malozi." Mbololo was the last Kololo chief who was defeated by the Ngambela of Sipopa in 1864. As Clay [17] notes,

> It is therefore difficult to state the date of the Mankoya subjection with any certainty. Many of the Mankoya were taken into the Barotse plain, together with the drums of their chief, which remain to this day as the Mankoya band of the paramount chief of the Barotse.

Clay suggests that originally the Nkoya, Bamashasha and Balukolwe were probably one tribe which was split up under Lozi attacks and the present three branches were formed.[18] Many of the early Nkoya chiefs were women, and succession was matrilineal until conquest by the Lozi, after which it became patrilineal. During the Lozi domination, the Nkoya were required to pay tributes in produce and labour. This was not scrapped until 1923.[19]

The first Europeans did not arrive in Nkoya territory until 1900. The Nkoya chiefs were kept in power by the British, but had less autonomy than the Lozi and many of the Nkoya institutions were abolished or severely cut back such as the reduction in the number of royal musicians. Under colonial rule the Nkoya fared worse than the Lozi, not benefiting from the education that helped the Lozi.

LOZI AND NKOYA ROYAL ENSEMBLES

Royal ensembles and their function

This study is based on field work conducted in Limulunga. Traditionally the Litunga spent six months of the year at his summer (dry season) palace in the village of Lealui in the flood plain. As the rains start, the Zambezi overflows and the water rises. At this time of year during March or April the Litunga makes the voyage across the water to his wet season residence at Limulunga. This ceremony, known as *Kuomboka* (literally, to wade out of water), is the main cultural event in the Western Province. The ceremony starts with the Litunga playing a set of large wooden kettle drums (*maoma*) to call the one hundred and twenty paddlers to Lealui. Two days later the royal barge *Nalikwanda* makes the voyage to Limulunga, with the Lozi and Nkoya royal ensembles and *maoma* drums on board to provide the music for the ceremony. *Kuomboka* formerly included thousands of canoes as the entire Lozi population moved with the king.

Although the present Litunga has stayed in permanent residence at Limulunga for a number of years , *Kuomboka* is still re-enacted every year and is now a major tourist attraction.

Both the Lozi and Nkoya have had royal court musicians for centuries. During processions and all public appearances the Litunga is always preceded by the music of the royal ensembles; they are the most important symbol of political power, and serve as a constant reminder of the power and vitality of the chiefs and their ability to ensure the well-being of their people.

The most culturally important Lozi ensemble is the Lozi royal xylophone and drum band, often referred to as the Luyana ensemble; Luyana is the old language of the Lozi and the entire repertoire of this ensemble is in Luyana. Second to this in importance is the royal *maoma* drum ensemble. This drum ensemble consists of four very large wooden kettle drums, with heads ranging in diameter from 75cm to 100cm, each one tuned to a different pitch. They are called, from lowest to highest, *mwamwa, mutumo ofu ngomalume, mupatu* and *mushakasho*. Today their main function is provide the drumming for the *Kuomboka* ceremony, but in former times they were used during battle and to announce states of emergency. Consequently they play a large part in the funeral of kings and also the crowning of the new king.[20] Third in level of importance is the royal Nkoya xylophone and drum band.

The instruments of the two royal xylophone and drum ensembles are housed in a building within the grounds of the palace, and are played every night through till the following morning. The Luyana ensemble consists of following instruments:

a) *silimba saLozi* (luyana) - twelve-bar xylophone
b) *mwenduko* - large master drum, single-headed
c) *mwatota* - medium drum, single-headed

The Nkoya ensemble (known as *siNkoya*) consists of the following four instruments:

a) *silimba siNkoya*- eleven-bar xylophone
b) *liolongoma* - large master drum, single-headed
c) *sitendewa* - large, double-headed buzzing drum
d) *luwawa* - small, double-headed buzzing drum

The Luyana ensemble is always positioned in the eastern section of the building. This is significant since it reinforces the superiority of this ensemble (and what it symbolises) over the *siNkoya* ensemble. The Lozi believe that "all good things come from the east" including the sun and God, "men are always buried towards the east, and women towards the west".[21] Figure 117 shows the layout of the instruments.

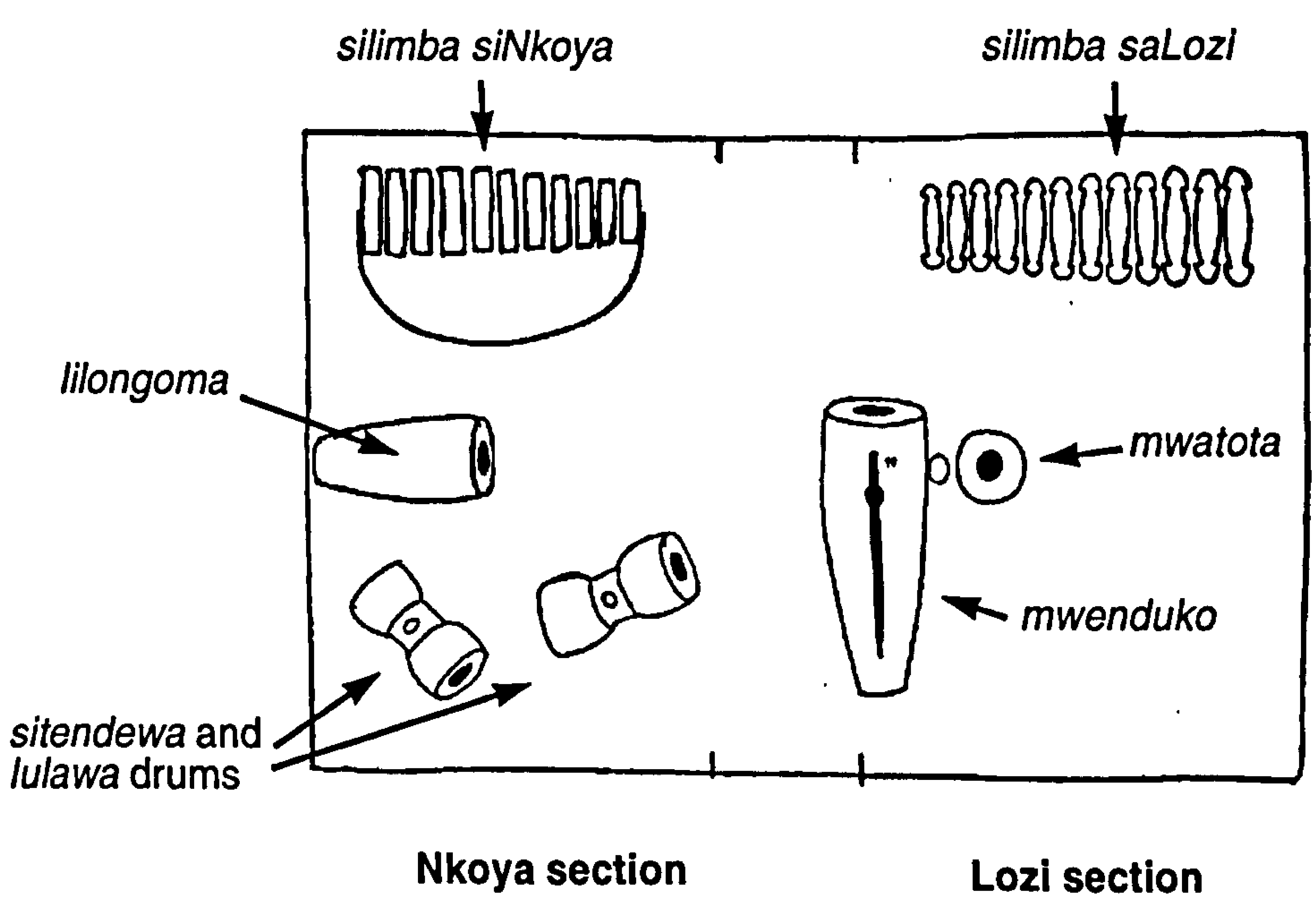


Fig. 117 Layout of Luyana and *siNkoya* ensembles.

The royal Lozi and Nkoya ensembles play in the palace enclosure every night and morning at the following times:

1) 21.00 hrs. to 22.30 hrs., Lozi ensemble.
2) 24.00 hrs. to 01.30 hrs., Nkoya ensemble.
3) 03.00 hrs. to 04.00 hrs., Lozi ensemble.
4) 06.00 hrs. to 07.00 hrs., Nkoya ensemble.

Between 21.00 hrs. and 04.00 hrs. a strict curfew around the immediate vicinity of the palace operates. The first performance of the evening by the Lozi ensemble tells the people that night is drawing in and it is time to sleep. The end of this first song puts the curfew into operation. Although the ensembles play within the palace grounds, the music carries a considerable distance through the night, to the extent that it can be heard easily within a mile of the palace. After spending two nights in this building to observe and record performances, I could understand how the music travelled so far; the volume within the concrete walls is very loud, and also harsh. However, outside the palace compound the music, especially that of the Lozi ensemble, has a mellow, almost floating quality.

The Lozi ensemble is said to have a "bigger voice" than the Nkoya ensemble.[22] This is a result of both the instrument and the musical style; the royal Lozi xylophone has larger bars, larger calabash resonators with large mirlitons, and is played with longer, heavier beaters than the *silimba siNkoya*. The musical style of the Luyana ensemble is characterised by slow tempo with very little syncopation, most songs being formal and serious in nature. Luyana music has one melody that is harmonised rather than two independent but complementary melodies which characterise Nkoya music, and is the usual style of much African xylophone music.

The Luyana repertoire consists of twenty-one songs, all of which have specific meanings. Common themes are praise songs recollecting famous kings, deeds and battle prowess. There are also royal mourning songs and music for women's dances. All of the Luyana songs are in the old Luyana language which is no longer used and little understood. The Litunga told me that there is no one left alive who can recite the praise songs: the last *Induna* (adviser, nobleman) with this knowledge died in 1987. Before that, the only other living exponent died in 1984.[23] These praise songs were never recorded so unfortunately the songs have been lost with these men. The songs today are therefore purely instrumental without any vocal accompaniment, although people still know the meaning of each piece of music.

No songs have been composed for the Luyana ensemble for the last one hundred years. During discussions with the Litunga and his musicians the King asked the musicians why they no longer composed new songs for the *silimba saLozi*:their reply was that they felt they "were not capable". This is borne out of respect of the old ways and culture rather than their lack of skill as musicians since new songs are composed for the *siNkoya* ensemble.

According to the Litunga,[24] the royal Lozi establishment did not have a xylophone and drum ensemble at first, but relied on the royal lamellophone, *kanombyo*. The Luyana xylophone was derived from the *kanombyo* using the same unique tuning system allowing the songs to be transferred directly to the new instrument. Brown [25] notes that "it is common knowledge in Western Zambia that the people of Kalabo District (west of the Zambezi flood plain), where the Lozi kingdom was first established, do not play xylophones. Xylophones are found to the south and east of this location."

The royal Nkoya ensemble, according to the Litunga,[26] was introduced to the royal Lozi court one hundred years ago, so is a relatively new tradition in Limulunga. However, the royal Nkoya ensemble pre-dates the Luyana ensemble, though it is difficult to say by how long. The *siNkoya* ensemble is very similar to the royal ensembles of the Bapende, Batshioko and Balunda in southern Zaire and the bordering area of Angola. The common factor in all these ensembles is the use of a pair of very unusual, double-headed buzzing (with mirlitons) drums. These drums are reserved exclusively for the use of the chief's musicians and are never used by common folk. These drums, with their unique sound, symbolise the power of the chief/king. According to Boone [27] this type of drum is not an "ancient instrument" of Zaire and Angola, but of "Rhodesian" (Zambia and Zimbabwe) origin, "probably introduced into the area by the rulers of the Balunda".

The *siNkoya* ensemble is very much alive and developing (new songs are still being composed) as opposed to the almost archaic, unchanging Luyana ensemble. The royal Nkoya repertoire is much larger than that of the Luyana tradition. The present *silimba siNkoya* player, who has been at the court in Limulunga for twenty-seven years, knows about sixty or seventy royal Nkoya songs.

Construction details of the silimba saLozi

This royal instrument is quite unique amongst African xylophones; the features that set it apart are its construction, tuning and music. Most notable about its construction is the shape of the bars (see figures 118 and 119). The Litunga said that the special shape of the bars is symbolic of the royal barge *Nalikwanda* (the ends of the bars are the same shape as the bow and stern of the barge), and hence the power of the king.[28] The Litunga added "that anyone could make a *silimba saLozi* for themselves, but only the royal instrument may have the special shaped bars".[29]

It is a traditional role of the Lozi King to take part in the making of the royal instruments, principally the *maoma* drums. The present Litunga, more out of personal interest, also made the *saLozi* xylophone in current use. This xylophone has twelve bars, but according to Brown [30] the "Luyana xylophone has ten keys, but in the past seems to have had twelve". The present Luyana xylophone in Limulunga was made in 1978, so it appears that the tradition has reverted to instruments with twelve bars.

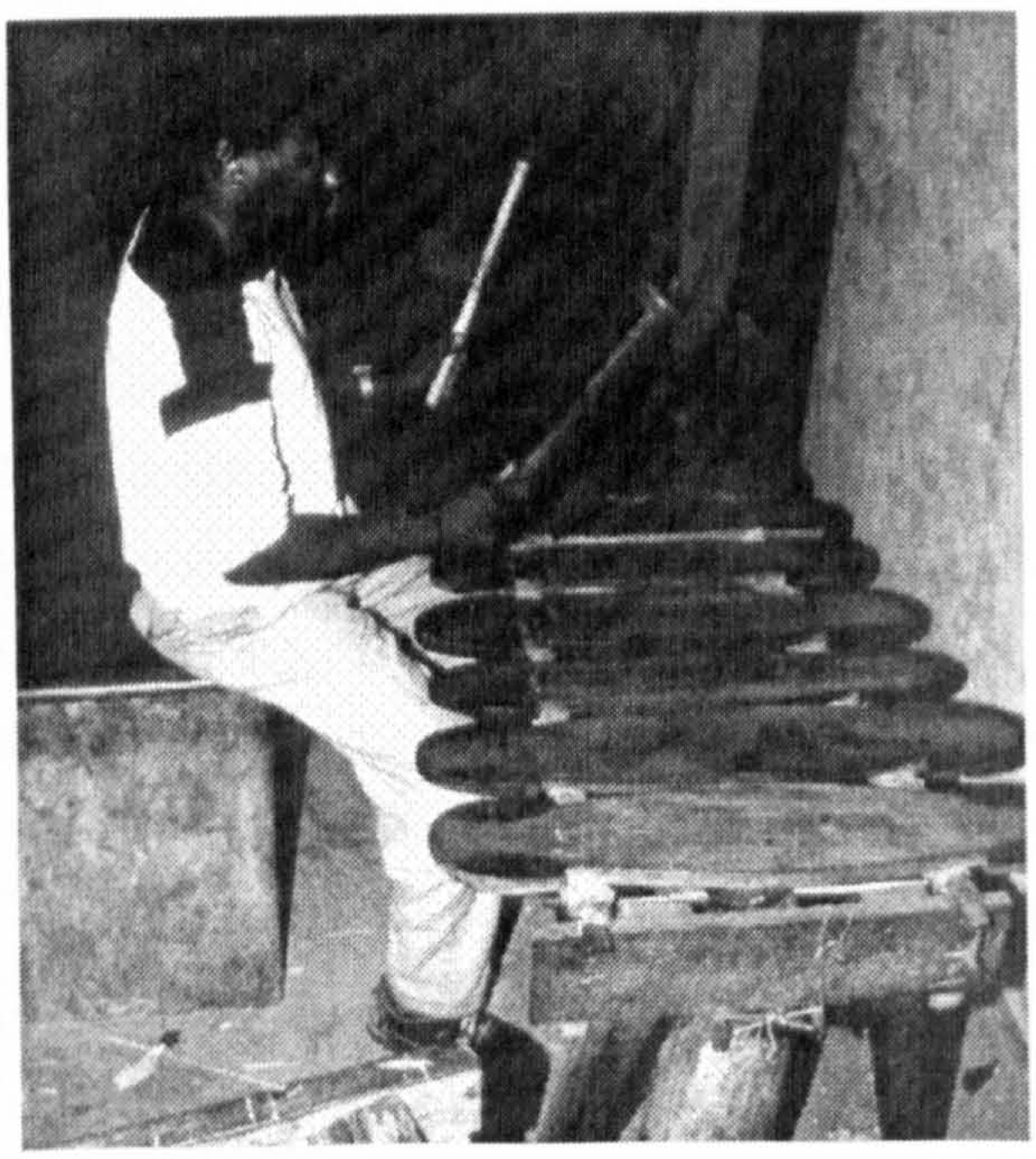


Fig. 118 Luyana xylophone in palace compound.

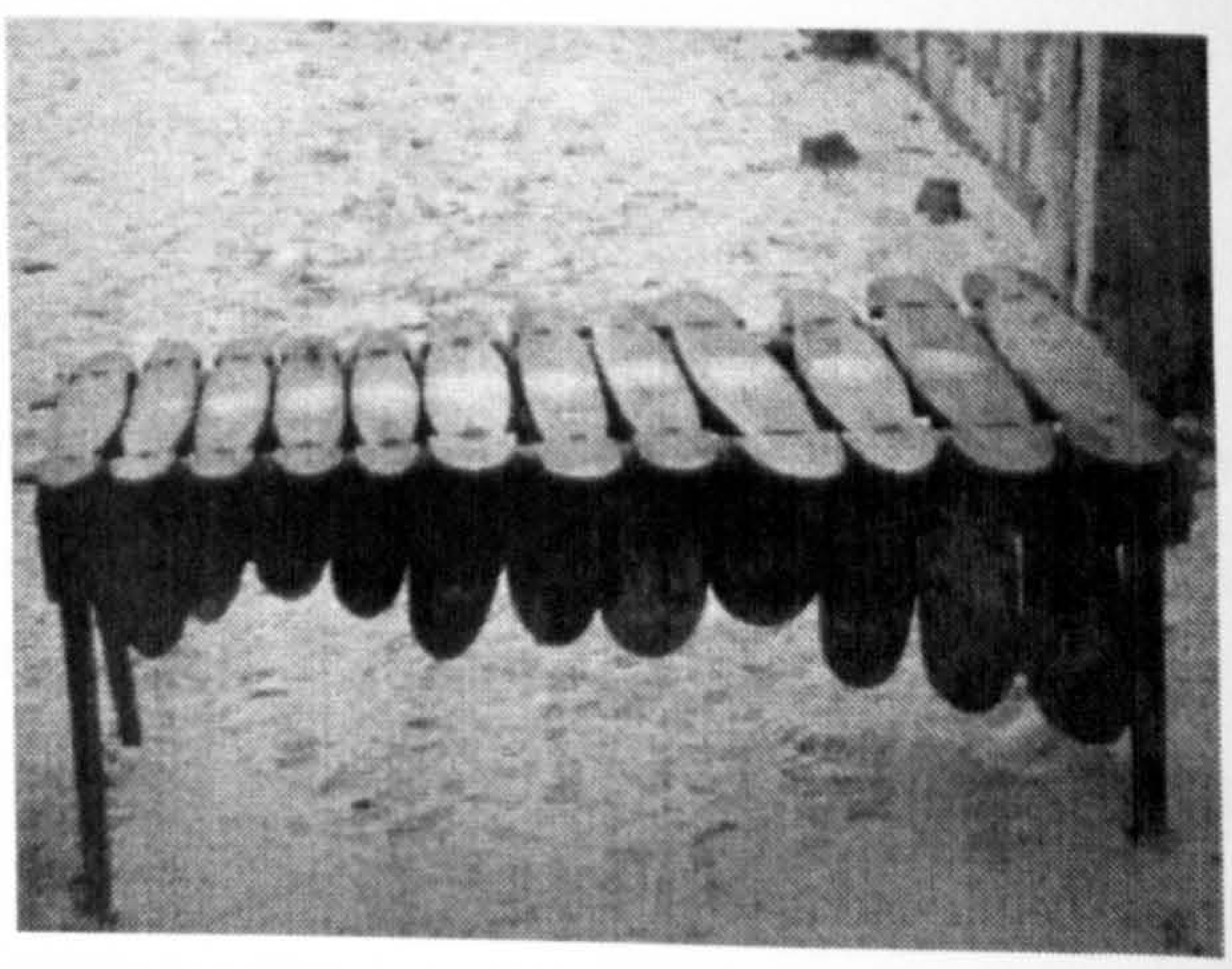


Fig. 119 Luyana xylophone.

The bars are arranged with the lowest pitch on the player's right so he is in effect playing left-handed. The Litunga said this is the traditional way that the Luyana xylophone is always played, and not a consequence of the musician being left-handed.

The making of the instruments of the Luyana ensemble is always done in secrecy, and usually within the palace walls.[31] Timber for drums is delivered to the palace under cover of darkness, and the drum carvers vow to hide the nature of their work. This secrecy is bound up in the traditional belief of the power of the royal instruments. For centuries the instruments have symbolised the power of the Lozi kingdom, and since royalty are believed by the Lozi to be direct descendants from god, the following historical account by Gluckman [32] of the instruments' power is not surprising:

> A sanctuary for a man threatened with throttling or a beating is safe if he can lay hold of a royal drum or xylophone. Also, the bandsmen are sanctuary unto themselves. I am told reliably that throughout this region, when the drums encouraged the armies into war and chosen warriors sang songs to excite them, the drummers had nothing to fear, save a chance spear or arrow. If their army broke, no-one would kill them, but they would be seized and added to the conquering royal band. Even defeated warriors who sought sanctuary round their drums would be spared to be taken as slaves. The protection of the drums was recognised over a large number of tribes.

Apart from keeping secret the making of instruments during their actual construction, very little mystique surrounds Luyana instrument manufacture. According to the Litunga it is only during the making of the *maoma* drums that special traditions must be adhered to. *Maoma* drums are made from a huge tree with a massive girth, known as *mutondo*. This tree, which is rarely found in the sandy Lozi and Nkoya territory, symbolises the power and strength of the King. Consequently, neither the Litunga nor *ngambela* (chief adviser to the king) or any of the senior *induna* (advisers) may be present at the felling of the tree.

The timber used for both the Lozi and Nkoya xylophone bars is known locally as *mukwa* or *mulombe* (*pterocarpus angolensis*). This medium-sized tree reaches a height of 20 metres with a 60cm diameter bole. The reddish-brown heartwood is hard but reasonably light with a specific density of 0.52. *Pterocarpus angolensis* is also commonly used for xylophone bars in Zaire.[33]

The Lozi and Nkoya do not believe that trees have any spiritual properties as do the LoDagaa and Sisaala peoples in Ghana. The Litunga placed great emphasis on the proper drying/seasoning of the timber.

Ideally a large dead tree is sought to shorten the drying period. Once felled, the tree is left in the forest through two rainy and two dry seasons so that the timber "can expand and contract many times".[34] Although the Litunga said it was an advantage if the tree had been attacked by fire, no actual smoking or curing of the bars takes place. Once the tree has been left for two years on the forest floor it is split into wedge-shaped planks and taken to the palace compound. The bars are roughly shaped and left for a further six months to dry. They are then made into the traditional Luyana shape using an adze (see fig. 118).

The bars are tuned in the usual manner for xylophones by removing timber from the middle of the bar to lower the pitch, and from the ends to raise the pitch. The Litunga regarded the tuning process as a long continuous task due to the timber ageing and its response to seasonal changes. The present royal Lozi xylophone was tuned with reference to the old instrument it replaced. The tuning of the *silimba saLozi* is the same as that of the ancient royal lamellophone, *kanombyo,* which was the predecessor of the royal xylophone.[35]

The tuning of the *silimba saLozi* is set apart from all other Zambian xylophones by having a number of unusually small intervals of one hundred cents (one semitone) or less in the scale.[36] The tunings of the Lozi and Nkoya royal xylophones are given in table 6.

Table 6 Tuning of Lozi royal xylophone.

key	Hertz	cents (above C)	interval (cents)
1	117.1	1008	
2	138.4	98	300
3	1532	273	175
4	172.6	480	207
5	181.3	565	85
6	202.7	758	193
7	226.2	948	190
8	239.9	1050	102
9	263.1	10	160
10	295.4	210	200
11	326.6	384	174
12	343.8	472	89

During my research it was only possible to record the tuning of the one *silimba saLozi* in Limulunga. With nothing to compare it to, conclusions (other than the existence of small intervals) are difficult to form. However, the court musicians stated clearly that this *silimba saLozi* left a gap between notes one and two (this practice of leaving out notes of the scale in the low register is common to all xylophones in Zambia). Brown [37] gives the intervals of the *silimba saLozi* in Lealui and Nalolo, and these, together with those of the Limulunga instrument, are shown below:

Lealui	320 195 65 195 240 155 90 215 185
Nalolo	340 360 150 275 110 135 205 75 85
Limulunga	300 175 207 85 193 190 102 160 200 174 89

These tunings are clearly different from each other and also from the instrument in current use in Limulunga. Since all the Luyana instruments are supplied by the royal establishment in Limulunga these differences are not regional.[38] On the question of tuning, the Litunga said that it was important that the royal Lozi xylophone at each of the palaces should have a different voice so as to distinguish the royal establishments.[39] He also stated that the sound of the *silimba saLozi* was made different from all other xylophones by the use of small intervals, and that this was intentional so that, along with its other unique qualities, Luyana music was instantly recognisable.

Looking at the three *silimba saLozi* tunings above it is apparent that very few octaves are true,[40] where as the *silimba sinKoya*'s are accurate. The style of royal Lozi music relies heavily on the intervals of fourths and fifths played in unison; the most common combinations of notes played are those with two or three notes in between, ie. 2 & 5, 3 & 6 etc., and 2 & 6, 3 & 7 etc. When considering this point a definite pattern emerges. Making an adjustment for note 2 which is normally left out, we arrive at the following intervals for keys spaced three notes apart:

Limulunga	672, 660, 675, 570, 645, 652, 636, 623.
Lealui	580, 697, 655, 680, 700, 645.,

and for keys spaced two notes apart:

Limulunga	465, 467, 485, 468, 485, 452, 462, 534, 463.
Lealui	515, 455, 500, 490, 485, 460, 490.

The intervals of the Limulunga instrument are considerably diminished from the pure fourth and fifth, to the extent that there are eight notes in the scale, whereas the Lealui xylophone has the more usual seven note scale.

Most of the xylophones in Western Zambia have a frame consisting of two horizontal rails which support the bars and four wooden legs which raise the instrument to a height comfortable for playing when standing. Although the Luyana instrument is similar in design, it is made lower so that the musician plays whilst seated. The Luyana xylophone was the only instrument I saw played in this way. Unlike most folk xylophones of the Lozi and Nkoya, the Luyana instrument has a very solid, well built frame using joinery usually associated with furniture (see figure 120).

Fig. 120 Luyana xylophone frame.

The Luyana xylophone has a single row of elongated calabash suspended from the two rails. Three rows of holes are drilled along each rail so that the calabash can be fine-tuned by raising or lowering their position.[41] The Litunga stressed that this was important not only because of seasonal changes but also because the instrument is usually played during the cooler hours of darkness. It is sometimes necessary therefore, when the instrument is played in the heat of the day for a ceremony, to adjust the position of the calabash. This method of fine-tuning the resonators works because the elongated (marrow-shaped) calabash react acoustically like a tube, so that when the sound source is moved away from the resonator the length of the tube is in effect lengthened.[42] On the Luyana xylophone in Limulunga some calabash were only 2.5cm from the keys, whilst others were 7.5cm.

The elongated calabash that are used for resonators are grown purely for this purpose. Cooking utensils, bowls and cups are always made from the spherical or bottle-neck calabash. Consequently the elongated variety used for xylophone resonators are grown by only a few farmers on the fertile soil of the flood plain. Once harvested the calabash are left to dry (whole) in the sun for about one month. The top (stalk end) is then cut off and the dried pulp removed by scraping. The pitch of a dried calabash can be heard quite easily by holding it loosely at its top in a vertical position and gently hitting it on the ground (earth). The pitches of the smaller calabash are tested either blowing across the aperture (opening) or by tapping the bottom of the gourd whilst holding the aperture to the ear. Ideally calabash are selected that are slightly flat of the pitch of the intended bar. Thus, tuning is usually effected by cutting down the calabash or making the aperture slightly larger thereby raising the pitch. Two small holes are burnt through the top of the calabash to locate the sticks that suspend the resonators from the rails.

The *silimba saLozi* has large mirlitons, one on each calabash. These are made by cutting a 20mm diameter hole near the bottom of the calabash and sticking a membrane over the hole so that it is air-tight. The material used for the membranes today is the very thin red or blue striped plastic bags produced in India and China. Previously materials such as the diaphragms of small rodents or the peritoneum of an ox were used, both being very thin and producing a similar sound to thin plastic bags.[43]

Luyana drums

Two hand-drums usually accompany the *silimba saLozi*; these are the *mwenduko* which is a very long (1.8 metres) single-headed drum, and the smaller *mwatota*, which is also single headed (see figure 121).

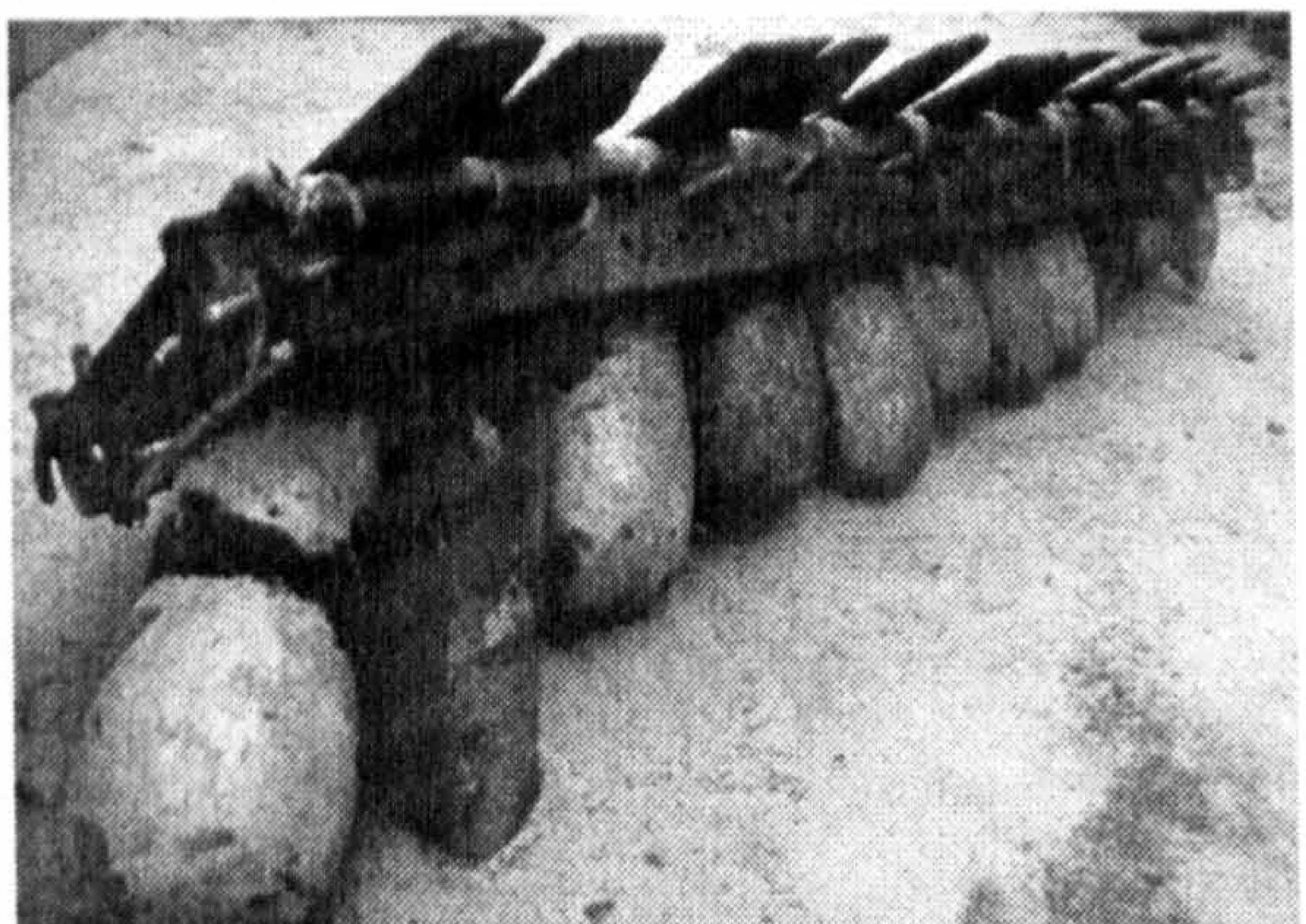
The two drums shown in figure 121 are permanently housed in the instrument building. Due to the length of the *mwenduko* it is supported at an angle so that it can be played whilst standing. The *mwenduko* is tied to a wooden stake embedded in the ground. The *mwatota* is also tied to the same stake but in a vertical position.

Both drums have a large amount of tuning paste applied to the centre of the skin. This paste is made from a mixture of soap, charcoal and a small amount of oil, though in former days banana took the place of soap. The paste is removed after every performance and re-applied before the following one. The paste not only lowers the pitch of the drums considerably, but also changes the sound, producing a tone with a sharp attack and a deep, almost beating decay, especially notable on the lower pitched *mwenduko*. The *mwenduko* is a very powerful drum and can be heard all over Limulunga during the night and early morning performances.

Fig. 121 Luyana drums.

Silimba siNkoya

The *silimba siNkoya* (see fig. 122), unlike most Zambian xylophones, is portable and can be played whilst walking. In construction, this xylophone is very similar to the *madimba* xylophone from southern Zaire shown in figure 123. The frames of both of these instruments consist of two rails upon which the bars rest. The rails are attached to a bail or arc which enables the xylophone's bars to be kept from hitting the body of the player when the instrument is slung from the shoulders. The xylophone also rests on the arc when the instrument is played on the floor and this is the usual style of playing (see fig. 124, *siNkoya* ensemble).



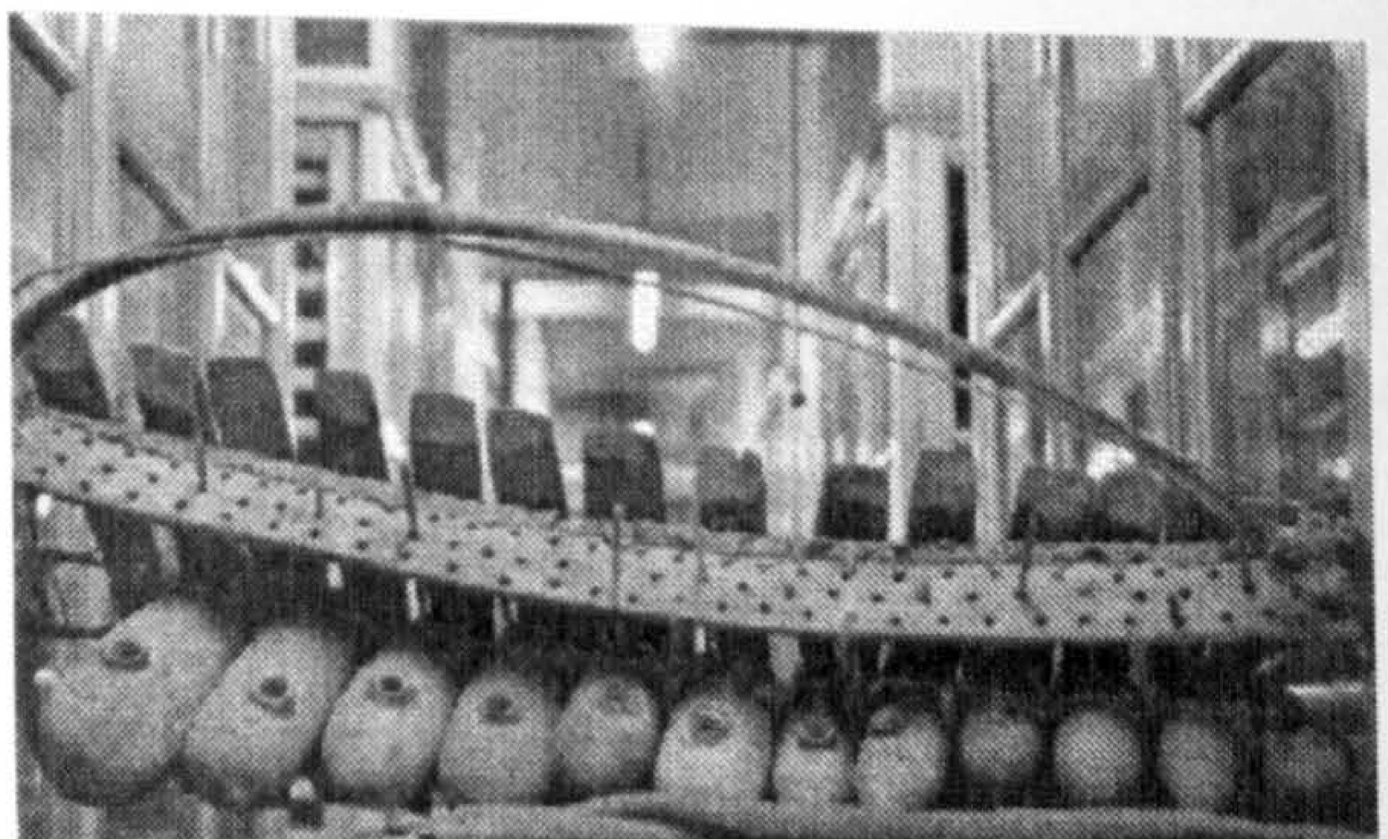


Fig. 122 *Silimba siNkoya*. Fig. 123 *Madimba* (Bena kanioka, Zaire).

Fig. 124 *SiNkoya* xylophone ensemble.

The bars of the *silimba siNkoya* are made of the same timber, *mukwa* (*pterocarpus angolensis*), as the royal Lozi xylophone. Unlike the Luyana xylophones, there is little difference between the tunings of *silimba siNkoya*. The tuning of the *silimba siNkoya* in Limulunga is given in table 7. The intervals of a *silimba siNkoya* studied by Brown [44] are also shown in the last column of table 7.

Table 7 Tunings of *silimba siNkoya*.

note	Hertz	cents (above C)	interval (cents)	interval (cents)
1 (1)	158.7	335		
2 (3)	202.0	752	417	333
3 (4)	239.9	1050	298	326
4 (5)	268.4	44	194	220
5 (6)	297.1	220	176	169
6 (1)	323.0	365	145	133
7 (2)	364.1	572	207	214
8 (3)	404.7	755	183	171
9 (4)	481.2	1055	300	318
10(10)	539.5	53	198	173
11(11)	592.4	215	162	221

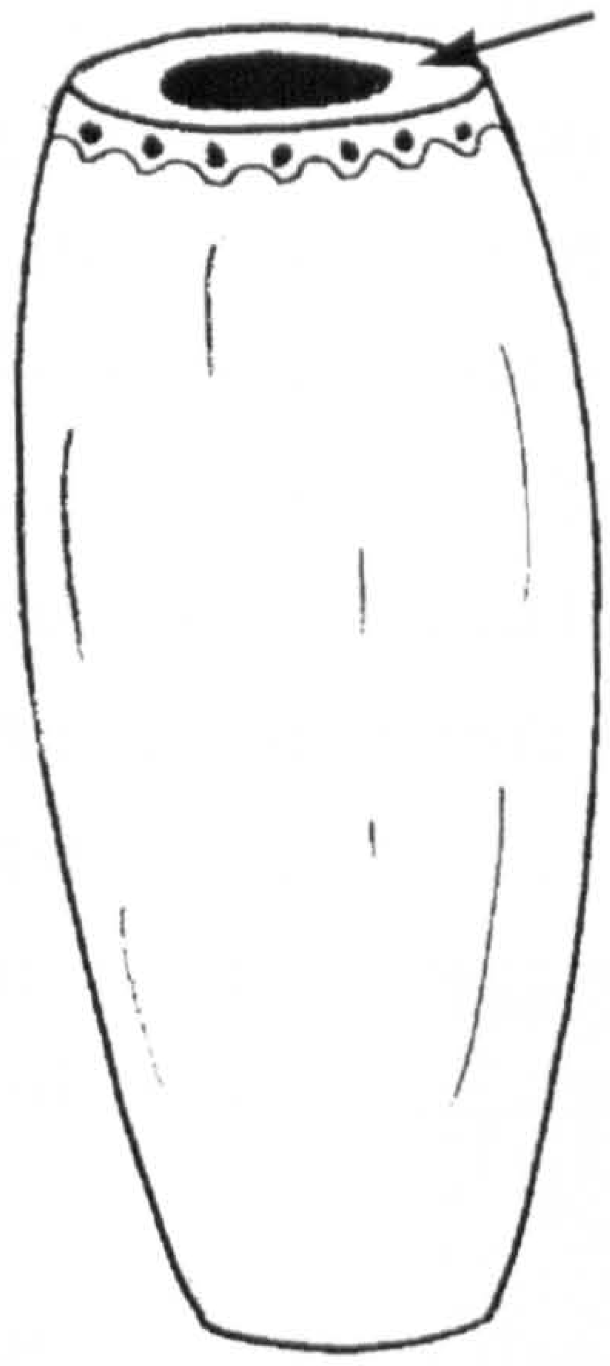
The note numbers that appear in brackets in the table are the pitch numbers in the scale after taking into account the missed pitch between 1 and 2. From the above tunings it can be seen that the octaves are accurate. *Silimba siNkoya* always miss a note between pitches 1 and 2; this results in a large interval, usually 300-400 cents. There is also a large interval of about 300 cents between pitches 2 and 3. This practice of having a minor or major triad in the lower three notes is also common amongst the Lozi and Nkoya folk xylophones.

Above these triads is a closer stepped scale with intervals generally less than one tone (200 cents). Brown [45] explains that the large interval between pitches 8 and 9 implies that a pitch between the two is missing; he therefore leaves out 9, preferring to refer to it as pitch 10, thus making the scale heptatonic. *Silimba siNkoya* are essentially hexatonic since the 'missing' pitch between 8 and 9 is also missing an octave lower. The confusion stems from the fact that certain Lozi and Nkoya xylophones do miss certain pitches in the lower two octaves which are included in the higher octaves. However, since the *silimba siNkoya* only ever has eleven bars the 'missed' pitch never occurs in the instrument.

SiNkoya drums

The three drums in the royal Nkoya ensemble are led by the single-headed *liolongoma*. This drum is similar in shape to a latin conga, having a 35cm diameter head and a pronounced belly in the shell, decreasing in size to a small bottom opening (see figure 125). The two other drums, *sitendewa* and *luwawa,* are quite different, both being double-headed. The shells are double-bellied, with a narrow straight waist (see figure 126). The unusual feature of these drums is that they have mirlitons. The mirlitons are made by cutting a 30mm diameter hole in the waist of the shell. This hole is then covered with a thin membrane, usually a piece of plastic bag.

The *sitendewa* is larger than the *luwawa,* the former being tuned lower. All three royal Nkoya drums are tuned by applying a large amount of tuning paste. After each performance the paste (made from charcoal, soap and oil) is scraped off. Prior to the following performance, the drums are placed close to a fire so that the skins are heated and become taut. The tuning paste is then applied (see fig. 127).



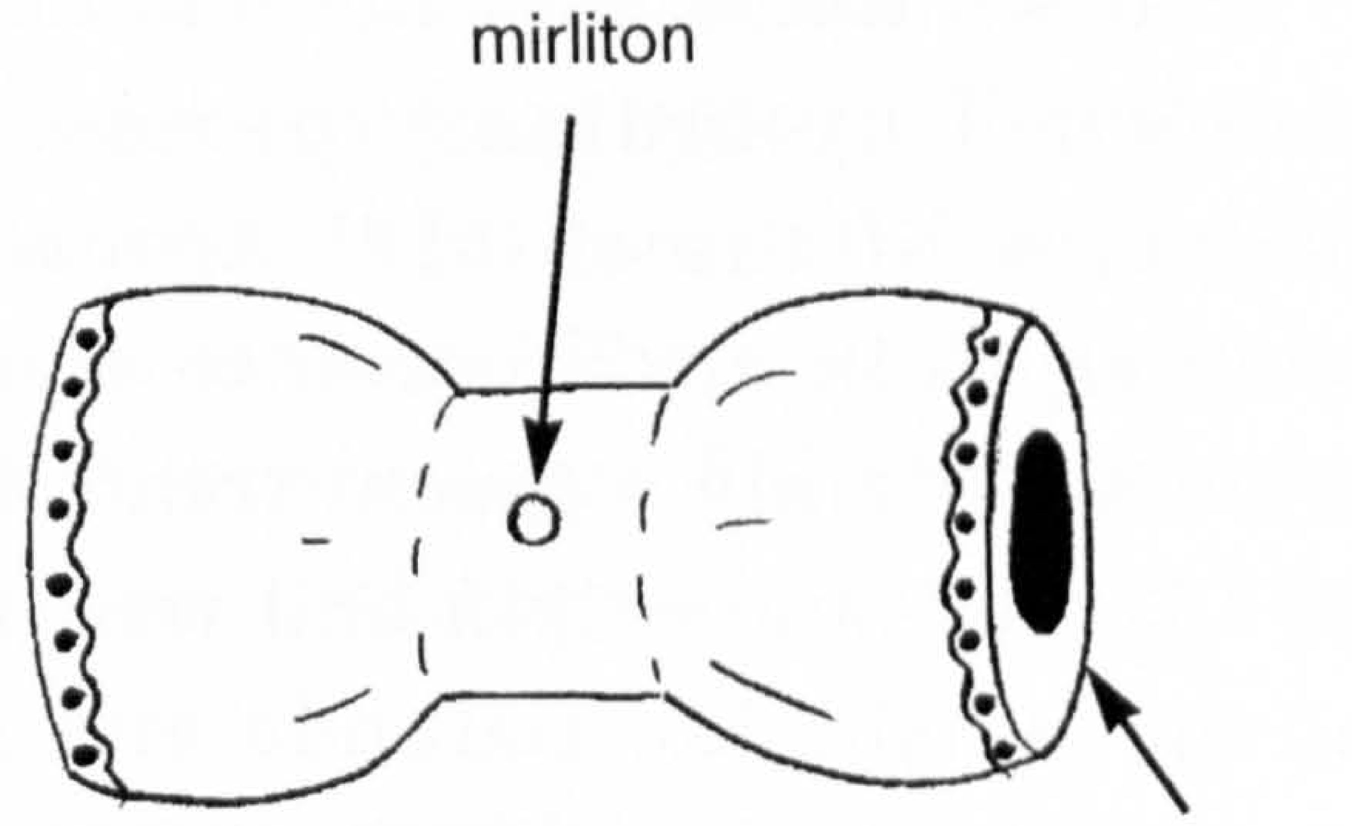


Fig. 125 *Liolongoma* drum. Fig. 126 *Sitendewa* and *luwawa* type drums.

Fig. 127 Heating the drum skins and applying the tuning paste.

Brown [46] notes that these double-headed buzzing drums are called *munkupele* among the Nkoya. This unusual type of drum is also used by the following peoples in Angola and Zaire:

a) the Chokwe in Angola call it *munkupele,*

b) the Batshioko in southern Zaire call it *mukupela* or *mukupiela,*

c) the Balunda in southern Zaire call it *dikubila,*

d) the Bapende in southern Zaire call it *kadia m'buji*.

Brown noted that the *munkupele* drums among the Nkoya may not be owned by ordinary people, these instruments always being the property of the chief.[47] Around Limulunga this is not the case as ordinary folk are allowed to own *sitendewa* or *luwawa*, though this is almost certainly a recent trend. Boone[48] notes that this type of drum is of "Rhodesian" origin and was probably introduced by previous rulers of the Batshioko, Balunda and Bapende. Boone reports that amongst the Batshioko and Balunda, this drum symbolises dignity and as such is only used by musicians of kings and important chiefs; lesser chiefs are not permitted to possess such drums.[49]

These double-headed drums produce an amazingly loud, almost electric sound, due to the buzzing of the mirliton. In order to produce the correct sound they have to be struck very hard with the hand. The tone produced has a very long decay for a membranophone, and this, together with the striking method, dictates the slow style that these drums are played in. The high and low-pitched *munkupele* usually play in interlocking fashion to produce a steady alternate low and high buzzing drone. The master drum, *liolongoma*, plays syncopated rhythms over this more or less steady pulse.

The *sitendewa* and *luwawa* in Limulunga were both made of *mukwa* (*pterocarpus angolensis*) since this timber is reasonably light and very resonant. Nowadays it is very difficult to find trees large enough to make drums purely from heartwood; the sapwood may be 75mm thick, so it is common to see drums that appear to be made from ordinary white wood (see fig. 127).

Traditionally, these double-headed drums were skinned with antelope skin but nowadays, since these animals are so scarce, the thicker hide of long horn domestic cattle is used.

FOLK XYLOPHONES OF THE LOZI AND NKOYA

Xylophones are very popular amongst the Lozi and Nkoya; every village seems to have one or two instruments set up under either a purpose-built shelter or under the cover of a large mango tree. The xylophone (*silimba*) is the main instrument of musical expression for the Lozi and Nkoya. The folk xylophones of the Lozi and Nkoya are very similar in construction and tuning

Folk xylophones range in size from small fourteen-bar instruments to massive twenty-eight-bar instruments played by four people. The size of the *silimba* is up to the individual maker; he is not constrained by tradition as are many African xylophone makers. The *silimba* is quite unusual amongst African xylophones in that the legs of the frame raise the instrument three feet off the ground so that they are played whilst standing (see fig. 128).

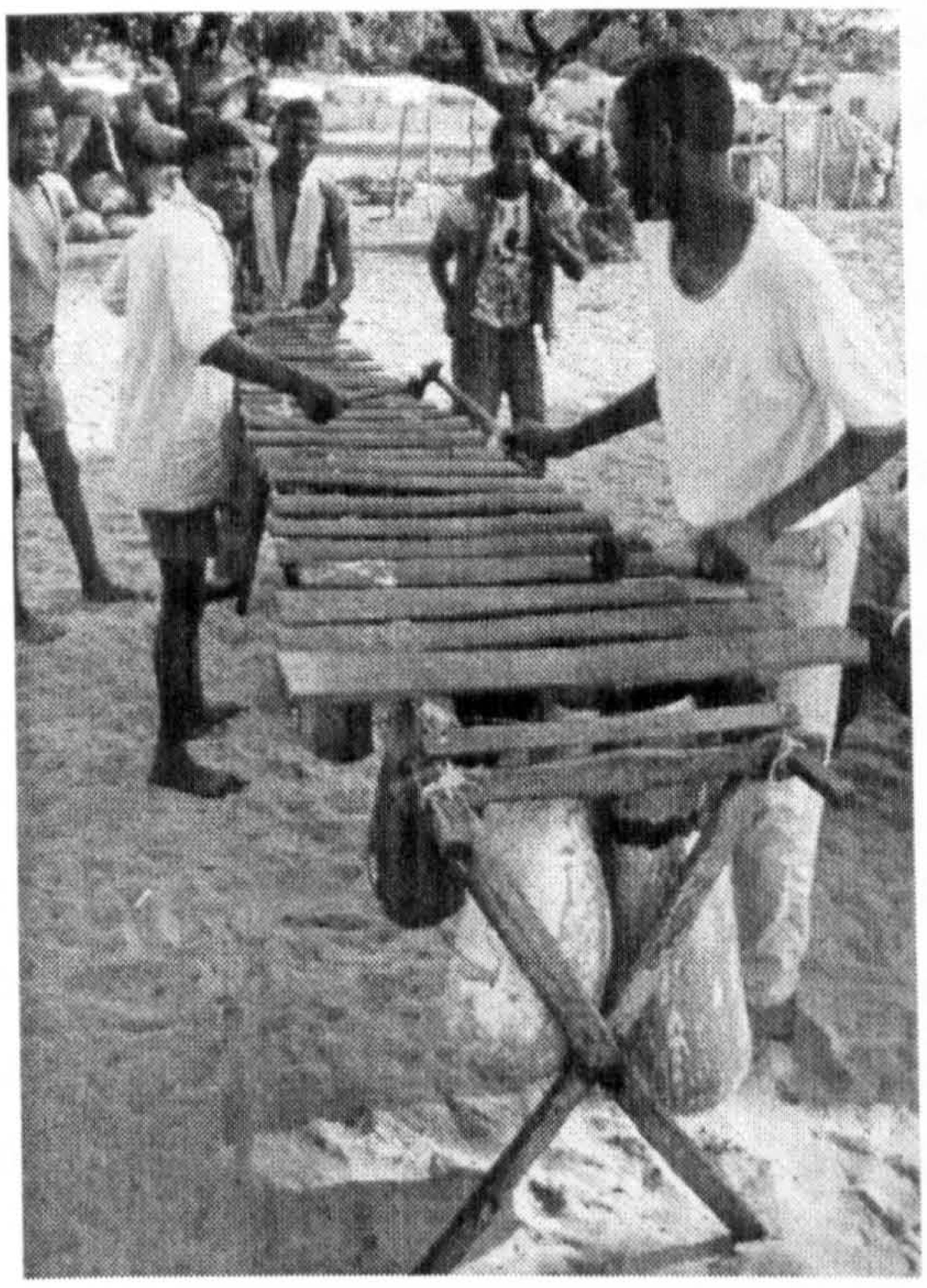


Fig. 128 *Silimba* being played at a millet beer stall.

Most of the folk xylophones are used purely for entertainment, although there are also specific xylophones for initiation (boys and girls) and circumcision ceremonies.[50] During my research I did not manage to find any such instruments.

In the towns the *silimba* is played at millet beer stalls providing the entertainment for the clientele (see fig. 128). The musicians are usually youths aged between ten and sixteen. Typically, a group of three boys will acquire a xylophone and strike a deal with a beer seller to provide the entertainment. The thick, soup-like, millet beer is brewed (usually by women) in an oil drum. The xylophone players get paid a small amount of money for each drum that is drunk.[51] There is quite a lot of competition between groups of players - the better they are the more money they can earn by attracting more customers.

The *silimba* is only played by males and they normally start learning at a very young age; children often stand on boxes so they can reach the bars! The musicians described their music as being a critique on society, taking stories/events and publicising them through their music. One such song, called *nyanja,* tells of a man who kidnapped a young boy and extracted his heart and kidneys and used them for his witchcraft. The man was later caught and convicted. The dual message of the song was that people are not always what they appear and that such crimes are always found out eventually.

The folk xylophones are not usually accompanied by drums, although occasionally, a log or slit drum (*chingubu*) may be used. As a result of this the xylophones are made as loud as possible by using two calabash resonators for many of the bars.

The quality of folk xylophones is quite variable because musicians will often make their own instruments as opposed to buying from a specialist maker. Most xylophone makers do not make a living purely from instrument making, and like the majority of the population in the rural areas, they are first and foremost farmers. A few Lozi and Nkoya instrument makers do make a more or less constant living from xylophone making (as well as drum and general craft making) by making smaller instruments for the tourist trade. These men usually move to Livingstone where tourists flock to see Victoria Falls. Instruments made for the tourist trade are usually of poor quality and are instantly recognisable by the burnt patterns on the bars.

I saw a large *silimba* in the process of being made just outside of Limulunga on the flood plain. The maker, Lubinda Mushoke, sold instruments on a commission basis locally around Mongu. Lubinda said he made only one or two instruments every dry season when he was not occupied with farming. Having gathered all the materials, it generally takes between three and four weeks to make a large twenty-bar *silimba.*

Any type of locally available timber is used for the frame, which is considered the easiest part of the instrument to make. The frame is usually made after the bars. The bars are made of the same timber, *mukwa* (*pterocarpus angolensis*) as are those of the royal xylophones. Lubinda has a stock of *mukwa* drying in an outbuilding, which is replenished every year. Although he used to cut his own timber, this has become increasingly difficult due to the scarcity of suitable trees around Mongu. Consequently, Lubinda occasionally buys hand-sawn boards from the government sponsored furniture workshop in Mongu. Timber which Lubinda has cut himself is split with wedges and left to dry for two years. When converting logs in this manner it is difficult to get sections large enough from which to make the lowest-pitched bars; they are usually 15cm wide and at least 80cm long. Since this timber grows spirally it is impossible to split the log so that straight boards are produced. Therefore, Lubinda splits the *mukwa* into thick wedges so that he can carve a straight board from a twisted wedge. This is done by making one side flat by cutting diagonally across the grain with an adze and then turning the board over and repeating the operation. This involves a lot of work and consequently many tourist instruments and some DIY instruments have badly twisted bars.

All of the bars are roughly shaped with an adze and left to dry for at least two weeks before final shaping and tuning. Lubinda tunes his instruments with reference to his own twenty-bar *silimba*, unless the buyer specifically asks for a different tuning. The tuning is done with an adze, removing timber on the under-side of the bar between the nodes to lower the pitch, and on the under-side at the ends of the bar to raise the pitch. Lubinda has a long pit dug into the ground (functioning as a resonator) over which he places the bars when testing the tuning. The bars rest on bundles of tied-up grass along either side of the pit. Every bar is first tuned individually to the reference instrument and then the new bars are tested together by playing pairs of notes alternately and in unison to check intervals. Lubinda starts by testing bars three pitches apart, ie. 1 and 5, 2 and 6 etc., producing the approximate interval of a fifth. The intervals in cents of notes three pitches apart starting from the lowest are:

690, — , 710, — , 718, 709, 663,
682, 677, 699, 688, 718, 693, 680,
700, 667, 706, 675.

Having tested intervals of a fifth, Lubinda then tests bars two pitches apart, ie. 1 and 4, 2 and 5 etc., producing intervals of an approximate fourth. The same procedure is then carried out with bars one pitch apart. The intention is to produce a scale where intervals of fourths and fifths occur all the way up and down the instrument.

The tuning of two Lozi *silimba* are shown in table 8. Lozi and Nkoya *silimba* always omit either two or three pitches in the first octave. These are left as gaps in the table. The first tuning in table 8 is that of Lubinda's instrument.

<u>Table 8 Tunings of two *silimba* in Limulunga.</u>

Hertz	cents (above C)	interval (cents)
93.4	616	
---	---	368
115.5	984	
---	---	322
139.1	106	---
		176
154.0	282	
		212
174.0	494	
		136
188.2	630	
		194
210.6	824	
		167
231.9	991	
		166
255.2	1157	
		155
279.1	112	
		189
311.3	301	
		189
347.2	490	
		150
378.6	640	
		190
422.6	830	
		165
464.6	994	
		176
514.3	1170	
		170
567.3	140	
		157
621.2	297	
		203
698.5	500	
		145
759.4	645	

Hertz	cents (above C)	interval (cents)
77.4	290	
---	---	455
100.6	745	
---	---	255
116.5	1000	
---	---	410
146.7	210	
		130
159.2	340	
		200
178.7	540	
		170
197.1	710	
		185
219.4	895	
		130
236.5	1025	
		160
259.4	1185	
		209
292.7	194	
		166
304.0	360	
		160
353.3	520	
		155
386.4	675	
		180
428.7	855	
		139
464.6	994	
		176
514.3	1170	
		155
585.3	125	
		185
625.9	310	
		187
697.3	497	

The tunings of two Nkoya *silimba* from Kaoma are shown in table 9.

Table 9 Nkoya *silimba* tunings from Kaoma .

Hertz	cents (above C)	interval (cents)	Hertz	cents (above C)	interval (cents)
77.0	282				
---	---	306			
91.9	588		91.9	588	
---	---	372	---	---	342
113.9	960		111.9	930	
---	---	400	---	---	328
143.5	160		135.3	58	
		125			180
154.2	285		150.1	238	
		248			142
178.0	533		162.9	380	
		127			163
191.5	660		179.0	543	
		195			185
214.4	855		199.2	728	
		175			144
237.2	1030		216.5	872	
		168			156
261.3	1198		236.9	1028	
		172			190
288.6	170		264.4	18	
		140			168
312.9	310		290.3	180	
		215			160
354.3	525		318.4	340	
		170			180
390.9	695		359.5	550	
		155			190
427.5	850		398.4	728	
		195			164
478.4	1045		438.0	892	
		157			163
523.9	2		509.8	1055	
		198			203
587.3	200		541.1	58	
		140			145
636.8	340		588.4	203	
		185			197
708.6	525		659.2	400	
		177			142
784.9	702		715.1	542	
					136
			774.1	678	
					157
			847.6	835	

The Nkoya silimba tunings are from instruments in Kaoma; the Nkoya capital which lies 200 kilometres east of Mongu. Comparing the four sets of tunings in tables 8 and 9, it can be seen that the low note of these *silimba* varies from 77 hertz to 93.4 hertz (D# to F#). It is very unusual to find an instrument with a lower starting pitch than D#. Lozi and Nkoya tunings are surprisingly similar; they either start at D#, in which case three notes are missed out, or they start two pitches in the scale higher at F#, in which case only two notes are left out. Therefore, between each of the lowest three or four bars, there are always intervals of a third (300 to 400 cents). Above these large intervals the scale ascends in a series of non-equal intervals arranged to produce a scale where intervals of approximate fourths and fifths occur between bars two and three pitches apart.

Having tuned all the bars and constructed the frame, the next task is to select and tune the elongated calabash resonators. It is usually impossible to find calabash large enough to correspond to the lowest pitches on the xylophone, so it is common practice to build a suitably large enough resonator by sticking together two or even three calabash (this can be seen in fig. 128). The calabash are stuck together with either beeswax or tree gum.

These elongated calabash are very efficient resonators because of their large apertures,[52] typically 10cm or more on the lower pitches. Even though a *silimba* with such large resonators is very loud, the makers increase the volume of the instrument by using two resonators for many of the bars. Usually bars one to ten have two resonators with the exception of bar two which always has just one resonator.

Fig. 129 Lozi *silimba,* note the three narrow bars.

Since the resonators are so large and numerous, it is difficult to fit them all under their corresponding bars. This is overcome by stringing in to the bars one, two or three untuned bars, thus increasing the spacing. Some makers use untuned bars the same width as adjacent ones, and therefore only one or maybe two are used. Other makers use untuned bars of half the usual width and therefore tend to use either two or three to gain sufficient space (see fig. 129). Full-width untuned bars are usually marked with some sort of pattern to distinguish them (see fig. 128, bar four), while half-width ones are obvious and are left unmarked. Each calabash resonator has one mirliton near its lower end. The holes, about 2cm in diameter, are covered with pieces of plastic bag.

Most Lozi *silimba* around the Mongu/Limulunga district have between nineteen and twenty-one bars giving a range of about three octaves. These instruments are usually played by three people, each person normally limited to playing one octave. The playing style of the lowest octave is characterised by fast, repeated patterns in duple time playing the lowest note (pitch 1) on every beat so that a continuous loud drone is produced. Consequently, pitch 2 is rarely used (hence it only has one calabash resonator) since the low pitches 1 and 2 played in quick succession would overlap. The player of the middle octave plays the melody which is embellished upon in the highest octave in a counter rhythm, often in triplets.

Nkoya *silimba* are played in a similar style although it is more common to find smaller two octave instruments among the Nkoya than the Lozi. Such instruments are played by just two musicians.

COMPARISON OF ROYAL AND FOLK INSTRUMENTS AMONG THE LOZI AND NKOYA

All of the xylophone traditions amongst the Lozi and Nkoya are thriving. It may appear that the royal Lozi tradition is stagnant since there is no one left who can recite the praise songs in the Luyana language, but it is viewed with such respect and reverence by the people that it can be seen as the most important tradition, and as such, will definitely not fade away. The royal Nkoya tradition, like the Lozi and Nkoya folk traditions, is very very much alive and still developing with new additions to the repertoire.

The main difference between the two royal traditions and the two folk traditions is how rigid the royal traditions are in terms of music and instruments used. The royal traditions were created to promote respect for power and the stability such power can give. The traditions therefore must appear to remain stable, despite what ills the people suffer (famine, hardship, or in former years, war) there is always something which will survive hardship and give hope to the people.

Brown [53] argues that the Lozi royal tradition is set apart from both the Nkoya royal tradition and the two folk traditions:

> (I) hope to show that musical structures in Western Zambia are closely related to society and that musical structures in this region cannot be fully explained without considering their relationship to society. The essence of the argument is that Nkoya musical structures reinforce social cohesion and Lozi (royal) musical structures reflect social stratification. This contrast in musical structures is a product of differences in social development of these two peoples. My argument is based upon a comparison of tuning systems and musical style among the Nkoya and Lozi.

Brown adds "The similarity in commoner's and royal instruments is a reflection of the homogeneity and cohesion of Nkoya society".[54] Most of Brown's arguments I agree with, in particular that the Lozi royal tradition reinforces social stratification. As explained earlier, Lozi royal instruments and music are completely different from anything else found in Zambia. It is also true that Lozi society is very class-orientated; this is instantly apparent even to outsiders with greetings involving bowing and clapping guided by social standing. However, I do feel that the royal Nkoya tradition does not exactly promote social cohesion because the sound of the ensemble is so different to the Nkoya folk tradition. This striking difference comes from the use of the double-headed mirliton drums, and the history of ownership involved with these instruments as described in this chapter under *siNkoya* drums.

Traditional folk music and dance is very popular in Western Zambia. There are many local dance and music groups all over the region and they regularly compete. The Nayuma Museum in Limulunga, which is basically a celebration of Lozi culture, has a dance arena where groups regularly perform. In this way the people are encouraged to take an active part in their culture and this success is very similar to the way the LoDagaa people have encouraged their culture in North West Ghana.

The Lozi and Nkoya royal traditions survived the colonial era through Western Zambia being made a Protectorate, keeping the royal establishment in power, albeit as a puppet government with no financial power. Members of Lozi royalty were educated and this has enabled them to feature prominently from an early stage in Zambian independent politics. Thus, although Western Zambia is remote from the centre of government, it has been able to influence decision making unlike the Sisaala in northern Ghana.

CHAPTER XI

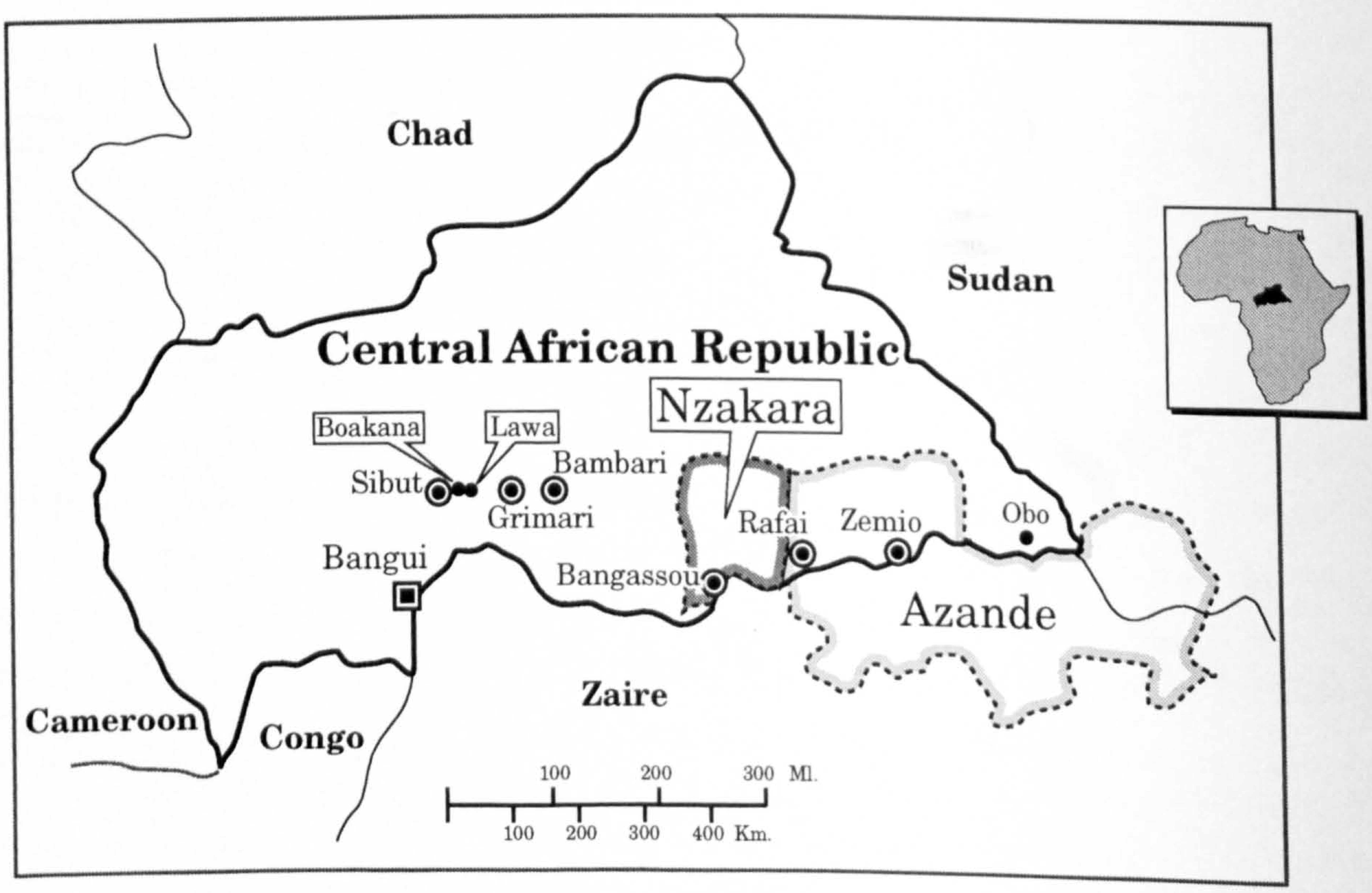
XYLOPHONES OF THE AZANDE AND NZAKARA IN CENTRAL AFRICAN REPUBLIC (C.A.R)

INTRODUCTION

This study seeks to examine the role of xylophones among the Azande and Nzakara living in the eastern part of Central African Republic (see map 5). These two neighbouring peoples share similar origins and culture and both, significantly, use a unique type of xylophone, known as *manza* by the Azande, and *nzanzangoula* by the Nzakara. These portable instruments have ten bars tuned to a pentatonic scale and arranged in paired octaves, with the lowest pair usually on the player's left:

1 1' 5' 5 4' 4 3' 3 2' 2.

The xylophone is played with four beaters, two held in each hand to facilitate playing the paired octaves. The *manza* is reserved exclusively for the use of chiefs, kings and their court musicians. In addition to the *manza,* the Azande also use a log xylophone known as *kpaningbo,* and the making and function of this instrument is briefly covered.



Map 5 Azande and Nzakara in C.A.R.

Sources of information.

Very few publications deal directly with *manza* and *nzanzangoula* xylophones. This may in part be due to the rarity of such instruments in their respective cultures, due to their special use and the consequent restriction on ownership. The most notable publication is Olga Boone's *Les Xylophones du Congo Belge* [1] (present day Zaire). This book, published in 1936, is part of a series of analytical notes on the collection of what is now the Musée de l'Afrique Centrale.[2] The book deals mostly with instrument construction, materials used, and geographic distribution of instruments and peoples, with a little field research on the music. Boone had to rely on scraps on information sent back by missionaries and colonial administrators so there is little information on how the instruments were constructed, the music, the musicians, or the importance of the instruments in the society.

Simha Arom conducted a study of the music of Central African Republic [3] but does not mention the *manza* or *nzanzangoula* of the Azande and Nzakara. He does cover the music of the *kalangba* xylophone of the Banda-Linda and the *manza* xylophone of the Sabanga peoples; these instruments are very similar to the *manza* of the Azande and Nzakara in that they have ten bars arranged in paired-octaves and are tuned to a similar pentatonic scale. However, the function of the instruments is completely different since the Sabanga and Banda-Linda use their xylophones for recreational and ceremonial music as opposed to court music.[4]

Ethnographic studies and accounts of the Azande are more numerous and provide a relatively thorough historical account. E.E. Evans-Pritchard made exhaustive studies of spiritual beliefs among the Azande.[5] Eric de Dampierre wrote a comprehensive historic and ethnographic study of the Nzakara and the Bandia kingdom.[6]

Research methodology

My attention was first drawn to the *manza* type of xylophone during a study of the collection of one hundred and forty-nine xylophones at Le Musée de l'Afrique Centrale in 1987. These instruments stood out from the many types of xylophones in Zaire as being particularly well made and of a very sophisticated design.[7]

Two field trips were made to C.A.R. The first field trip, planned to be for five weeks, was abruptly cut short with my forced ejection from the eastern region after only two weeks.[8] The second, more successful period of field research was conducted between March and June 1990. Prior to the field trips, a week was spent at the Université de Paris X, Nanterre, studying at the Laboratoire d'ethnologie et de sociologie comparative. Dampierre, who has spent many years researching in C.A.R. among the Nzakara and Azande, gave much help offering his comprehensive library with field recordings he made in the 1960s at my disposal. Dampierre advised me where I might still find the *manza* in use, but was realistically pessimistic about finding Azande in C.A.R. still using the *manza*. He gave me the names of four Nzakara xylophone players and one maker living around the town of Bangassou.

The first month of the field trip was spent around Bangassou conducting interviews and travelling by bicycle to outlying villages trying to find musicians, makers and instruments. From Bangassou I continued east to Zemio to study Azande instruments and then returned to Bangui by bicycle stopping at Bambari and Grimari to catch a glimpse of the xylophones of the Banda, Linda and Sabanga peoples.

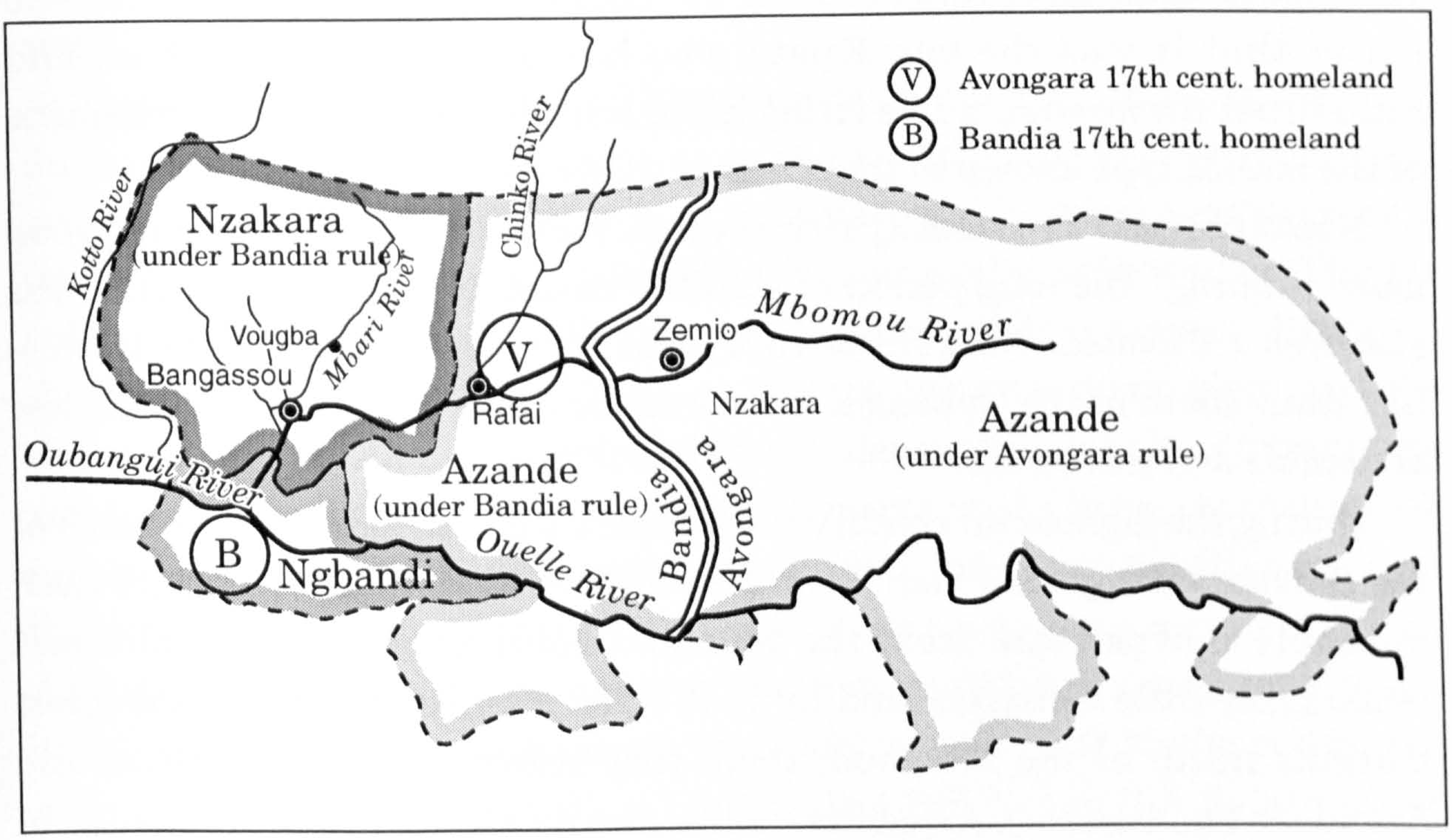
Historic and geographic background of the Azande and Nzakara

Before the colonial era the Azande, under their ruling clan the Avongara, ruled over a large region which is centred between the Uelé river in Zaire and the Mbomou river in C.A.R., with pockets spilling over into C.A.R. and Sudan (see map 5). An Ngbandi clan, the Bandia, ruled to the west of the Avongara over the Nzakara and some Azande (see map 6). The Azande live in what is today the Mbomou and Haut-Mbomou regions of C.A.R., the Al Istiwa Iyah region of Sudan and the Haut-Zaire region in Zaire.

The Azande are an agglomeration of invading Sudanic and indigenous tribes of different origins, languages and cultures which merged into one more or less common group of people over the last two and a half to three centuries.[9] The original Ambomu conquerors, under the leadership of their ruling clan, the Avongara, dominated the area both politically and militaristically holding back the Arab slave-traders who decimated the Banda [10] population and many others in non-Azande areas in C.A.R. Although oral traditions identify the Avongara as a foreign conquering group, they were probably an indigenous clan that subdued its neighbours.[11] Cordell cites Ngura as the first identifiable Avongara leader who "ruled an Azande group in 1750 and later rulers reckoned their descent from him." [12]

The Avongara Azande state consisted of a series of individual chiefdoms; the Avongara appointed members of their ruling clan as chiefs with domains set up as individual units. Cordell [13] notes that no Azande 'nation' as such existed:

> Instead they founded a series of large chiefdoms spread through space and time. Ties with the Avongara clan legitimised each chiefdom, but expansion occurred through division and migration rather than through the growth of a unitary state.



Map 6 Avongara and Bandia kingdoms. Source: Eric de Dampierre, *Un Ancien Royaume Bandia du Haut Oubangui*, p. 92.

Division was actually built into the political system since domains were not inherited as whole units; Evans-Pritchard [14] writes: "The king died and the kingdom was not inherited by any one son. Each of them became an independent ruler of his own territory."

The Arabs made contact with the Azande in 1841 at Gondokoro but were overwhelmed by Azande strength.[15] The usual slave trading techniques of fostering inter-tribal wars to divide enemies and then obtaining prisoners as slaves did not work with the well organised Azande kingdoms. Some

Azande chiefs traded with the Arabs obtaining guns which they used to run their own slave trade, taking Sere and Ndogo peoples.[16] The main Azande population in the Uelé region (Zaire) carried on their expansion virtually unhindered until the European colonial (Belgium, Britain, and France) scramble for power in the late 1890s. However, the western section of the Azande territory in C.A.R. was overrun during the eighteenth century by the Bandia, an Ngbandi clan from the south.

The Nzakara live to the west of the Azande in C.A.R. (see map 6). Baxter [17] puts forward the theory that the Nzakara seem to originally have been a Banda speaking people. Dampierre [18] states that the Nzakara lived in relative tranquillity for four or five centuries under the rule of the dominant, warlike, vou Kpata clan, until some time in the eighteenth century. Dampierre also states that it was the vou Kpata who had a rich musical culture and introduced the *koundi,* a five string harp, and the *kpan(d)ingba*, a xylophone of the *manza* type known to the Nzakara today as *nzanzangoula.*[19]

Nzakara territory is mostly rich savanna (with easy access) providing good game hunting. The long period of stability meant that much of the land was also well cultivated. Nzakara territory was therefore very attractive to war-like clans south of the Oubangui, where the land is more densely forested, less accessible and less fertile.

During the eighteenth century the Nzakara suffered defeat at the hands of the Bandia, an Ngbandi clan from the southern bank of the Oubangui river, probably downstream from the Mbomou confluence.[20] The Bandia met remarkably little resistance and by 1800 ruled a series of states on the forest margins north of the Mbomou; there they ruled over both Nzakara and Azande.[21] The Bandia conquerors, unlike the Avongara, assimilated much of the culture of their subjects, adopting the Nzakara language and intermarrying on a wide scale.[22] Cordell, quoting Dampierre, writes "the Bandia adopted major institutions, such as the ancestor cult, which integrated them into indigenous lineage organisation".[23] The Bandia rulers, unlike the Avongara, established a large unified kingdom. Under their kings Mbali and later Bangassou at the end of the nineteenth century, the Bandia state north of the Mbomou river extended some 200 kilometres north into the savanna with an equivalent west-east axis; much larger than any single Azande unit.[24]

During the latter half of the nineteenth century Mahdist forces took control of virtually the whole of present day C.A.R. for slavery purposes, but largely left the stronger Azande and Nzakara to their own devices.[25]

After the final defeat of the Mahdist forces by the Europeans, the Anglo-French Convention of 1899 split up the area into the present defined borders resulting in joint Anglo-Egyptian rule in Sudan, French rule in C.A.R. and Belgian rule in Zaire. Colonial military rule ensued and effectively stopped the slave trade and halted Azande and Nzakara expansionism.

During the first twenty years of colonial rule in all three countries, the military administrations set about breaking up the power of the Avongara and Bandia. This involved dismantling the military strength through seizure of weapons, and curtailing the control of the chiefs' legal powers by replacing them with District Officers. These policies affected the root of Azande and Nzakara life and culture and led to the end of the supremacy of the Azande and Nzakara kingdoms.[26]

Once the Azandé's power had been destroyed, the civil administration in Sudan reversed the policy and sought to build up Avongara chiefs, presumably to cut down the cost of colonial rule in what was seen as a remote, inhospitable region [27] with little further exploitable wealth. Similar policies were adopted by the French and Belgian colonial powers. However, the destruction of Azande and Nzakara culture was almost complete, and the European introduction of sleeping sickness, decimating whole communities, acted as the final blow. The colonial governments in the three countries took preventative steps by moving people away from the rivers to settlements on the roads, but for most this came too late and was also resented by the Azande and Nzakara whose life was made more difficult away from water supplies. The Azande and Nzakara gradually moved back to the rivers, but more recent policies, such as those by President Bokassa in C.A.R. introduced to keep a tight control over people, forced villagers back to settlements on the roads.

The Azande and Nzakara suffered massive depopulation during the 1950s as a result of venereal disease. The present threat of AIDS is even more disturbing.

The Azande and Nzakara have suffered much over the last century and the situation seems unlikely to improve. A major problem for the Azande is that their once powerful series of related kingdoms was carved up in 1899 resulting in the Azande living in the remotest parts of all three present day countries; C.A.R., Sudan, and Zaire. In turn, this has resulted in the Azande regions lacking a political voice at a national level which is so important in terms of gaining investment in the infrastructure; education, health, communications and industry.

XYLOPHONE TRADITIONS AMONG THE AZANDE AND NZAKARA

From the capital, Bangui, I travelled to the town of Bangassou which is the centre of the Nzakara nation. Eric de Dampierre had previously given me the following list of people living around Bangassou who he suggested might be able to help with my research:

Gbiate, living at Banguiville, Bangassou (musician),
Bazouma, living at Yogbo-Mbonyo (musician),
Sano, living at Vougba (musician),
Kété, living at Mbalazimé (musician),
Dengba, living at Banguiville, Bangassou (xylophone maker, musician).

From my arrival in Bangassou I stayed with Gbiate, who helped and guided me, the two of us cycling to villages trying to find makers and musicians. It soon became apparent that the xylophone tradition among the Nzakara was fading into obscurity; Gbiate himself had not played for at least twenty-five years and we were unable to find anyone in Bangassou who still possessed one of the ten-bar portable xylophones, *nzanzangoula*.

Dengba, a very old instrument maker, was more encouraging, but still he only had a very old set of xylophone bars, given to him many years ago because he was the only person in the area who would look after them understanding their importance.[28] Most of the information contained here on the Nzakara tradition was gathered during a series of interviews with Dengba. During my stay in the Bangassou area I managed to find only two complete instruments; these were owned by Sano, the chief of the village of Vougba which lies on the Mbari river, 50km north east of Bangassou. Among the other villages I visited was Mbalazimé to find Kété, the musician Dampierre had recommended. Kété was very old and so frail that he was unable to play. He also had not played for twenty-five years. I could not find Bazouma, the musician in Yogbo-Mbonyo. In all the other villages I visited, they either did not know anyone who possessed *nzanzangoula*, or referred me to Sano at Vougba.

The instruments

The Nzakara traditionally have three different melodic instruments:

a) *nzanzangoula*, the ten-bar portable xylophone,

b) *koundi* or *ndara*, five or ten string harp,

c) *koundi*, twelve or thirteen reed lamellophone.

In addition to these the Nzakara also have skinned drums and many different sized log, or slit drums used mainly for communication. The art of making the slit drums has been all but lost because these large instruments take months to carve and no one is prepared to pay for replacements when they eventually rot. A log xylophone, *kpaningbo,* is also occasionally played in and around Bangassou, although this has been introduced by the Azande living in the area. Nevertheless, the young Nzakara men do play this xylophone which is gradually being assimilated into their own culture.

Today, the rarest of all the instruments is undoubtedly the *nzanzangoula*. This xylophone was used exclusively by chiefs, kings and their court musicians, whereas the other instruments were used for both folk and court music. This section describes the two xylophones in Vougba.

These two *nzanzangoula* are owned by Sano, the chief of Vougba and are shown in figure 130. Both of these instruments are very old, at least sixty years, according to Sano, and possibly much older. The workmanship is of extremely high quality, as good as the best Azande *manza* in the collection of Le Musée de l'Afrique Centrale. Unfortunately the *nzanzangoula* in Vougba were not in good playing condition, with loose or missing calabash resonators showing they are not in regular use. Figure 131 shows the method of playing whilst standing.

Fig. 130 Sano, chief of Vougba playing *nzanzangoula* with a friend.

Sano said that the *nzanzangoula* had not been in regular use for about twenty years, although they had been repaired over this time, replacing the broken calabash and re-stringing the bars.[29] Unfortunately no one in the area (including the whole Bangassou area) still grows the special elongated calabash (*mami kpaningbo* [30]) used for the resonators.[31] The broken resonators had been replaced with bamboo tubes which can be seen in figures 130 and 131 (the outer skin of the bamboo has been removed). The original calabash resonators were very brittle and have gone black because of the wood smoke in the hut in which they were kept.

Fig. 131 Playing *manza* whilst standing.

It can be seen from figures 132 and 133 that the arrangement of the bars on the two *nzanzangoula* is different (notice the size and order of the calabash). Sano used the term *nzanzangoula* to refer to their xylophones in general, although each instrument has its own particular name. The instrument in figure 131 is called *manza,* and has the usual arrangement of paired-octaves with the lowest pair on the player's left, and the other pairs ascending in pitch from right to left:

1 1' 5' 5 4' 4 3' 3 2' 2

The xylophone in figure 133 is called *ngokoua*. It is tuned two pitches higher than the *manza*, and has the following arrangement of paired bars:

$5\ 5^1\quad 3^1\ 3\quad 4^1\ 4\quad 1^2\ 1^1\quad 2^2\ 2^1$,

where the small numbers indicate higher octaves, so the combined range of the two instruments together is 1 to 2^2, or approximately 2600 cents.

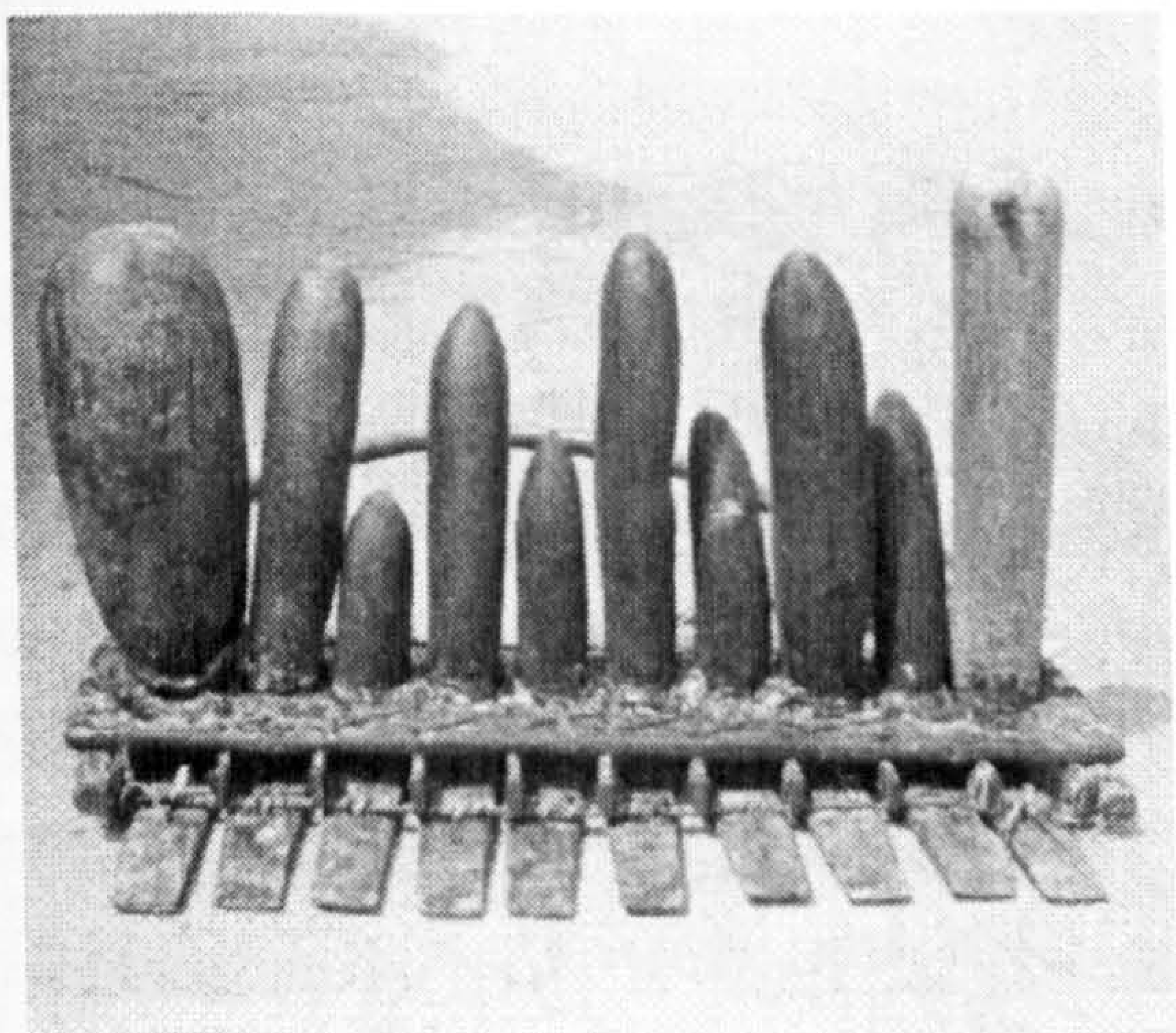


Fig. 132 *Manza*.

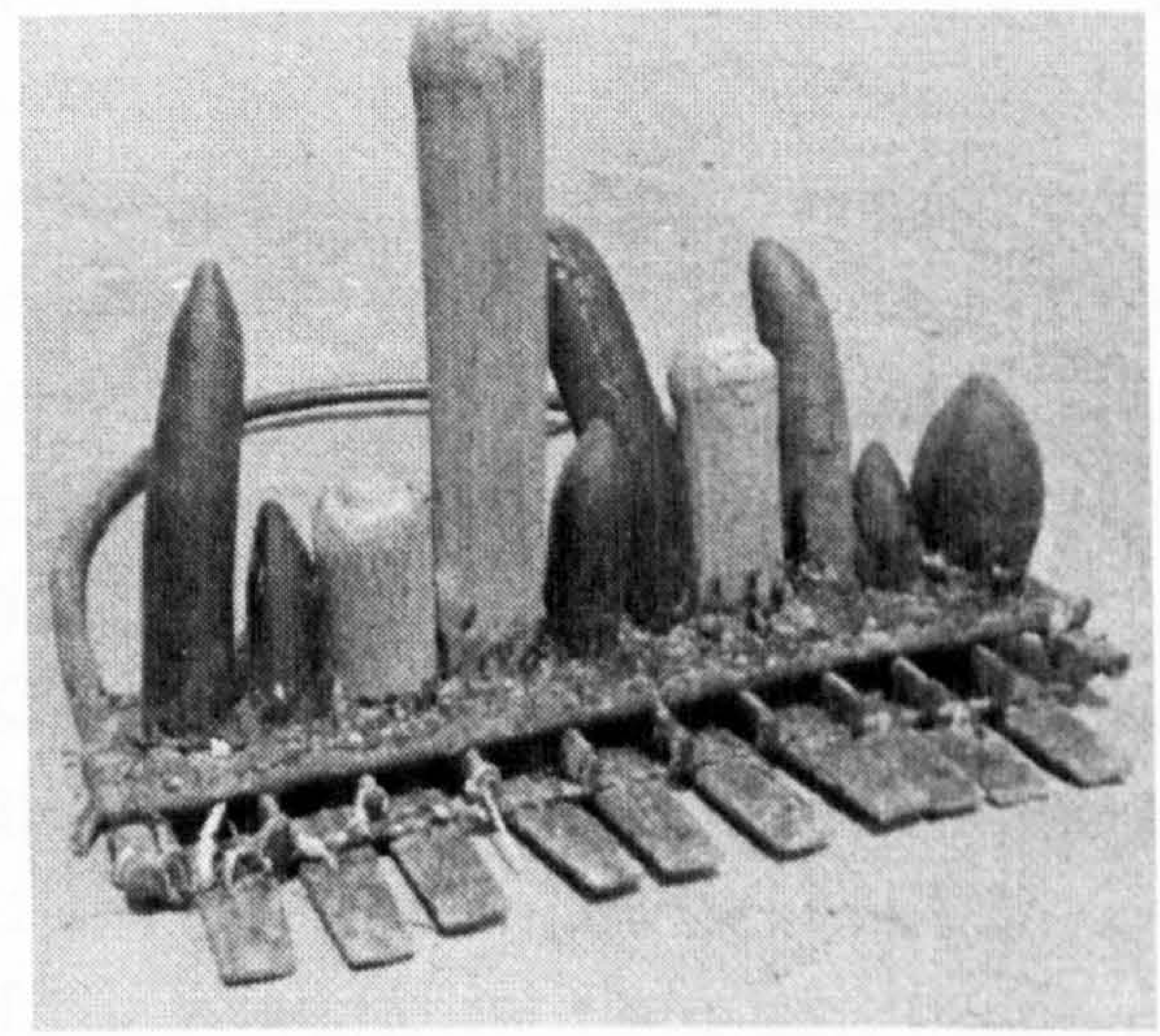


Fig. 133 *Ngokoua*.

The tunings of the two *nzanzangoula* are given in table 10.

Table 10 Tunings of *nzanzangoula* in Vougba.

manza Bar	Hertz	cents (above C)	interval (cents)	*ngokoua* Bar	Hertz	cents (above C)	interval (cents)
1	156.5	310					
2	174.2	496	186				
3	205.3	780	284	3	205.9	785	
4	227.5	952	178	4	229.1	970	185
5	280.7	122	**364**	5	281.1	124	**354**
1^1	315.7	325	203	1^1	312.0	305	181
2^1	359.1	548	223	2^1	359.5	550	245
3^1	412.9	790	242	3^1	408.2	770	220
4^1	458.2	970	180	4^1	460.3	978	208
5^1	570.0	148	**378**	5^1	570.6	150	**372**
				1^2	628.0	316	166
				2^2	702.5	510	194

Considering that these instruments are at least sixty years old, and have not been re-tuned for many years, the accuracy of most of the octaves is quite surprising (apart from note 2). In the light of this we can assume that pitches and intervals given above are reasonably close to the maker's original intention. This pentatonic scale is characterised by four intervals that are close to one tone (200 cents), on average they range between 180 cents and 240 cents. The octave is made up by one large interval averaging 367 cents shown in bold in table 10.

I failed to find any *manza*-type xylophones among the Azande further east around Zemio. Most of the time people did not know what I was talking about, but just two old men said that they did remember a xylophone from when they were children, and described what could only be the *manza*-type of instrument. Consequently I have nothing to compare these tunings with apart from those given by Boone [32] of twenty-one Azande *manza* collected between 1900 and 1935 in the Upper Uelé region in Zaire (the main stronghold of the Azande clans). In all likelihood, the instruments in Vougba were made around about the same time as those detailed in Boone's study.

Table 11 *Manza* pitch ranges in Hertz (Boone)

Azande *manza* pitch ranges from Bomokandi, Uelé, Bili, Poko Doruma, Bambesa, Likati regions	Azande (Abandja) *manza* pitch ranges from Yakoma
205 - 735	165 - 595
205 - 765	185 - 675
215 - 685	220 - 745
215 - 715	
215 - 720	
230 - 770	
230 - 820	
250 - 820	
260 - 935	**Nzakara *nzanzangoula* pitch ranges from Vougba**
260 - 1190	
265 - 780	
275 - 945	156 - 570
280 - 825	206 - 702
290 - 1000	
300 - 1085	
320 - 1095	
360 - 1200	

The tunings of all the *manza* given by Boone are pentatonic, and all of them non-equitonal, like the instruments in Vougba. Comparing the pitch ranges of the *nzanzangoula* in Vougba to those instruments studied by Boone, it emerges that those from Vougba are pitched lower than the average of Boone's sample. The pitch-ranges in Hertz given by Boone [33] are shown in table 11.

I have listed the *manza* from Yakoma separately from the rest of Boone's sample because these instruments have a lower pitch range and, significantly, they come from Yakoma which is at the confluence of the Mbomou and Uelé rivers just eighty kilometres from Bangassou. According to Boone, two of these xylophones (nos. 33912 and 33911) were made by the Abandja (Azande) in Monga which is on the Bili river forty kilometres east of Yakoma. For these reasons the intervals of the three *manza* from Yakoma are shown in table 12 to give a comparison to the *nzanzangoula* from Vougba.

Table 12 Tunings of three *manza* from Yakoma (Boone)

museum no. 33912			museum no. 34939			museum no. 33911		
Hertz	cents (above C)	interval (cents)	Hertz	cents (above C)	interval (cents)	Hertz	cents (above C)	interval (cents)
165	402	244						
190	646	214	185	691	129			
215	860	223	210	820	301	220	900	183
245	1083	**325**	250	1121	**317**	245	1083	**295**
295	208	194	300	238	215	290	178	250
330	402	221	340	453	147	335	428	195
375	623	237	370	600	220	375	623	257
430	860	223	420	820	284	435	880	203
490	1083	**339**	495	1104	**334**	490	1083	**339**
595	222		600	238	203	595	222	206
			675	441		670	428	184
						745	612	

The scales of the Yakoma *manza* are very similar to those of the *nzanzangoula* from Vougba. Both have a series of four intervals mostly between 180 and 240 cents, and one larger interval (shown in bold in table 12) averaging 367 cents for the Vougba instruments and 325 cents for the

Yakoma. It is also noteworthy that although the three Yakoma instruments all start at different pitches, the large intervals in the scales lie between the same absolute pitches, ie 1083 to 1121 cents, equating roughly to the western note B, and 178 to 238 cents, equating roughly to the western note D. This is not really surprising since *manza* are normally played in pairs or even in threes, and also instruments 33911 and 33912 were collected in the same year, 1932, and by the same person, Arnould. Instrument 34939 was collected by Janssens.

It is more significant, however, that the large interval on *nzanzangoula* from Vougba (between approximately 970 and 150 cents above C, table 10) lies very close to the same absolute pitch as the large interval of the Yakoma *manza;* (between approximately 1100 and 240 cents above C, table 12). So the *nzanzangoula* from Vougba are tuned about one semitone lower than the Yakoma xylophones. This similarity is a little surprising since although the geographic origins of the instruments are very close, the instruments are from different (although related) ethnic groups; Nzakara and Abandja (Azande).

All of the Azande (and related peoples) *manza* in Boone's sample have the same arrangement of bars paired in octaves (the lowest pair on the player's left) in the following manner:

1 1' 5'5 4'4 3'3 2'2

Boone states that in Zaire, the *manza* from Uelé, the *kalangba* (very similar instruments of the same name are used by the Banda-Linda in C.A.R.) and the instruments without calabash from the Oubangui region always have the same arrangement of the bars; "dans le meme ordre toujours".[34] It is therefore interesting to find that one of the instruments from Vougba has the bars arranged in a different order. Could this be a unique instrument to the Nzakara, or do the Azande also have such xylophones that did not come to the attention of Boone? Considering that the Nzakara and Azande xylophones are so similar to each other in every aspect of construction and tuning, and that these instruments are also different from the other ten-bar portable xylophones of the Banda-Linda and Sabanga, it may be possible that the Azande also had *manza* with paired-bars arranged in a different order.

The ten-bar *manza* of the Azande and Nzakara have a number of common features which set them apart from all the other ten-bar xylophones (*kalangba*) found further west among the Banda, Linda and

Sabanga peoples in C.A.R. and Zaire:

a) *Manza* never have mirlitons fitted to the resonators whereas the *kalangba* always do.

b) The basic construction of the two instruments is similar; the frame of both types consists of a centre-board with holes cut along its length to accept the resonators. Whereas the bars of *kalangba* rest on two padded wooden poles running parallel either side of the centre-board, the bars of *manza* are supported on cord which is wound around individual support pieces, tied at right angles to the centre-board, one between each bar (see figs. 134 and 135). This method used on *manza,* although not unique among African xylophones,[35] is quite unusual as Boone [36] notes:

> Ils possèdent en effet une élément absolument nouveau dans le mode d'isolement de touches: des chevalets en bois servent de point d'attache aux cordes tendues sur lesquelle reposent les touches. Ce procédé ne peut être rapproché d'aucun autre et constitue donc une caracteristique propre aux Azande.

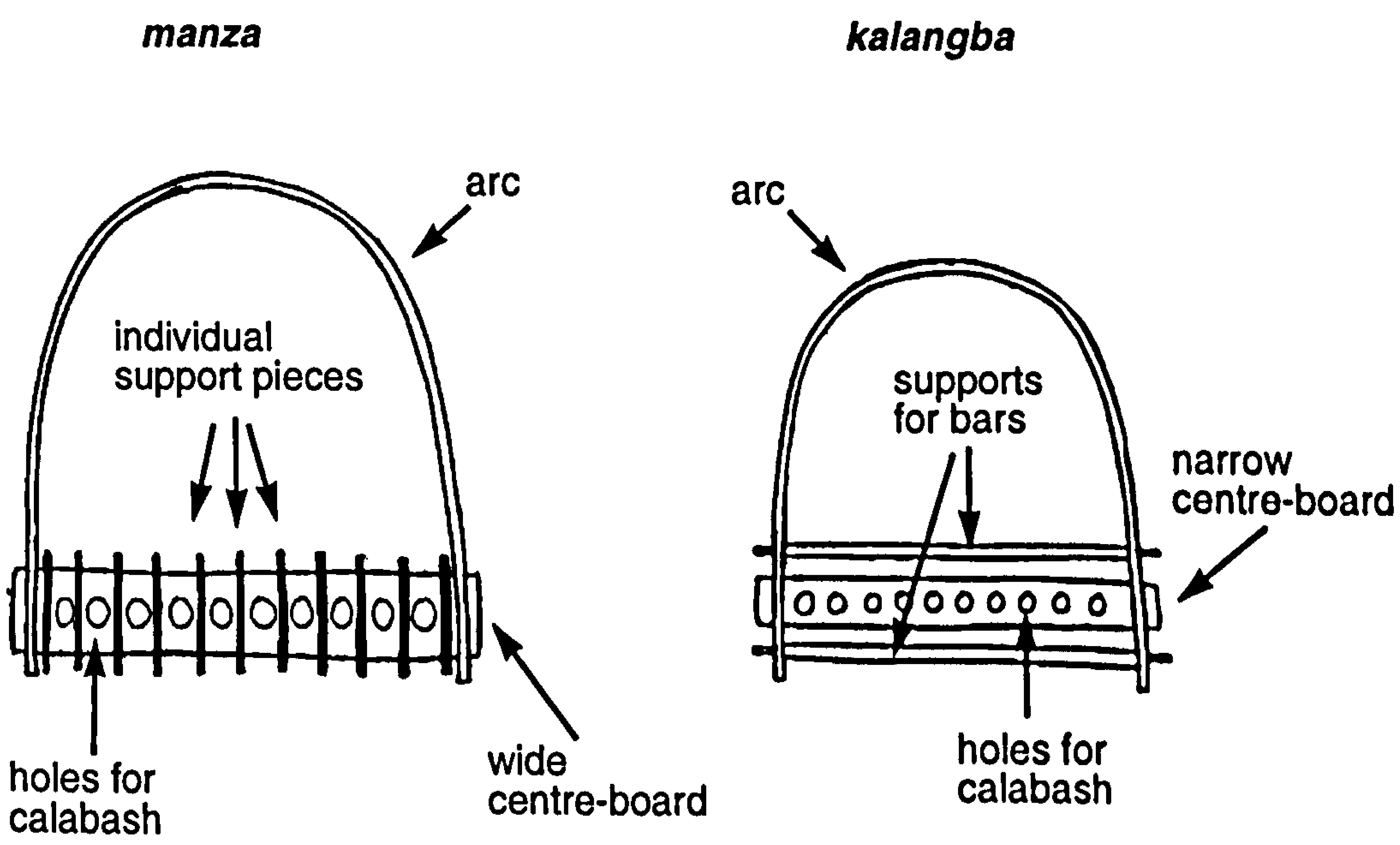


Fig.134 *Kalangba* and *manza* frame.

c) The bars of the *manza* are all the same width and wider than those of the *kalangba* making the *manza* a bigger instrument (see figs. 136 and 137). The bars of *kalangba* decrease in width from the lowest to the highest pitch. This makes the faster playing style of the *kalangba* possible, whereas the *manza* music is played at a slower tempo.

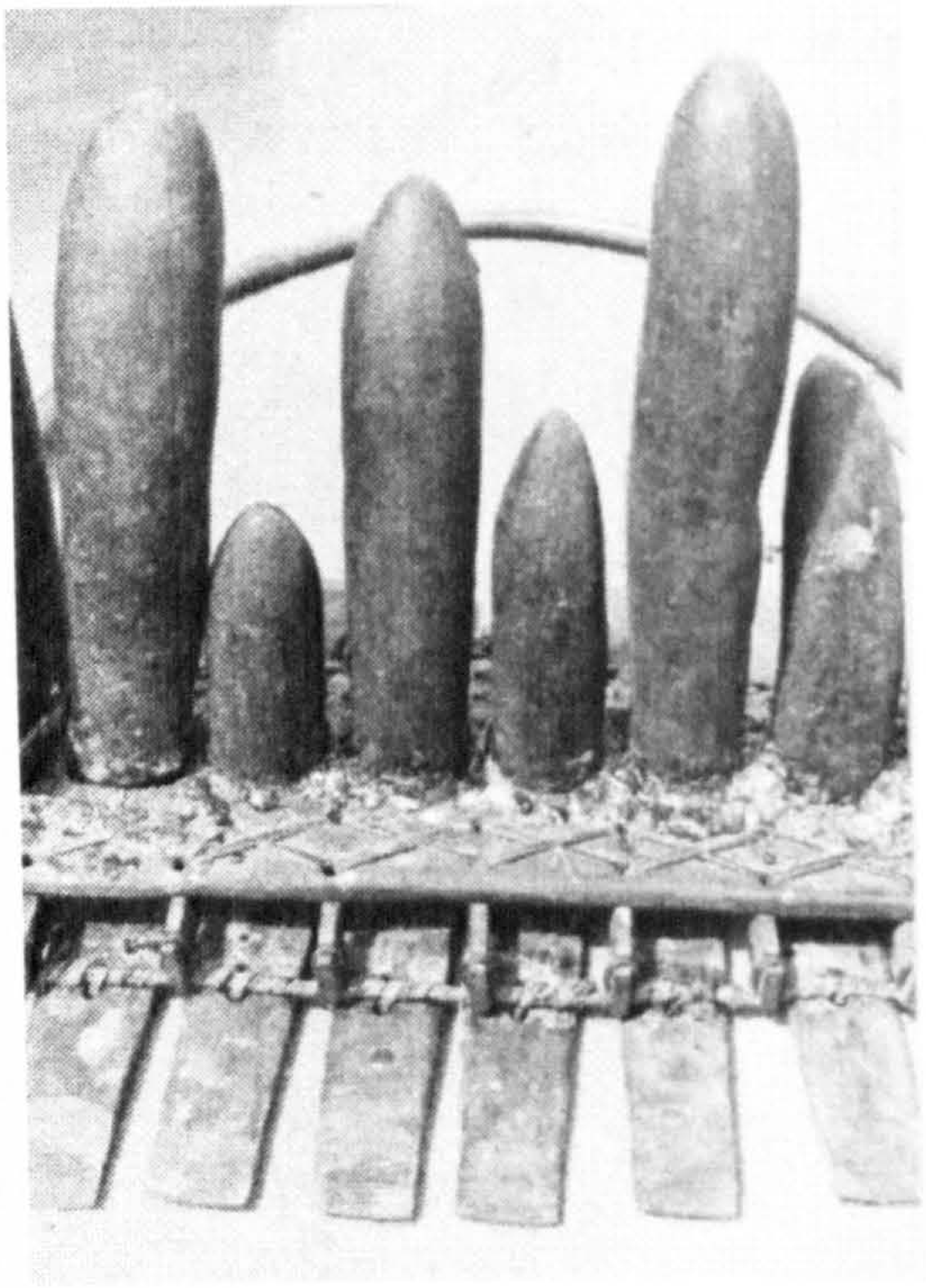


Fig. 135 Under-side of *manza* showing bar supports.

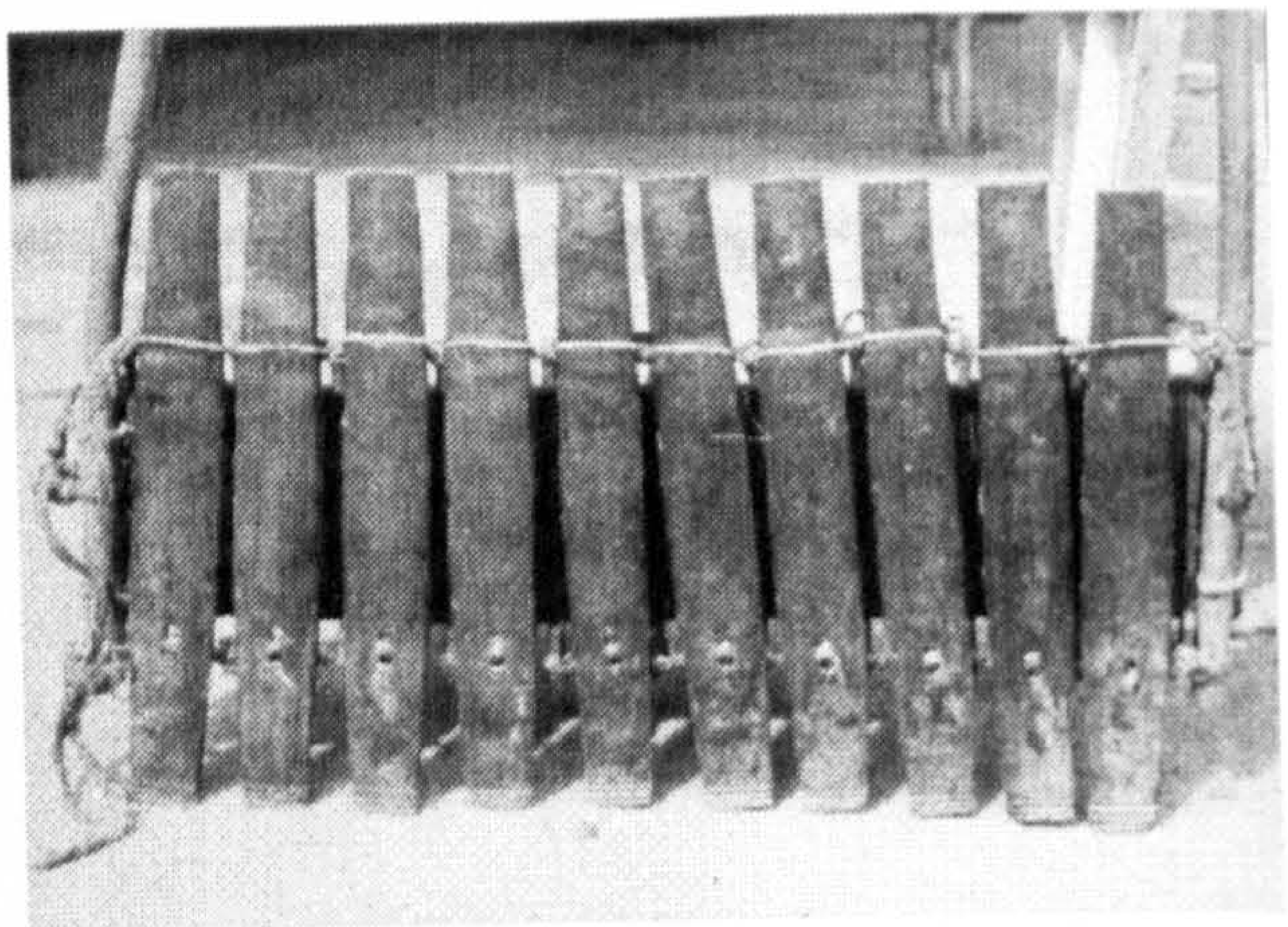


Fig. 136 *Manza*.

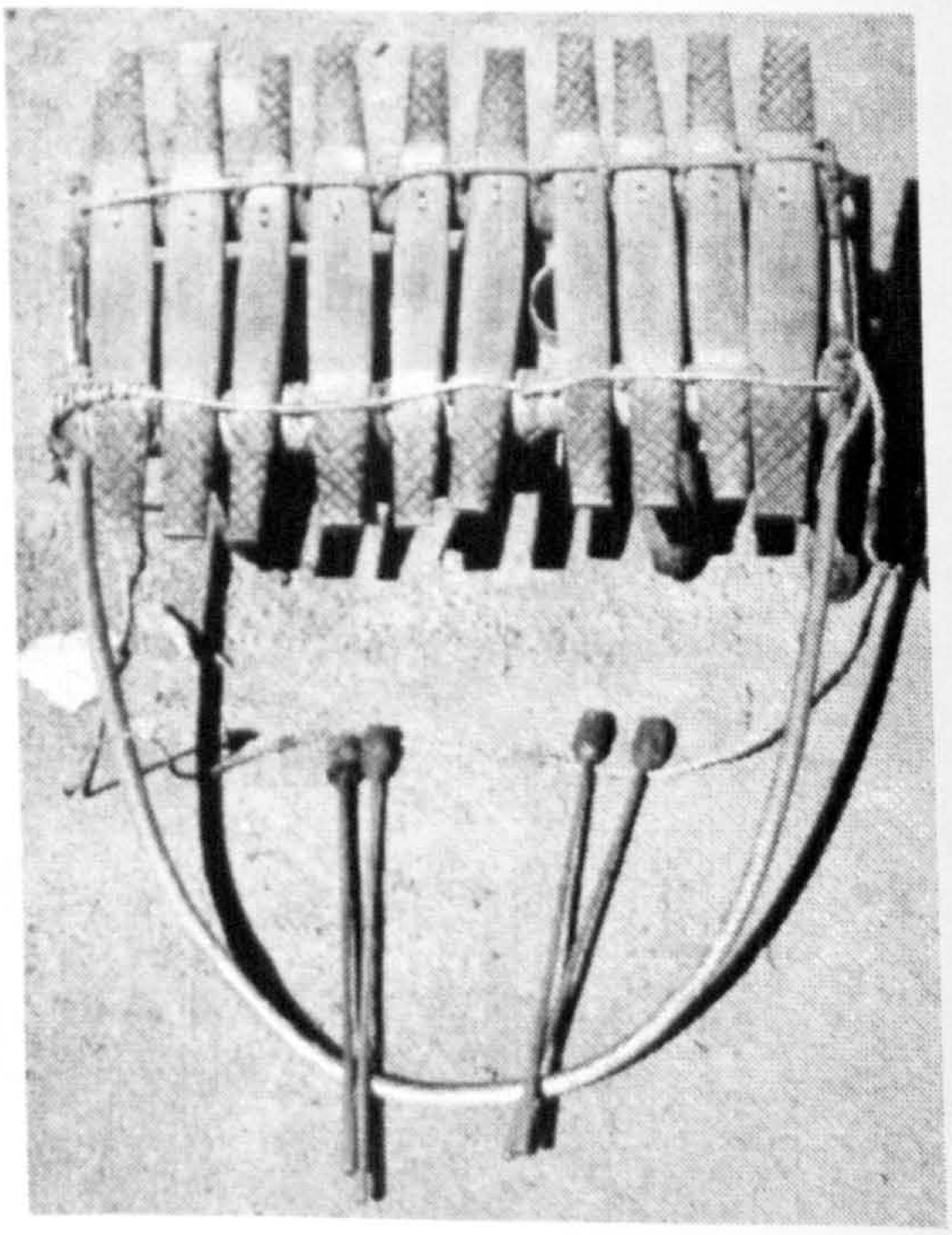


Fig. 137 *Kalangba*.

Nzanzangoula construction

Since the *nzanzangoula* tradition in C.A.R. is almost dead, there are no Nzakara still making these xylophones in the Bangassou area, and most likely, in the whole of C.A.R. The situation among the Azande in C.A.R. is the same or maybe even worse. From my research it appears that Azande *manza* tradition disappeared before the Nzakara tradition. The only evidence I found that there ever was an Azande *manza* tradition in C.A.R. was the memories from childhood of two old Azande men in Zemio.

Most of the information in this study is from interviews with Dengba, an old Nzakara xylophone maker living in Banguiville, Bangassou. Dengba says himself, that he is the last xylophone maker around Bangassou. Azande and Nzakara xylophone making is a highly specialised skill, relying on both a good musical ear, and an excellent wood-working ability. Dengba learnt instrument making from his father. Dengba said that most xylophone makers use just an adze, a few knives, and some iron hole-boring tools.

There are no special rituals involved in making *nzanzangoula*. Dengba said that although there is no set order in which the various parts of a xylophone are made, it is usual to start on the bars. They are made of timber known locally as *so(h)* (*pterocarpus tinctorius*).[37] The common English name for the *pterocarpus* group is padauk or padouk (Burmese origin). All the padauk species have a clearly defined, thick band of white sap wood. The heart wood is bright red upon cutting and darkens considerably to a deep brown after exposure to light. As noted by Dechamps,[38] much of northern Zaire (like southern C.A.R.) is either savannah or sparse forest, "regions des savanes et de forets claires", where species of *pterocarpus* are abundant and grow very large (often to 50 metres with a diameter of 1 metre at the base) being unhindered by a forest canopy.

A large tree is preferred since the wood "grows harder with age".[39] There is no special time of year for felling, although it is usually done during the dry season after the two metre high grass that covers the savannah has been burnt, making travelling easier. The tree is felled by cutting away the buttress roots and making a large fire around its base. It is left to burn for at least one day, making the subsequent axe work easier. Since these trees are so large they are left where they fall and converted on the spot. The bark and sap wood are stripped off, and a section of bole (only about 2 metres) is converted into a baulk using a large two-handed adze. An axe is then used to cut across the end grain at either end of the roughly-squared section. Iron wedges are then driven into both sides of the baulk thus splitting and lifting a roughly-shaped board. Converting timber in this way is hard work so only a small part of the tree is made into boards, enough for a few instruments. For this reason it is often possible to find a tree already felled with plenty of useable timber.

The boards are cut down to a thickness of about 25mm with an adze, and then split length-wise into 75mm strips. These are left out in the sun to dry. Dengba stressed that it was very important that the timber was dry before cutting the strips into shorter lengths for the bars so they did not split at their ends.[40] The bars (*banguili kpaningbo*) are cut to shape, without carving away the arch for tuning, and left for another month to dry.

Each xylophone maker has his own style of bars, differing in shape and/or in the designs cut into the bars. In fact Dengba said that in virtually every aspect of design the maker personalised the instrument in his own style.[41] Figure 138 shows the design of the bars of the *nzanzangoula* in Vougba; note the three flutes running across one end of the bars, the five burnt holes in the shape of a T near one node, and the gouge marks at the tip of the other end. Many of the *manza* I studied at the Musée de l'Afrique Centrale had bars shaped in the form of a spear; (symbolic of the power of the Azande nation?) (see figs. 139 and 140). The surface of the bars of the *manza batanga* (Azande-Manziga, museum no. 10843, fig. 139) are patterned like the scales of a fish and carved away at an angle on the edges. The bars of the *manza* in figure 140 (Azande-Bitimati, museum no. 34513) are similar in shape but have a flatter surface with ripples running across the grain.[42]

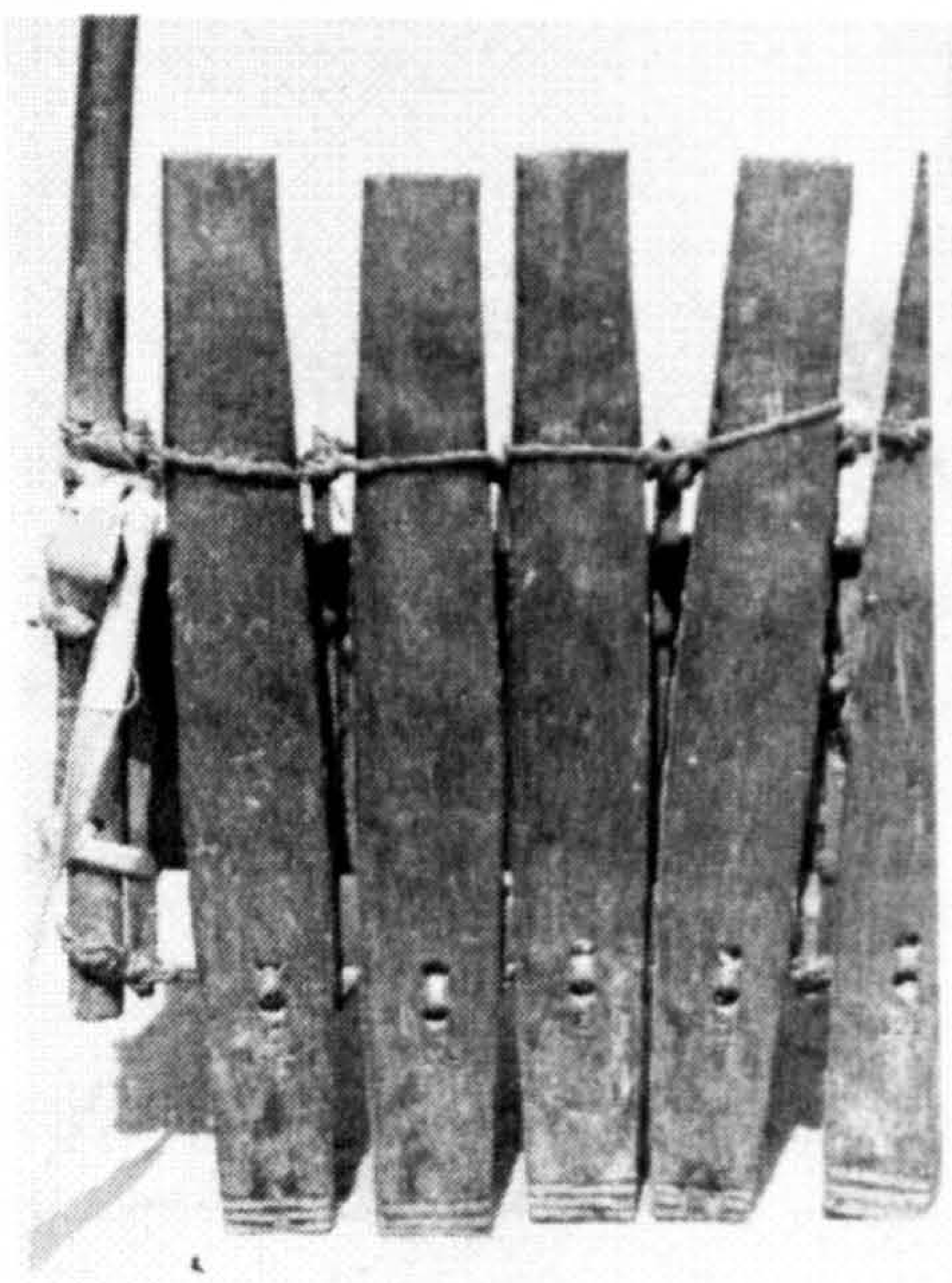


Fig. 138 *Manza* bars in Vougba.

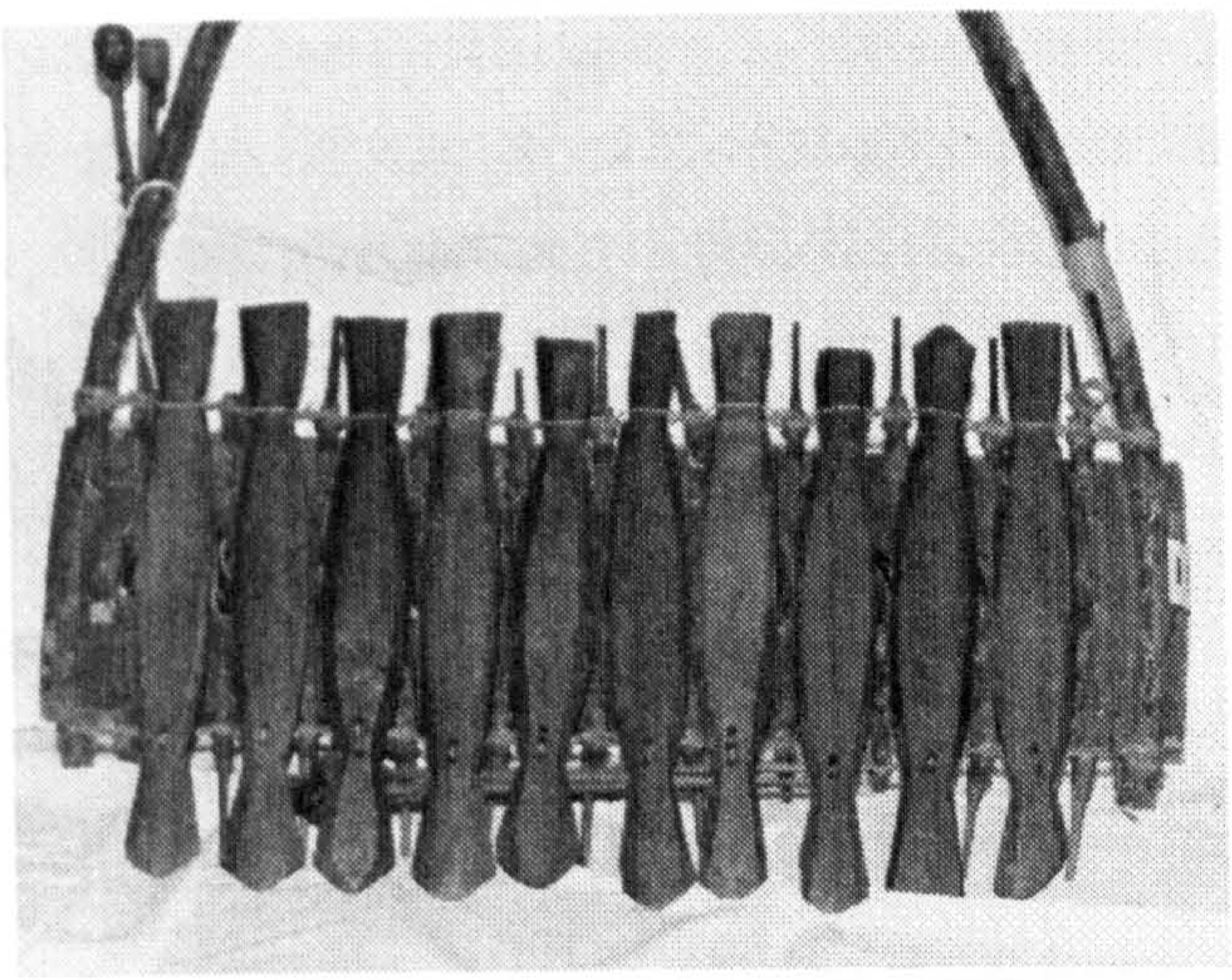


Fig. 139 *Manza batanga*,museum no. 10843.

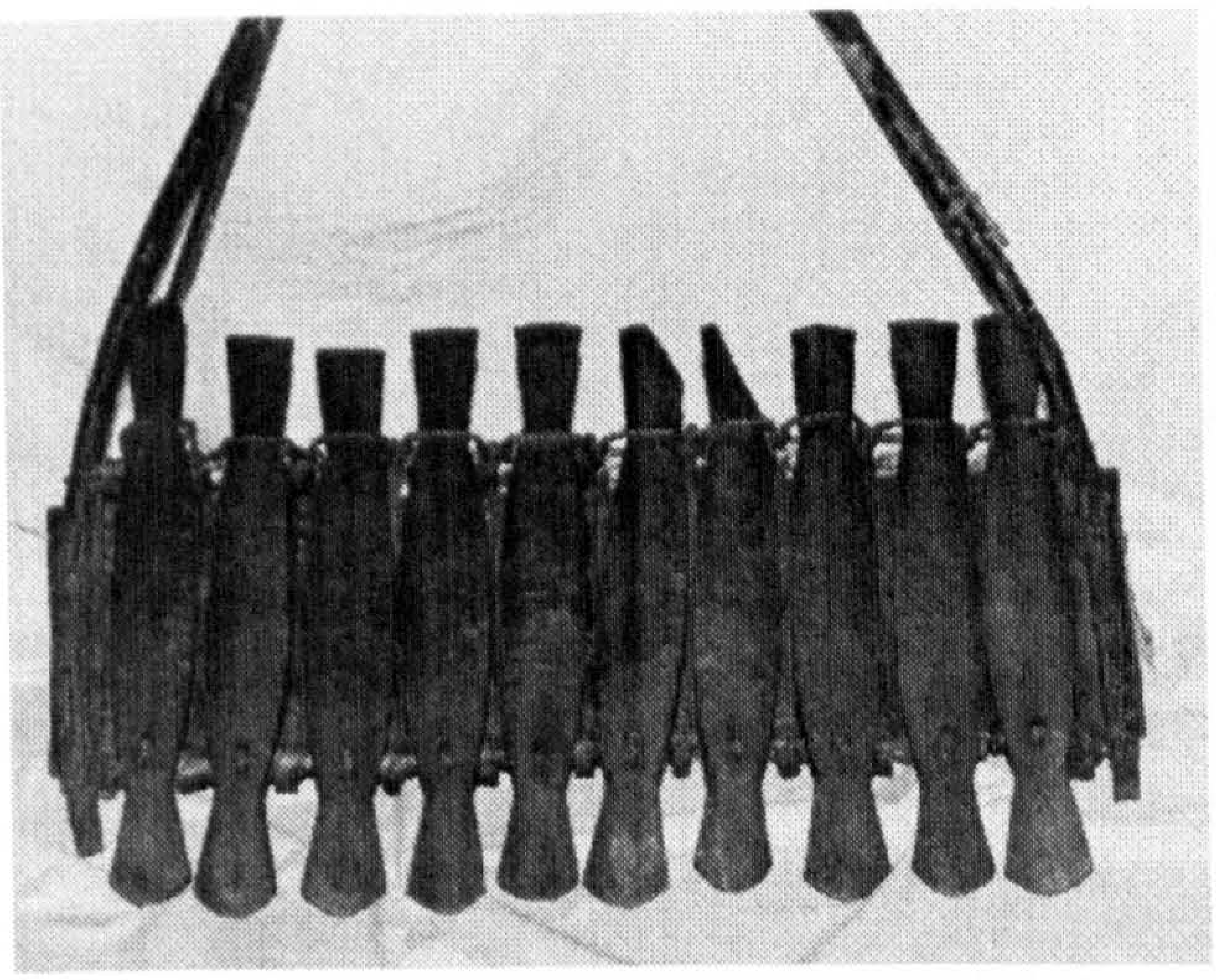


Fig. 140 *Manza,* museum no. 34513.

Once the maker is satisfied that the bars are dry, the process of tuning and scraping the surface of the bars is started. All the bars are cut to the same length and the position of the nodes marked. A groove is cut at these positions on the under-side of the bars to locate the supporting cord. The ends of the bars are then thinned considerably (thus raising the pitch). This is only done for appearance since bars with full thickness at their ends appear clumsy and heavy. The bars are then tuned, starting with the lowest-pitched, by cutting an arch on the under-side in the middle of the bar thus lowering the pitch (see fig. 141).

Since the bars are all the same length and the range of the xylophone is almost two octaves, the lowest-pitched bar is very thin at its centre (about 5mm), while the highest-pitched bar requires very little arching. Dengba said that he tuned the lowest bar first and then tuned each note up the scale in ascending order. The octaves are then paired together and tuned to the same pitch. Much time is then spent smoothing the surface of the bars by scraping with a knife, and finally the designs are carved/burnt.

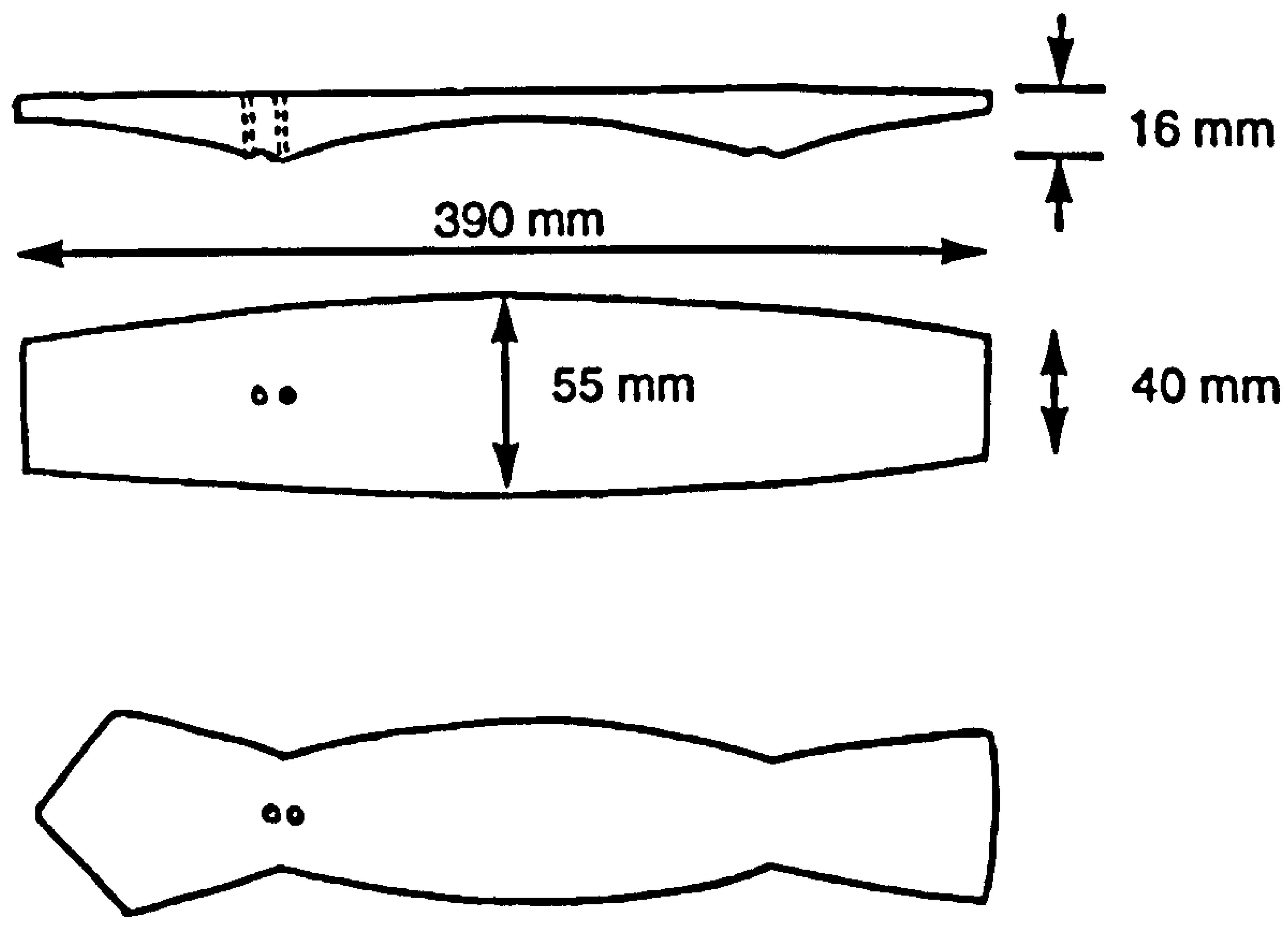


Fig. 141 Bar shapes.

Elongated calabash are selected which are flat of each respective bar. They are tuned to the same pitch as the bars by either increasing the aperture, or by cutting down the length thus raising the pitch. A light weight timber (*spathodea campanulata*) is used for the centre-board (see fig.142). The bars are placed on the centre-board (*gbongbo kpaningbo*) in paired-octaves, and their positions marked. A hole is cut for the calabash underneath each bar.

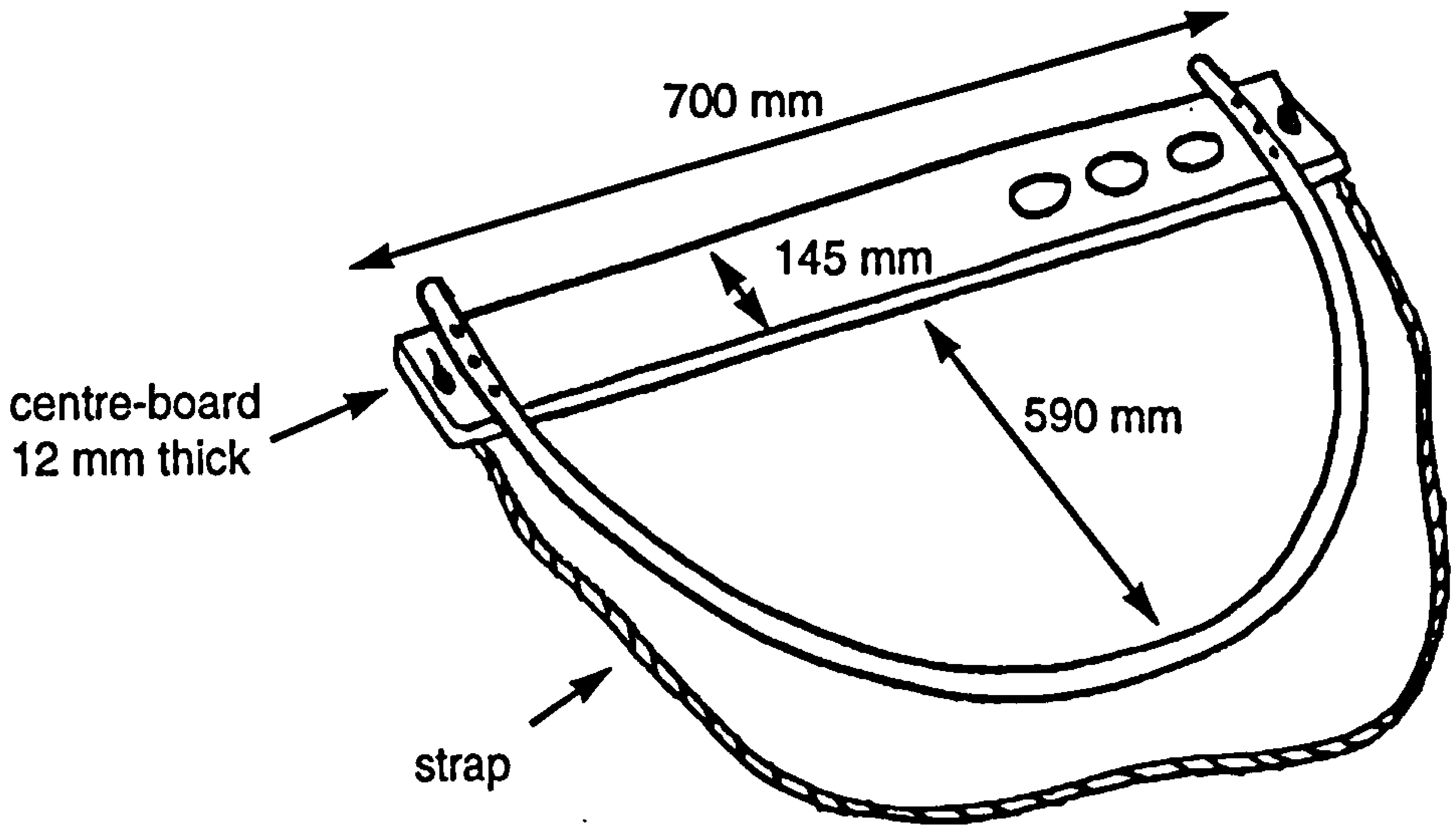


Fig. 142 Frame dimensions of *manza* in Vougba.

The support pieces (*kalakili kpaningbo*) are carved from the same timber as used for the centre-board. As with other parts of *manza*, the support pieces vary in design (see fig. 143). The support pieces are laced in position with raffia. Here again, the maker personalises his instruments with his own pattern of lacing. Some variations are shown in figure 144.

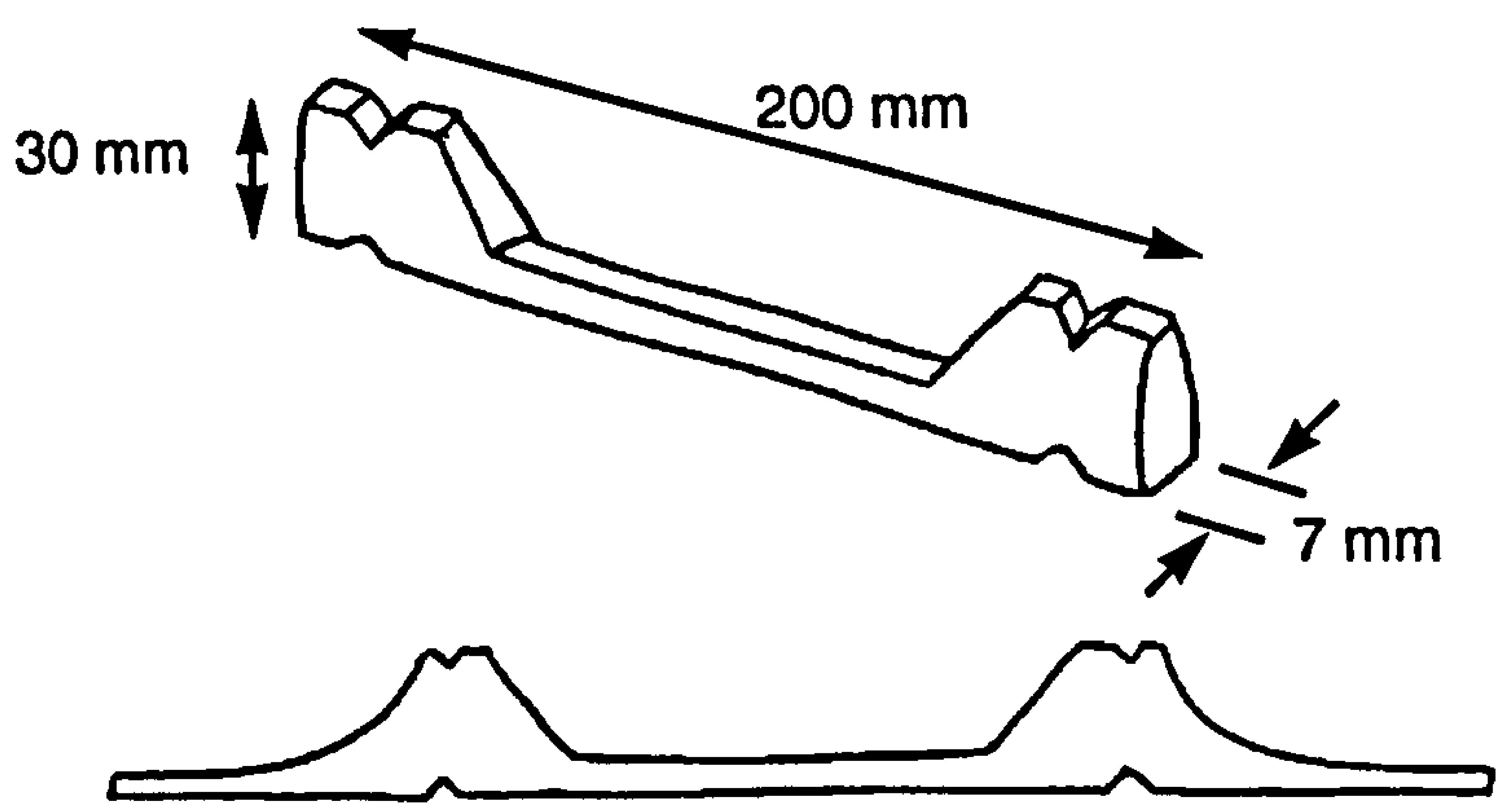


Fig. 143 Support pieces, the type in the lower half of the diagram extend to the full length of the bars (see fig. 139).

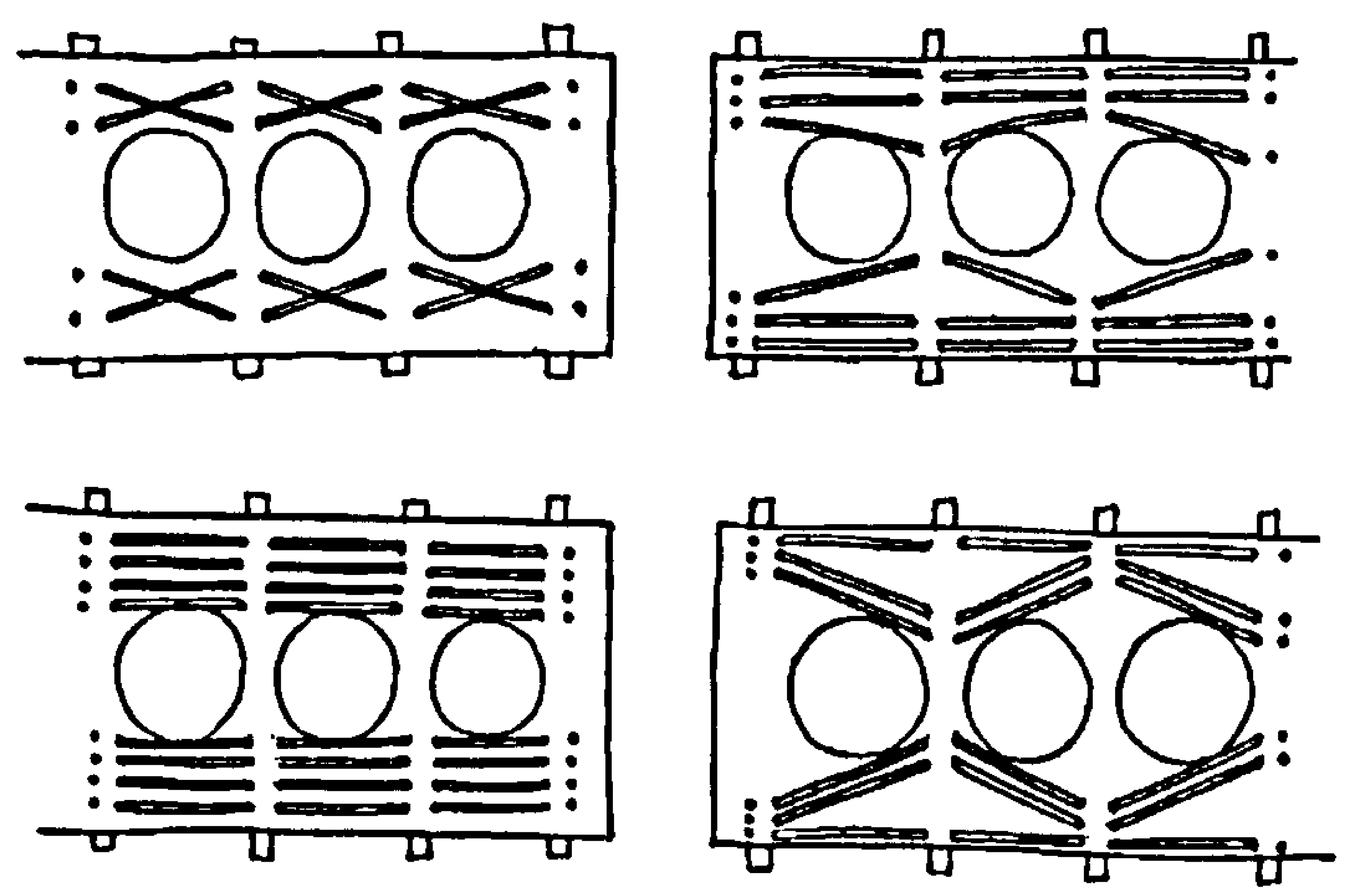


Fig. 144 Variations of lacing patterns.

Each calabash is attached to the centre-board with a piece of split cane which passes through the board, into the neck of the calabash, and out through the other side of the board (see fig. 145). The join between the calabash and centre-board is made firm with black resin (*zian*). The resin is collected by cutting a deep gouge into the bark of the very large *besso* tree (species not known); after a few minutes the thick black gum starts to ooze out. This hardens quite quickly, but can be softened by applying heat.

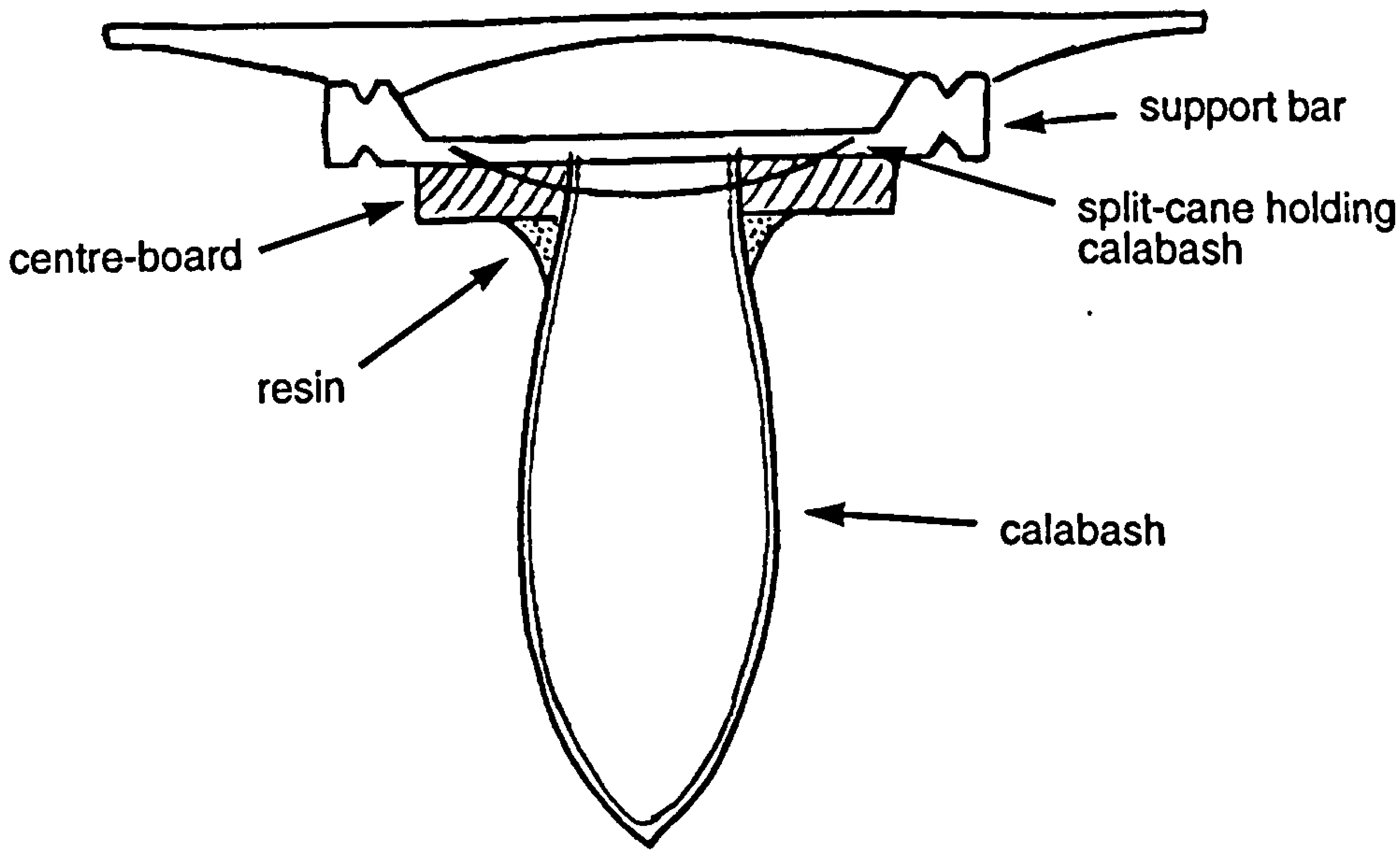


Fig. 145 Cross-section of typical *manza* showing construction.

Nzanzangoula are usually played while seated (see fig. 130). The instrument is held firm by sitting on the bent branch that is attached to the frame. This part of the frame is called *ndouba kpaningbo*. It is made by cutting a suitable branch and bending it (while green) into a semi-circle, tying the ends together to hold its shape and leaving it for a week before attaching it to the centre-board.

The role of the musician and the function of nzanzangoula in old Nzakara society.

The information here was told to me during discussions with Dengba in Banguiville during April 1990. This is an historical note on the role and position of the Nzakara court musician, and the function of *nzanzangoula*. Boone notes that "the *manza* is a relatively rare instrument, and in general, is the reserve of chiefs".[43] This was also the case among the Nzakara; chiefs played the instruments while the paramount chief or king had his own group of court musicians whom he maintained. This tradition suffered seriously during the initial stages of colonialism (1900 to 1920) when the power as law makers and rulers was taken from the Nzakara chiefs and kings. First to go was the court tradition since the king no longer had the wealth to keep his musicians. Regional and village chiefs kept up the tradition but this was discouraged by the French colonialists, who actually banned the playing of drums and xylophones, incarcerating any offenders. By the time the colonial power relaxed this policy the damage was done.

Nzakara court musicians were regarded as the custodians of their people's history and culture. Dengba's father was a court musician in Bangassou, and the following account of the history of the area was told to Dengba by his father: The town Bangassou was named after the paramount chief (king) of the Nzakara, who died in 1907. During the first few years of French rule Bangassou co-operated with the colonial rulers providing them with animals and ivory. In return Bangassou was educated in Bangui by the French. There was, however, much dissent among the Nzakara; even though Bangassou was a very powerful and respected leader many of his subjects/advisers disagreed with his policy of co-operation. The colonial rulers asked the Nzakara to destroy all their weapons, including the lethal throwing knives, *pinga*. To quell the growing feeling of nonconformity among the Nzakara, which was led by the king's son Labasso, Bangassou gathered all his subjects together, and from his throne, raised up high on a platform, he spoke of the advantages of conformity and co-operation telling his people not to harm the French.

Personally, Bangassou still believed in his ultimate power and arranged a contest of strength between his people and the colonialists. A goat was tied-up a long way off, and a very strong warrior was to kill the goat with a throwing knife, but failed. A French soldier killed the animal with the first bullet from his gun, and thus the contest was won. From this point Bangassou hated the French, and desperately wanted guns. This was the real end of Bangassou's power and influence. He was given a gun in exchange for the promise that his nation would not rebel.

Bangassou was killed by an elephant during a hunting expedition, and was buried in the forest so no one would know of his death. The French went to the forest, dug him up, and brought the body back to Bangassou for a public burial in order to weaken his following and disperse his subjects. Following the burial there was much unrest, with Bangassou's son, Labasso inciting rebellion. Labasso was consequently imprisoned, and any further dissent from French rule was promptly dealt with.

Up to the demise of Bangassou's power, Nzakara kings had many court musicians. They played at all public appearances, and were seen as status symbols which the rulers jealously guarded. The court musicians had a high status in Nzakara society, being maintained by the king and living in his compound. As such, they had access to the king, and were regarded more like advisers than solely musicians. The musicians played only to the king or at his request, and were assigned to outlying villages to spread news, espouse the power of the king over his domain, and report back to the court. In charge of all the musicians was the *baba,* who not only was the most respected musician, but also the one most knowledgeable about the history of the Nzakara. The court musicians lived solely by their music, all their needs being met by their patrons. In present day C.A.R. professional musicians do not exist as Arom notes: "Les population de la République Centrafricaine ne connaissent pas de caste de musiciens, pas plus qu'il n'existe dans ce pays musiciens professionels".[44]

Along with the *nzanzangoula,* the court musician also used a five string harp known as *koundi,* although the xylophone held a more important position. The music of *nzanzangoula* tells the history of their ancestors, their laws and wisdom. The music was not for recreation alone; every song/dance had a specific meaning/story. Requests were made to the king through the xylophone and song. All important matters were dealt with by the xylophone, whereas the harp was used on less serious business. Dengba said that musicians were able to speak through the instruments alone, but now this ability has been lost. It is therefore difficult to say to what degree of understanding this method of communication went.

Nzanzangoula were also used during the ancestor cult (*tungà bundu*),[45] which is the most important cultural event among the Bandia and Nzakara. Individual spirits of the ancestors are represented by metal spear heads (*mbasinà*) at altars (*àgbà kpakpa*), concealed in the bush. During an annual celebration, the *mbasinà* are put on public display and the ancestral spirits are invoked and praised; this cult has preserved the ancient history and unity of the Nzakara and Bandia, as Dampierre [46] notes:

> En pays Nzakara, le culte des ancêtres occupe manifestement une place primordiale: ils y sont figurés invoqués par leurs noms. Ils garantissent la paix et l'unité du lignage et du clan.

Both missionaries and the French colonial administration tried to suppress this cult. Missionaries, believing demons were being invoked, made a policy in the 1950s to raid the altars in the bush and seize the ancient *mbasinà*. Dampierre notes that many *mbasinà* were lost in this way.[47]

The training of musicians started at an early age, and usually the tradition was passed down father to son. If the musician's children were not interested in learning then the musician would try to find someone else who was willing from as early an age as five or six. Since Dengba's children were not interested, he took on two students, Gbiate and Kété. The training lasted many years, the apprentice having to learn a large repertoire together with all the history and laws of the Nzakara.

One such story tells how the *nzanzangoula* came to the Nzakara. This is Dengba's version: The originators of the music were the Avopata (vou Kpata) people who lived deep in the jungle. Although they weren't educated they were a very wise people. A young Avopata boy was captured and made a slave of the king. The king named him Kole after the fruit of a tree the boy ate. At first Kole would not speak although he understood Nzakara, but as he grew up the king came to love him and Kole started to speak. At this time the king was very fierce and unreasonable, killing any of his advisers who questioned him in any way. However the king, in private, did listen to what Kole had to say, and heeded his advice that if the king carried on killing his advisers he would soon have none left. Kole suggested the king would gain more respect by giving punishments rather than death. Kole made the first xylophones and taught songs to the Nzakara so that they could keep their history through the music.

The Azande xylophone tradition in C.A.R.

During my research in the Azande region of C.A.R. I failed to find any *manza* xylophones, makers, or musicians. The only confirmation I got that the Azande in C.A.R. used to have such a tradition was from two old men living in Zemio. These men had memories of seeing *manza* in Zemio when they were children.

The Azande have, however adopted a new xylophone from the Azande in Zaire during the last fifty to sixty years.[48] This log xylophone, known *as kpaningbo,* is tuned to a pentatonic scale and usually has thirteen or fourteen bars, although instruments do range from having twelve to sixteen. The *kpaningbo* is very similar in construction to the *amadinda* and *akadinda* log xylophones from Uganda. The large bars, which are made from split logs, rest on two banana plant trunks placed on the ground. The bars are prevented from hitting each other by sticks driven vertically into the supports. Each musician uses two stout wooden sticks and strikes the bars at their ends to produce the characteristic log xylophone sound. Three musicians usually play the *kpaningbo,* two on one side of the instrument, and one on the other, each player restricted to the notes shown in figure 146:

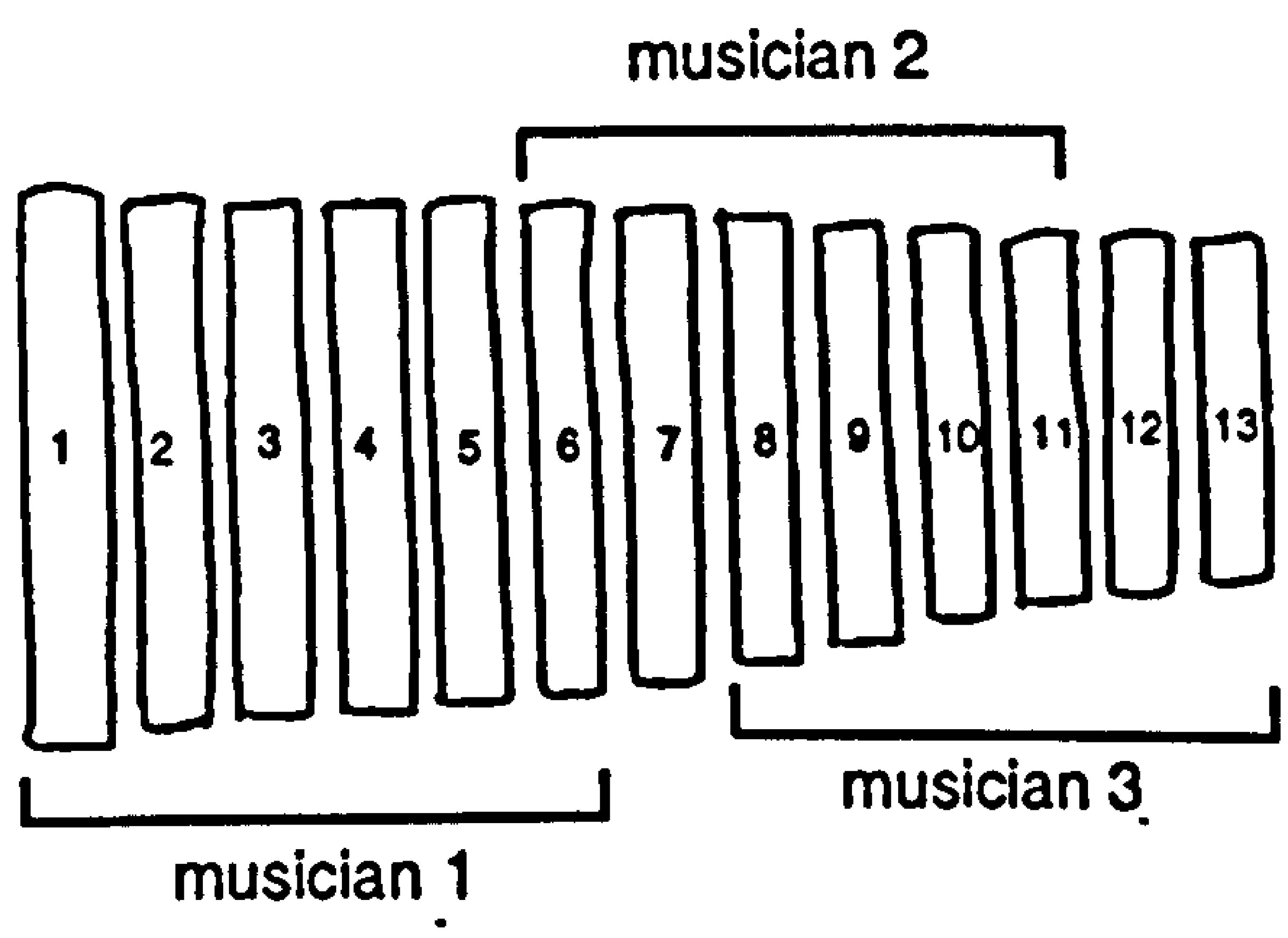


Fig 146 Players' position on *kpaningbo.*

Performances usually take place at night during the full moon (since there is enough light to dance), though any event such as a marriage or independence day will be celebrated with a *kpaningbo* dance. The *kpaningbo* is accompanied by one long double-headed drum (*gaza*) played at one end with a stick and one hand, and a two tone log or slit drum (*gourou*) played with two rubber-tipped beaters. A *kpaningbo* ensemble in Zemio is shown in figure 147. The music accompanies ring dances in which the dancers, both men and women, complete rhythmic cycles of short steps usually in an anti-clockwise direction. Some of the dancers use a pair of clapperless bells mounted on wooden handles which are struck together on the off-beat at a fast tempo. *Kpaningbo* music is based on lines of cross-rhythm and polymeter, as opposed to the straight, rhythmically-balanced, interlocking style of the Ugandan *amadinda.*

During my stay in Zemio I commissioned a *kpaningbo* from a local musician and maker, Simplice Adakindi. *Kpaningbo* are regarded as relatively simple to make and consequently many musicians make their own instruments.

The timber used for the bars is known locally as *ngbouka.*[49] This timber is quite soft, light in weight, with a thick band of pale sapwood surrounding the slightly darker heartwood. *Ngbouka* trees are not that common, and are usually found in areas of low growing (up to ten metres high) dense bush. I travelled with Simplice and one helper to an area of bush about ten kilometres east of Zemio. The *ngbouka* is a slender tree, usually not exceeding eight metres in height, with the bole rarely growing larger than 225mm in diameter. The older, larger trees are often found to have rotten heartwood, so trees of about 150mm diameter are sought. Two trees are usually needed for one *kpaningbo*. The trees are felled and carried through the bush to the road where they are converted. Axes are used to cut the trunk into sections ranging between fifty to ninety centimetres in length. The sections are split in two in order to check that the heartwood is not rotten, and then the bark is removed before transporting the timber back home.

Fig. 147 *Kpaningbo* ensemble.

The split logs are left in the sun to dry for just two weeks before being cut to the final lengths for the bars. Since my time was limited and I had to leave Zemio, Simplice only left the timber to dry for a further two weeks before tuning. He said that this was not really long enough and the drying usually takes three months. Even so, the timber was quite resonant after only four weeks drying.

The tuning and shaping is done with an adze. The arch for tuning is carved into the sapwood on the top of the bar [50] (see fig. 147). Simplice started by tuning the lowest pitch first without reference to another instrument. The next five bars are then tuned in ascending order, checking intervals between adjacent bars. Having tuned these first six bars, intervals between bars spaced two and three notes apart are checked, ie.

bars 1 and 3, 2 and 4, etc., and then 1 and 4, 2 and 5 etc. Once satisfied with the first six bars, the rest are tuned in ascending order. The tuning is completed in one day, although Simplice said it was necessary to carry on retuning the xylophone periodically for about one year until the timber is completely dry. The retuning may be done half an hour before performance since it is usually a quick procedure. The tuning of the *kpaningbo* is shown in table 13.

Table 13 *Kpaningbo* tuning.

bar	Hertz	cents (above C)	interval (cents)
1	213.1	845	
			248
2	250.0	1093	
			207
3	277.2	100	
			220
4	314.7	320	
			283
5	370.6	603	
			192
6	414.1	795	
			285
7	488.2	1080	
			210
8	551.2	90	
			220
9	625.9	310	
			332
10	758.2	642	
			218
11	859.9	860	
			266
12	1002.7	1126	
			186
13	1116.4	112	

Intervals range from 186 to 332 cents. The scale is made up of series of two large and three smaller intervals, ascending from the lowest pitch in the following order:

L, S, S, L, S, where L is large and S is small.

After Simplice had finished making the *kpaningbo* a short celebration took place. This involved pouring some palm wine over the bars, and then playing a couple of songs whilst people danced. Simplice then took some palm wine in his mouth and blew it out in a mist (the same way a fire breather does) over the bars. He said this celebration involving the palm wine was done so that the instrument would make people happy and dance when it was played. Large quantities of palm wine are always consumed during *kpaningbo* dances, which sometimes continue through the night till dawn.

XYLOPHONES USED AMONG THE BANDA, LINDA AND SABANGA

This is a brief survey of the xylophones used in some of the villages and towns I stayed at during the bicycle trip from Bambari to Sibut in June 1990 (see map 5). The towns of Bambari and Grimari have an ethnic mix of the Banda, Sabanga and Linda peoples.[51] The villages in the field study, Boakana and Lawa are predominantly Mandja and Banda respectively.

The instruments

Two types of xylophones are used in this area:

a) five-bar portable xylophone,

b) ten-bar portable xylophone.

In Bambari, the Banda use both five and ten-bar instruments, calling both *kalangba*. The ten bar kalangba is similar in construction to the Nzakara *nzanzangoula,* but *kalangba* are tuned to a higher pitch, use mirlitons on the resonators, have a different method of supporting the bars and have a different musical function. The bars of the *kalangba* are always arranged in the following order:

1 1' 5' 5 4' 4 3' 3 2' 2

The Linda and Sabanga both use the same instrument, known to the Linda as *kalangba,* and to the Sabanga as *manza* (see fig. 148).

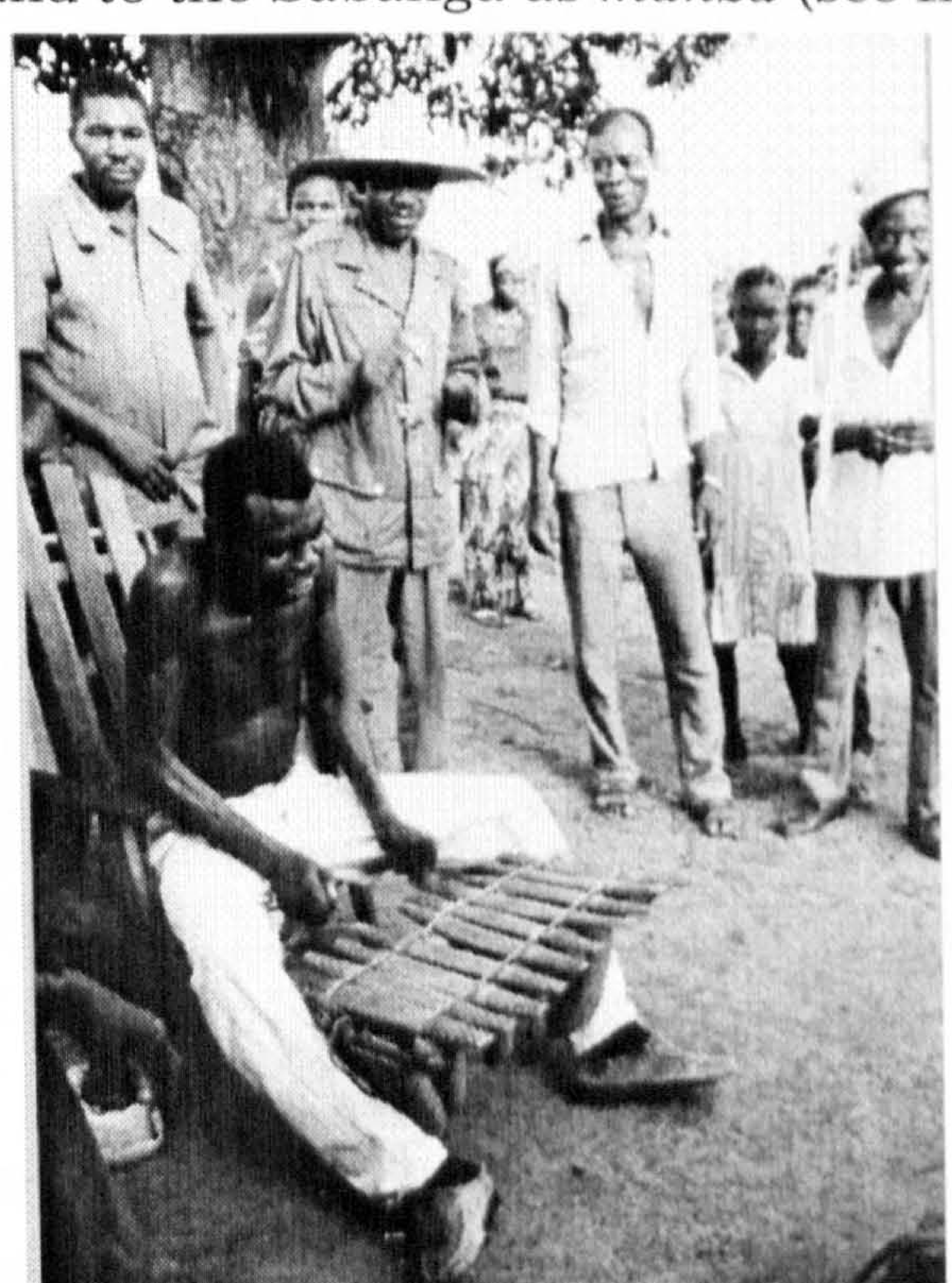


Fig. 148 Mapouka (Linda) playing Sabanga xylophone in Grimari.

The five bar Banda *kalangba* is, in essence, the same as the ten bar version but without the paired-octaves. The bars are arranged in the following order:

1 5 4 3 2.

The Banda in the village of Lawa only use the five-bar xylophone and call it *kalangba* (see fig. 149). The Mandja in the village of Boakana use a pair of five-bar xylophones, one pitched one note lower than the other. The lower-pitched one is called *gassa-kangba* while the higher-pitched instrument is called *guede-kangba*. The instruments have the following arrangement of bars:

1 5 2 3 4	2 1' 5 4 3
gassa-kangba	*guede-kangba*

The construction of all the above instruments is very similar. The bars rest on two parallel supports, one either side of the centre-board (see fig. 150). These soft supports are made by tying grass in position round the sticks and then wrapping pieces of rag around the grass as shown in figure 150.

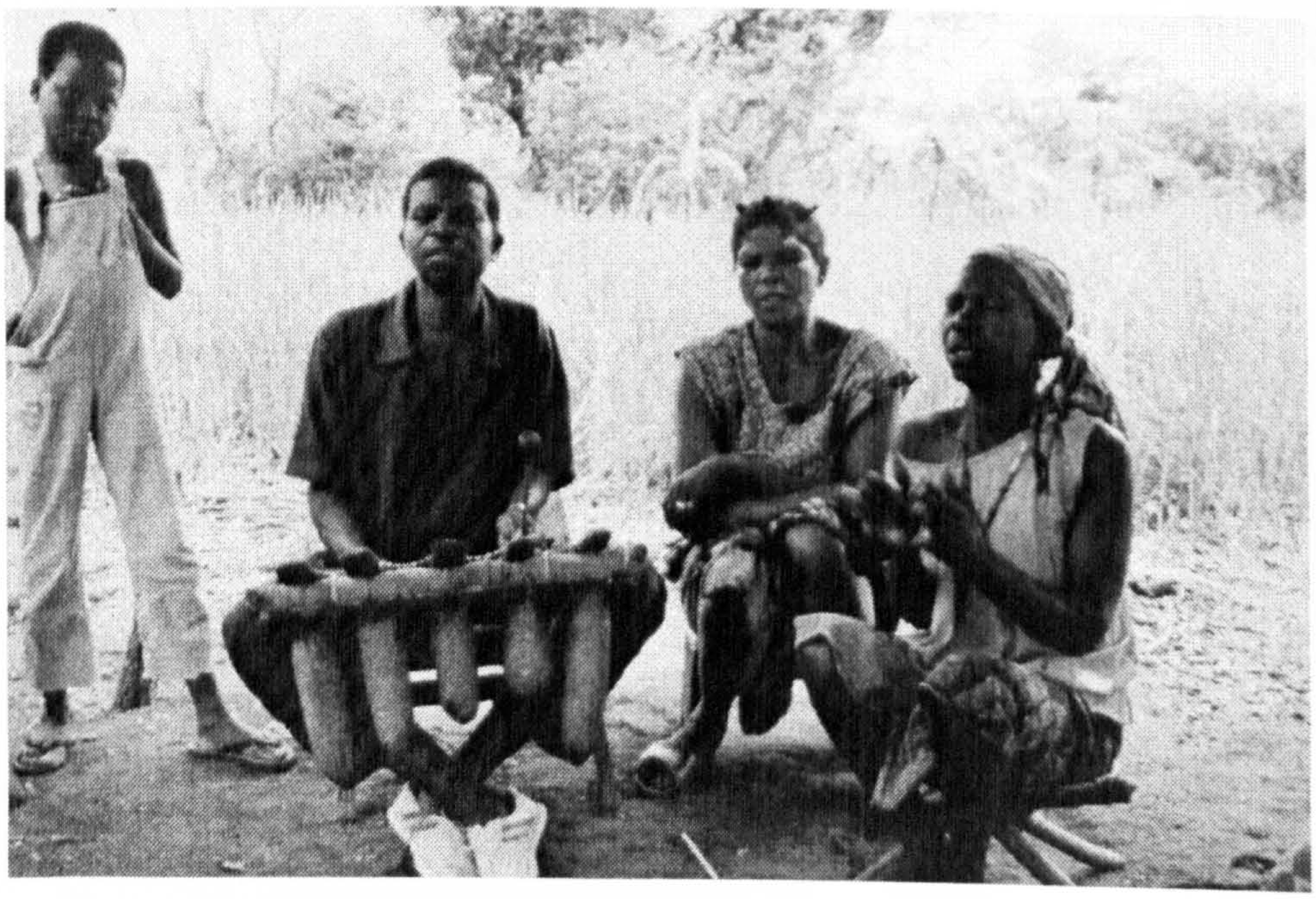


Fig. 149 Marcel Mandaba (Banda) playing *kalangba,* accompanied by singers, Monique Ndeyemo and Apholcine Kotimo in Lawa.

The distinctive buzzing sound of the *kalangba* type instrument is produced by mirlitons on the resonators. On ten-bar instruments it is common practice to not use mirlitons on the three highest-pitched resonators (see fig. 151). The mirliton membranes are very thin; the usual material is the peritoneum of virtually any mammal.

Fig. 150 Laurent Malatendji (Banda musician and instrument maker) making a new *kalangba* frame in Bambari. Each calabash is held in place by a stick and black beeswax. Note the old frame in the background. The centre-board is made of very soft timber and is very susceptible to insect attack.

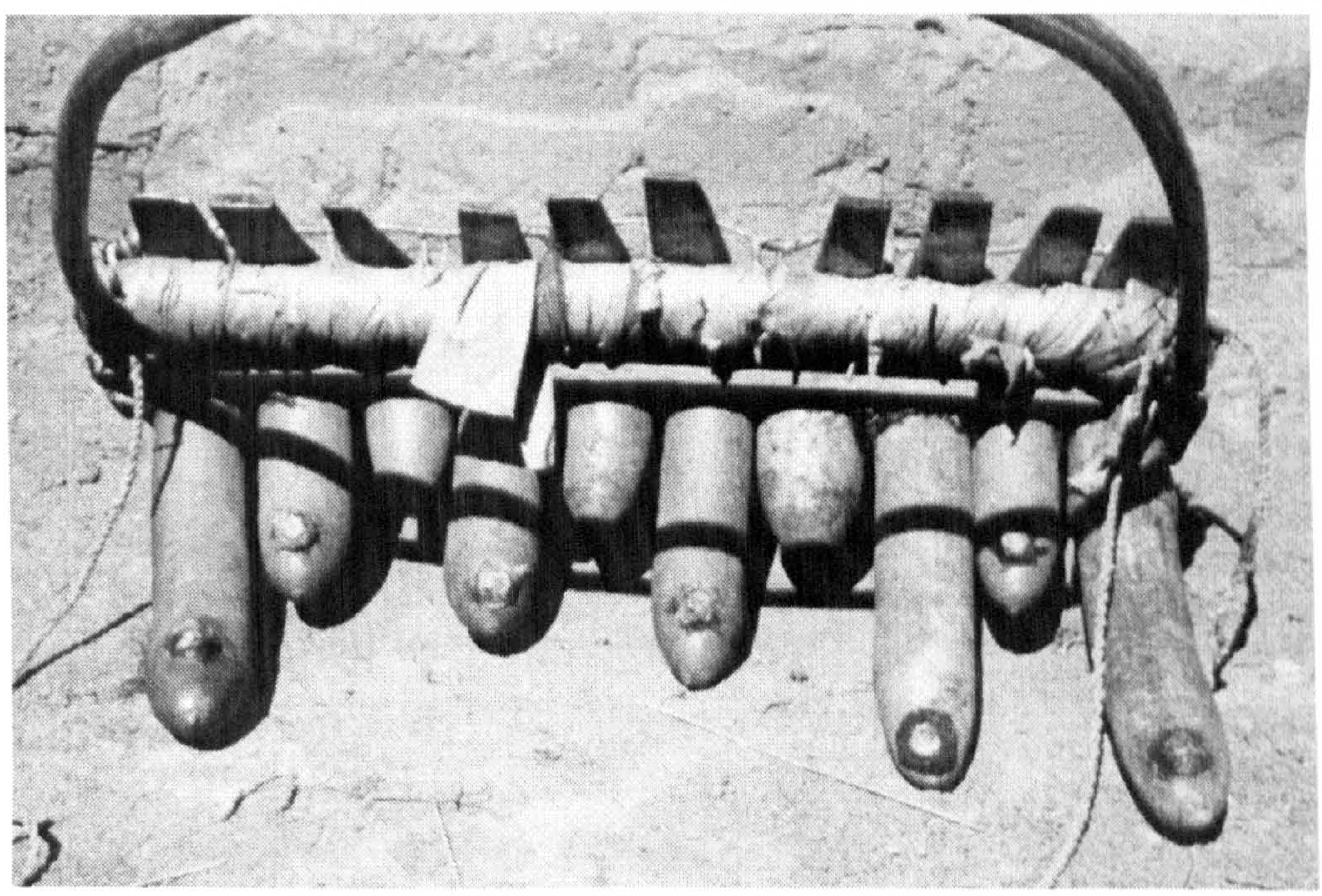


Fig. 151 Sabanga *manza*.

The mirlitons are made by cutting a hole in the resonator and sculpting a wax ferrule around it. The end of the ferrule is heated with a burning stick and the delicate membrane placed on the soft wax (see fig. 152).

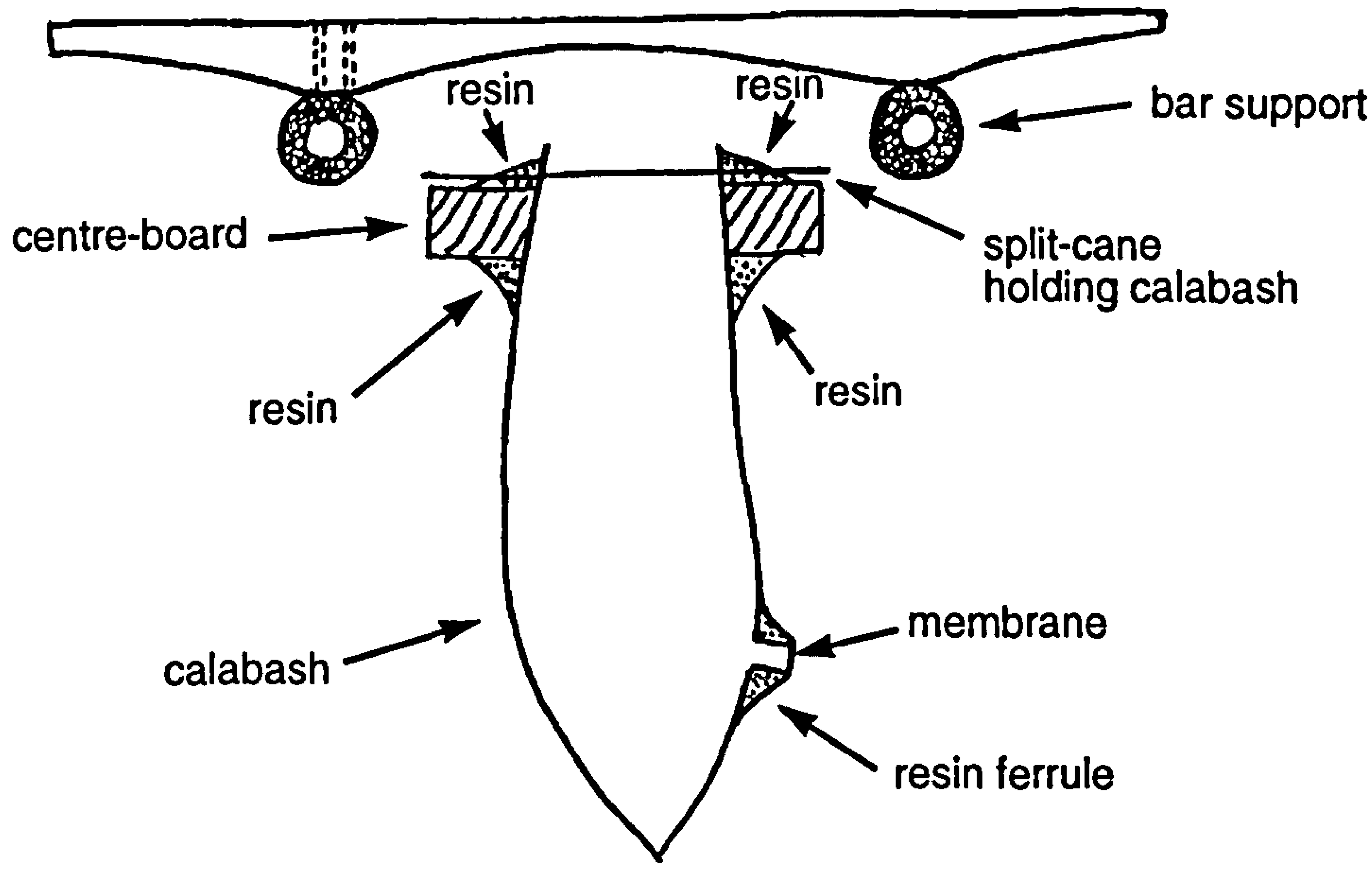


Fig. 152 Cross-section of *kalangba.*

The pitch ranges of ten-bar xylophones of the Banda, Linda and Sabanga are very similar, usually starting between 250 and 300 Hertz. The tunings of two *kalangba* and one Sabanga *manza* are shown in table 14.

Table 14 Tunings of two *kalangba* and one *manza.*

Sabanga *manza* (Grimari)			Banda *kalangba* (Bambari)			Linda *kalangba* (Bambari)		
Hertz	cents (above C)	interval (cents)	Hertz	cents (above C)	interval (cents)	Hertz	cents (above C)	interval (cents)
297.8	116		256.4	1172		253.0	1142	
		168			251			252
308.3	284		297.6	223		292.0	194	
		266			237			246
361.5	550		342.1	460		337.3	440	
		240			242			250
412.9	790		392.5	702		389.7	690	
		282			246			225
486.0	1072		452.4	948		443.8	915	
		216			224			235
550.5	88		514.9	1172		508.4	1150	
		227			251			244
627.7	315		595.2	223		585.3	194	
		285			243			251
740.0	600		605.2	466		676.6	445	
		193			236			229
827.3	793		785.0	702		772.3	674	
		253			220			222
957.4	1046		891.3	922		878.0	896	

The two *kalangba* from Bambari have very accurately-tuned octaves, and this is quite common with *kalangba*. These two instruments from Bambari are tuned to an almost equitonal pentatonic scale, all the intervals being very close to 240 cents. The *manza* from Grimari, however, has intervals ranging from 168 cents to 285 cents, giving it a definite non-equitonal feel.

The *kalangba*-type xylophones of the Banda, Linda and Sabanga are used to celebrate events such as the birth of twins (*ameya*) and successful hunting and fishing trips (*dengbele*). Kalangba are also used to provide the music for a number of cults and rituals such as men's and women's circumcision and boys' initiation ceremony. All these events are still essential to Banda, Linda and Sabanga culture so the xylophone music continues to thrive.

DISCUSSION ON THE PRESENT STATE OF AZANDE AND NZAKARA XYLOPHONE TRADITIONS

This study has shown that the *manza* and *nzanzangoula* traditions among the Azande and Nzakara have almost completely died out. This is because these xylophones were reserved for kings and chiefs and symbolic of their power. Since the hierarchy in Azande and Nzakara society has gradually lost its influence and importance over the last century, these specialist xylophones no longer have a role in society. It is a shame that these very fine instruments have not been been able to find their way into general use. It seems almost certain now that *nzanzangoula* will no longer be made and this skill, which took centuries to refine, will be lost.

On the other hand the *kalangba*-type xylophone, although similar in design, has a completely different function in Banda, Linda and Sabanga societies. Its use is not restricted to the elite, but rather, is used by the general population in the observance of rituals and cults which are still vigorously pursued. During the 1800s the Banda population was almost wiped out through slavery, and it is ironic that they managed to keep major aspects of their culture, whereas the Azande and Nzakara, who were barely affected by slavery, have lost major parts of their elitist culture this century.

It can be seen that states set up by the Azande and Nzakara appeared so threatening that colonial rulers set about systematically dismantling the very fabric of Azande and Nzakara society.

The Azande in C.A.R. have relatively recently adopted a new xylophone from their people in Zaire. This was met with little opposition from the colonials because it is purely for entertainment and does not inspire the feelings of pride and nationalism that *nzanzangoula* and *manza* music used to.

CHAPTER XII

COMPARISON OF XYLOPHONE TRADITIONS IN GHANA, ZAMBIA AND CENTRAL AFRICAN REPUBLIC

There are a number of similarities between the xylophone cultures examined in this dissertation. The creation and social structure of the Lozi and Bandia (Nzakara) kingdoms are historically very similar: both peoples established powerful, unified nations, through the expansion of one dominant clan. The power of the Bandia and Lozi nations enabled them to be virtually unaffected by the slave trade in the 1800s. The strength gave stability which enabled the complex and refined court music traditions to develop over the centuries. Both Lozi and Bandia rulers absorbed the culture of the people they came to dominate, as a consequence of which the existing traditions of defeated subjects were assimilated and developed further

The xylophones of the Lozi and Bandia court traditions featured prominently in the royal establishments, and had great symbolic meaning, their ownership being restricted according to social status. Traditions which are so specialised and elitist are vulnerable if the establishment which they praise is overthrown. The French colonial system took power away from the Bandia clan rulers of the Nzakara; this led to the removal of the role of *nzanzangoula*, and its subsequent decline in use. Although political and financial power was taken from the Lozi rulers by the British during the colonial era, the Lozi royal establishment was retained and the court music survived.

After the fall of the Bandia kingdom at the beginning of this century, Nzakara chiefs continued using the *nzanzangoula*. This xylophone still played an important role in the Nzakara ancestor cult. Unfortunately, Christian missionaries in C.A.R. during the 1950s thought of this pagan cult as worshipping demons, and set about ending it by destroying the altars. However, this may not be the only reason for the decline of the ancestor cult. Dengba, the Nzakara xylophone maker in Bangassou, believed that the young have lost interest in and respect for their culture. He believes that the younger generation are no longer taught to value the old ways, the French education system being seen as more important.

Nzakara culture and the modern systems of education and religion seem unable to co-exist. A cultural programme incorporated into the school curriculum could help to promote an awareness of the Nzakara culture and history. In addition to this, the younger generation needs to see Nzakara culture respected on a wider scale. In Ghana the government set up a ministry of arts to promote cultural awareness and organise cultural programmes over the whole country. Such a system could work in C.A.R.

As has been shown, the role of the xylophone in the LoDagaa and Sisaala societies is very different from that of the xylophones in Lozi and Nzakara societies. The societies themselves are not structured in the same way. The LoDagaa and Sisaala, unlike the Lozi and Nzakara, are not unified nations with hierarchical systems of leadership, but rather a series of small clan settlements held together by loose ties of marriage and clanship. The role of the Lozi and Nzakara instruments is to maintain the identity of the nation, and praise the strength of its leaders. The Sisaala and LoDagaa xylophone traditions developed as an integral part of culture, being used for the funeral ceremony and pagan cults.

The structure and values of a society, along with the role that instruments play within it, governs their manufacture. Although the Lozi and Nzakara xylophones have great symbolic significance, little mystique surrounds their manufacture, unlike the LoDagaa and Sisaala instruments with their pagan ceremonies. It is clear that the instruments of the court traditions and funeral traditions have taken many centuries to develop. This is very apparent with the Nzakara *nzanzangoula*, and shows itself with the high level of craftsmanship with which these instruments were made. In a similar way to that in which the Lozi created distinct forms of music and instruments to promote respect, the Nzakara developed a xylophone with a unique sound to set it apart from the xylophones of the surrounding peoples. Although, in essence, the *nzanzangoula* and *kalangba*-type xylophones of the Banda, Linda and Sabanga are similar (arrangement of the bars), the *nzanzangoula*'s sound is significantly different because it does not use mirlitons, and therefore produces a clear, pure sound. In addition to this, the bars of the *nzanzangoula* are much wider than those of the *kalangba*, thus limiting the speed with which the Nzakara xylophone can be played. *Nzanzangoula* music is characterised by a slow tempo, with more than one instrument used to produce a strong, chordal harmony, whereas *kalangba* music is characterised by rapid polyphony, usually played on only one instrument. The role of the *kalangba* in Banda, Linda and Sabanga society is similar to the role of the LoDagaa and Sisaala xylophones in that both instruments provide the music for all the important cultural events and structures of the societies. These instruments are in everyday use, and the playing of them not restricted by social status. These factors are decisive elements in the continuation of a music culture.

PART III

CHAPTER XIII

DESIGN FACTORS INFLUENCING THE TONE OF AFRICAN XYLOPHONES

The designs of African xylophones vary widely across the continent. To some extent they are governed by the materials available to the maker, but generally the principal factors determining tone quality, such as bar design and resonator type, have been arrived at through a long tradition of playing and making, involving much experimentation. The question as to whether instrument tone and design are products of the musical taste, or whether they determine musical style and taste, is complex and very difficult to answer. It is possible to gain some insight into this question by looking at what happens when a culture adopts the musical instruments of a neighbouring culture.[1]

This chapter aims to show which factors are important in determining the tone quality of African xylophones. The tone of a xylophone is determined by three principal variables:

1) The bars, including:
   a) timber species,
   b) design or shape (incorporating method of tuning).

2) The resonators, including:
   a) form and material,
   b) refinements such as the fitting of mirlitons (their design and material).

3) The striking of the bars, including:
   a) method,
   b) type of beater (material used and hardness).

Bars have been made by the author of forms representing the main xylophone types found in Africa. Sympathetically tuned resonators of various forms and materials have been made and tested with the different bars. A study has also been made on the use of mirlitons and their effect on tone. The tone of these bars and resonators has been studied using digital analysis to obtain objective results. In addition to this quantitative approach an attempt is made to describe the resulting tone quality of xylophone bars and resonators. Where possible reference is made to my field work, with African xylophone makers giving their account of the ideal tone they are striving for.

ACOUSTIC PRINCIPLES OF XYLOPHONES

Xylophones fall into the group of instruments known as bar-idiophones. Idiophones are those instruments whose body material itself (in this case the bar) produces the sound, without being kept taut in any way.

Sources of information

There is no published material which deals specifically with the acoustics of African xylophones. Larry Godsey's unpublished Phd. dissertation, 'The Use of the Xylophone in the Funeral Ceremony of Northwest Ghana'[2], includes two basic spectograms showing the effect of the use of mirlitons on calabash resonators.

Until recently most text books on acoustics dealt only briefly, and often inaccurately, with the subject of orchestral xylophones and marimbas. Within the last twenty years this situation has improved considerably; notable publications being Backus's *The Acoustical Foundations of Music*[3], Askill's *Physics of Musical Sounds*[4], Campbell and Greated's *The Musician's Guide to Acoustics*[5], and Fletcher and Rossing's *The Physics of Musical Instruments*[6].

The principal unpublished source of information on the acoustics of bar percussion instruments is James Moore's 1970 PhD. dissertation 'Acoustics of Bar Percussion Instruments'.[7] Moore's stated aims are to:

> (1) present a nomenclature for the bar percussion instruments that will clarify the terminology and characteristics for these instruments, (2) review (a) musical acoustics reference literature concerning percussion instruments, especially bar percussion instruments, and (b) literature containing material on tuning

and experimental work of relevance to bar percussion instruments, (3) describe the manufacturing and tuning processes of percussion instrument bars, pointing out in particular the influence of bar shape on the modes of vibration of the bars, (4) report the results of experimental work that measured the steady state and transient vibrational characteristics of percussion instrument bars, and (5) present suggestions for improving the manufacturing processes of bar percussion instruments[8].

Moore's work provides a valuable insight into the methods of making and tuning percussion bars used by the large American companies prior to 1970[9]. His experimental work consisted of testing the modes of vibration of bars of professional quality made by the leading manufacturers. Since the bars produced by manufacturers are essentially similar in outline and size (ie. width, length, thickness, and plan shape), when Moore refers to bar shape he means the shape of the tuning arch.

TYPES OF VIBRATIONS IN BARS

When a bar is struck three types of vibration take place: 1) transverse (at right angles to its length), 2) longitudinal (in the direction of axis of the bar), and 3) torsional (twisting). Transverse vibrations are the most important type in bar idiophones; they make up what we perceive as the musical sound. The longitudinal waves in bars are of very high frequency and as such are not generally heard.[10] Torsional modes of vibration are undesirable in bar idiophones but are "sometimes present together with transverse vibrations, thus changing the timbre of a sound but not its pitch."[11]

Transverse vibrations

The amplitude of excitation of transverse bending modes resulting from striking a bar is dependent on:

1) The shape of the bar. Initially, here, I shall assume the bar to be rectangular and of uniform thickness, although the latter is rarely the case in African xylophones.

2) The point at which the hammer strikes the bar. Xylophone bars are struck at their centre or sometimes their ends (where the antinodes of the fundamental mode of vibration are).

3) The bar's 'end conditions', or the position and nature of its supports. Xylophone bars are supported so that both ends are free to vibrate. The points of maximum vibration (antinodes) are at the ends and at the centre, so bars are supported at the points of least vibration (nodes) for the lowest transverse mode.

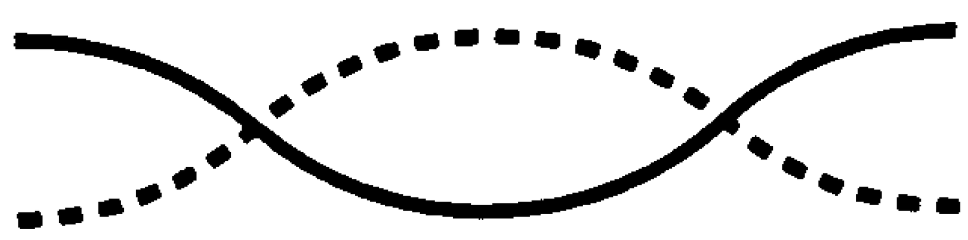
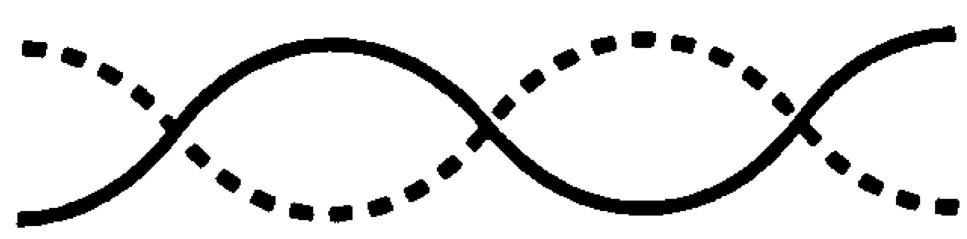
4) The type of beater used. Beaters of hard materials such as wood or metal fail to excite the fundamental at low frequencies. Generally beaters made of a relatively soft material such as rubber are used. Hugh Tracey[12] notes:

> Carefully graded heads are needed to bring out the tone of a *Timbila* [xylophone], from the very soft, large heads required for the double bass, *Gulu*, to the hard small heads used for the highest notes of the *Sange* and *Cilanzane*. The principle behind this fact is that a blow upon the surface of the *mbila* [xylophone] must immediately evoke the fundamental note by setting the wood in vibration. If a beater is too hard the shorter wavelengths are evoked and the fundamental note may remain dead. This gives the crisp, thin sound associated with European xylophones. On the other hand, if the beater is too soft it will not evoke a note in the higher registers. For this reason you will find all Chopi [ethnic group in Mozambique] players hold a slightly harder-headed beater in their right hands than in their left (except, of course, in the case of left-handed players). This means, over the whole orchestra, a gradation of beaters into six or seven degrees of hardness or softness - the softer the beater the larger its head.

Striking a bar with a hammer forces the bar to bend around its central (horizontal) axis, as shown for the lowest mode of vibration in table 15. The elasticity of the material forces the bar to return to its original shape and as the momentum continues, bending takes place in the opposite direction. The bar continues this bending back and forth until the energy is dissipated as internal friction (heat) and sound. The restoring force which brings the bar back to the original shape is the stiffness of its material. The stiffness of a bar is dependent on its dimensions and a constant known as Young's Modulus, which is a measure of the rigidity of the specific material from which the bar is made.

Table 15 shows the first four transverse modes of vibration and corresponding frequencies of a xylophone bar of constant thickness.

Table 15 The first four transverse normal modes of a bar. Source: Campbell M. and Greated C., *The Musician's Guide to Acoustics*, p. 430.

	Mode number	Frequency
	1	f_1
	2	$2.756\ f_1$
	3	$5.404\ f_1$
	4	$8.933\ f_1$

It is possible to work out the frequency of the first mode of vibration of a bar of uniform thickness with length L, and thickness t, so long as the density and stiffness values are known[13]:

$$f_1 = 1.03\ (Y/r)^{1/2}\ t/L^2$$

Where Y is Young's modulus of elasticity,
r is the density of the material.

The width of a bar of rectangular cross-section does not affect frequency, and is therefore left out of the above formula. Width does however affect the strength (amplitude) of the fundamental, a very narrow bar having a weak fundamental. The frequency is inversely proportional to the square of the length of a bar, and is proportional to its thickness, so adjustments in length will be more effective in tuning the bar than in thickness. Doubling the length lowers the pitch by two octaves, and doubling the thickness raises the pitch by one octave.

In practical xylophone making this formula is of little use, other than a very rough guide, since every piece of timber differs in density and rigidity. It is of more use with metallophones, though even here results can be unreliable unless a very accurate value for Young's modulus is established for the particular alloy used.

The usefulness of bars in tuned percussion instruments depends largely on the ability of the bar to produce a musical tone of definite pitch when struck. Such a tone is built up of partials whose distribution approximates to an harmonic series. Where the partials do not conform to an harmonic series the tone is less clearly defined. Considering these points and looking at the distribution of partials of a bar in table 15 (f, 2.756, 5.404, 8.933), the xylophone appears not to be capable of producing a tone of definite pitch. However, this is clearly not the case. A definite pitch is produced because the other modes of vibration are either quickly damped out, or are not excited at all. This occurs because of the way in which the bar is supported and struck. Table 16 shows the nodal positions of a rectangular bar of length L.

Table 16 Modes of vibration of a rectangular bar of length L. Source: Campbell M. and Greated C., *The Musician's Guide to Acoustics*, p. 433.

Mode no.	Frequency ratio f_n/f_1	Nodal positions
1	1	0.224L 0.776L
2	2.756	0.132L 0.5L 0.868L
3	5.404	0.094L 0.356L 0.644L 0.906L
4	8.933	0.073L 0.277L 0.5L 0.723L 0.927L

The first mode of vibration of a bar is not damped by the supports since the amplitude is zero at these points. The second and third modes are quickly damped because their antinodes lie close to the supports. The fourth mode is hardly excited at all because the striking point is at its node (as is that of the second mode).

Xylophone bars.

The example of a bar of constant thickness has been used so far. In practice this is rarely the case, the bars of most xylophones (and metallophones) having an arch carved into their underside, symmetrically about their centre. This arching or undercutting raises the ratio of the second mode frequency to the first mode frequency from the inharmonic ratio of 1:2.76. By this means the second partial can be made an integer multiple of the frequency of the first. Askill[14] states:

> the main difference between the [orchestral] xylophone and [orchestral] marimba is that the bars of the xylophone are tuned to a twelfth above the fundamental (3:1) as compared with the double octave (4:1) in the marimba.

The undercutting of the xylophone bar to create this ratio strengthens the sense of pitch. For a xylophone with tube resonators closed at one end, tuning the second modes of the bars to the third harmonic is especially advantageous since the "second mode of the air column has a resonant frequency three times that of the first mode."[15] Thus a tube resonator can amplify both the first and second modes of the bar (though in practice the open end of the resonator is placed under the bar at the antinode of the fundamental mode which is also the node of the second partial, so very little of the second partial's energy is transferred to the resonator).

Moore notes that until the 1920s manufacturers of orchestral bar percussion instruments did not tune the second partial.[16] When he carried out his research in 1970 some manufacturers would tune the third partials of bars upon customers' special request[17]:

> Tuning of the third partial is done only in the low register of the instruments, on the bars with fundamentals of C4 downward. For marimba and vibe bars the desirable ratios of the second and third partials to the fundamental are 4:1 and 10:1. For xylophone bars the desirable ratios of the second and third partials to the fundamental are 3:1 and 6:1. ... To change the frequency of the third partial independently of the first and second partials is a difficult task as very small amounts of material must be removed from the underside of the bar [Moore does not say where this material should be removed from]

without changing the tuning of the first and second partials. Rosewood bars in particular must be of exceptionally fine material, relatively free of imperfections and uneven grain, to allow tuning of the third mode of vibration. Aluminium vibe bars that are made of a material more consistent and homogeneous than rosewood, produce a tone of longer audible duration and may be more easily tuned to a desirable third partial.

The first three modes of vibration of low-pitched bars can usually be heard by holding the bar at one of the nodes for the desired partial and striking the bar at this mode's antinode (refer to table 15). To hear the second partial, for example, the bar is held between thumb and forefinger at its centre (or alternatively at 13.2% of the bar's length from either end) and struck at 31.6% of the bar's length from either end. To hear the third partial the bar is held either at 9.4%, or 35.6% of its length from either end, and struck at its centre (or alternatively at 22.5% of the length of the bar from either end).[18] The method of tuning the upper partials of a bar is examined later in this chapter (Experimental Work).

The distinction generally made between the xylophone and marimba is the different tuning of each instrument's partials. However, in reality it is only the bars in the low register of each instrument that follow the generally accepted ratios, and even then some manufacturers make little effort to adhere to the distinction. Campbell and Greated[19] note:

> ...not all xylophones have bars undercut in a uniform way. Measurements by one of the authors on a four octave orchestral xylophone have shown a rather more complicated pattern. For the lowest note on the instrument, C_4, the ratio of second to first mode frequency was found to be almost exactly 4: the second mode was thus two octaves above the first, rather than the twelfth suggested.... For the note C_5, the ratio was 3.8, ... by C_6, the mode ratio reduced to 3.1. For the highest pitched bar tested, C_7, the mode ratio was 2.5, which is actually less than the theoretical value of a uniform bar.

Visually it is possible to notice that the undercutting of bars on orchestral xylophones varies, the amount diminishing from the lower pitched to higher bars. Campbell and Greated put forward the explanation that the degree of undercutting varies because of the "relative insensitivity of the ear to lower pitched pure tones",[20] ie. low pitched bars tuned to the third harmonic may have this partial so greatly amplified by the tubular resonator that the fundamental would appear to be the third harmonic itself. I find this difficult to accept since C_4 (260.7 Hertz) is not a particularly low pitch; I rather think it likely that the instrument tested was of poor quality, since tuning upper partials is a time-consuming and therefore expensive procedure.

Moore[21] tested only the A pitches (110 Hz., 220 Hz., etc.) on one marimba and one xylophone. For the marimba he found that the second modes of vibration of bars A_2 (110 Hertz), A_3, and A_4 conformed to the desired ratio of 4:1, but that the second partial of bar A_5 was considerably flat of the ratio obtaining in the lower registers. For the xylophone he tested, only the lowest A_4 bar produced a second partial of the ratio 3:1.

As the fundamental pitch rises so does the sensitivity of the ear, to its maximum level in the region of C_6, where the fundamental is less likely to be dominated by higher modes. For the highest octave of the orchestral xylophone the higher modes decay so quickly that is not considered worth tuning them.

In practice it would be very difficult to make a standard orchestral xylophone with the bars uniformly undercut. They usually have all the bars of the same thickness, resulting in the higher-pitched bars being very short. If undercut to a degree sufficient to tune partials, the bars would be so short that the amplitude of the fundamental would be greatly diminished. Orchestral xylophones are probably made with bars of uniform thickness for ease of manufacture and design (though some believe it is due to ignorance and laziness). Many bar idiophones in Africa and, especially in Indonesia,[22] have bars that increase greatly in thickness with rising frequency.

A result of undercutting a bar in order to raise the frequency of its second mode is a tendency to move the nodes of the first mode of vibration towards the end of the bar. The arching of the bars of the *madimba* from south-central Zaire, for example, is so great that the nodes are only 18% of the length of the bar from each end (nodal positions will be referred as %L) as opposed to 22.4%L for bars of constant thickness. It follows that if an instrument is made with bars having different levels of undercutting, the difference must be gradual and so disposed as to allow the bar supports of the frame to be straight.

The type of woods used for a xylophone bar has more effect on the amplitude and rate of decay than on the tone. Thus, two bars of different woods tuned to the same pitch and having the same shape, will produce a similar tone but with differing amplitudes and rates of decay.

Resonators

Most bar idiophones use some form of resonator to enhance the sound of the bars(s); without a resonator the tone of a thin or low-pitched bar is barely audible. Xylophone resonators fall into two categories; specific and non-specific. Instruments with specific resonators are those which have a sympathetically tuned resonator for each bar; ie. the resonator and the bar are tuned to the same pitch. In instruments with non-specific resonators, one resonator serves several or all of the bars. Examples include the trough or box resonator of the the Javanese gambang, and even the dug out hollow in the ground of African pit xylophones.

Non-specific resonators

Trough resonators (usually a rectangular wooden box) are often modified in order to improve their response and efficiency. This can be done by one or a combination of all the following methods:

a) sloping the floor of the box up in the direction of the higher-pitched bars;

b) dividing the trough by means of vertical transverse partitions, so that each compartment favours the pitches of the small group of bars immediately above it (xylophones used in education often employ a combination of methods a and b); or

c) partially closing the top of the trough by means of two longitudinal boards, leaving a gap which increases in width from the low- to the high-pitched end of the instrument (as on the Javanese gambang - see Chap. V).

Trough resonators, especially wooden box types, tend to give an uneven response, favouring the bars whose pitches lie close to the fundamental pitch and partials of the box. The sustain of trough resonated instruments is generally longer than of those with individual resonators because less energy is taken by a less well tuned resonator (conversely the amplitude is smaller).

Specific resonators

Several forms of sympathetic resonators are used in xylophones:

a) cylindrical tubes (closed at one end),

b) conical tubes, and

c) spheroids.

Cylindrical tubular resonators are used by all the manufacturers of orchestral xylophones, marimbas and vibraphones. Instruments using cylindrical tubular resonators are widespread throughout all the major xylophone areas in the world: Africa, Central America, and South East Asia. Conical tubular resonators are geographically limited, to my knowledge, to some African xylophones (inversely conical resonators terminating in a point are used in Guatemala and Mexico, though these are acoustically more similar to a sphere than a cone). The use of spherical resonators is in most widespread use in Africa, although they are also found to a limited degree in S.E. Asia.

The three forms of resonators distinguished above have different acoustic properties, which are discussed below.

Tube resonators

Standing waves set up in a tube take the form of compressions and rarefactions moving down the tube. These waves are therefore longitudinal, rather than transverse as with bars. The normal modes of vibration are dependent on the shape of the tube (cylindrical or conical) and whether the tube is open at both ends (referred to as open), or closed at one end (closed).

Open cylindrical tubes are not generally used for bar idiophone resonators. Their disadvantages compared to closed tubes are a) they are relatively inefficient and b) they produce a fundamental pitch of twice the frequency of that produced by a closed tube of the same length. Open tubes have modes of vibration which form an approximate harmonic series.

The closed cylindrical tube produces a fundamental frequency one octave lower than the open type, but produces a series of only odd harmonics; the first three modes being the fundamental, the twelfth (1:3), and the seventeenth (1:5).

The conical tube has the same vibration frequencies as an open tube of the same length. This means that a conical tube produces an approximate harmonic series.

Spherical resonators

Spherical resonators used for bar idiophones are always closed, ie open at only one end. A nominally spherical resonator need not be strictly spherical, but can be of virtually any shape (bottles, cans etc.), provided that it has a narrow mouth (aperture) in relation to the cross-section of its main body, and that it is of a rigid material. Most African xylophones use spherical calabash (with or without necks) as resonators, as shown in figure 153. These are very similar in shape to the Helmholtz resonator (see fig. 153) named after the famous German physicist who developed it, which is used to detect sounds of a particular frequency in the presence of sounds of other frequencies. Helmholtz developed spherical resonators for frequency detection because "Their advantage [over tubes and cones] consists partly in their other proper tones being very distant indeed from their prime tones, and hence being very slightly reinforced, and partly in the spherical form giving the most powerful resonance".[23]

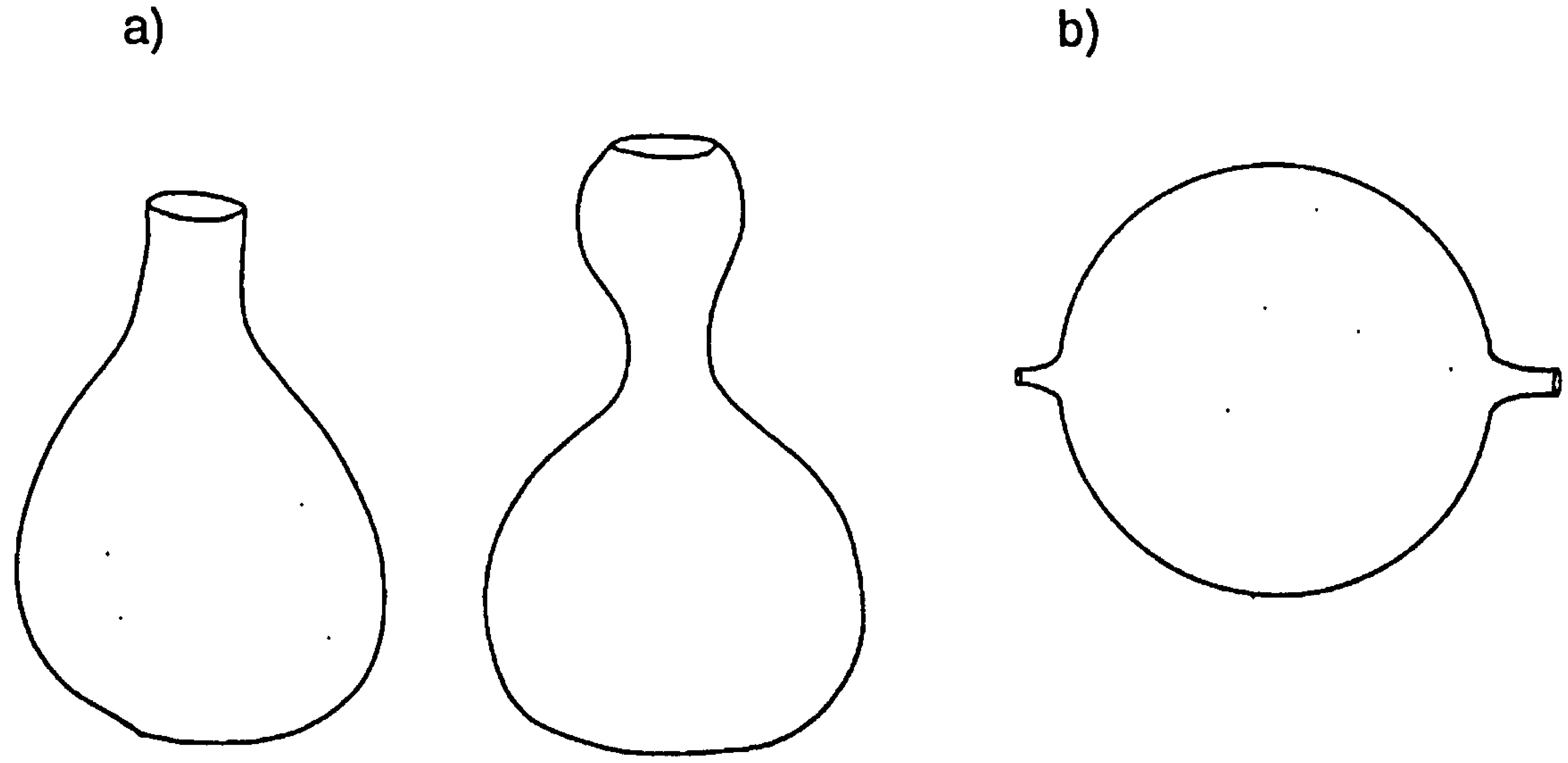


Fig. 153 a) African calabash resonators and b) the Helmholtz resonator. Note that the Helmholtz resonator has an extra neck.opposite the aperture for inserting into the ear.

The air inside a spherical resonator can be set into motion when a sound source (such as a bar) tuned to the fundamental (resonant) frequency of the sphere is made to vibrate close to the aperture. This action causes the pressure in the sphere to rise above the outside ambient pressure as air flows in. When the air pressure in the sphere reaches its maximum the air starts to flow out until the pressure is the same as that outside. At this point, however, the air has gained momentum and so carries on driving out until the pressure in the sphere is lower than that outside. When the pressure inside the sphere is at a minimum, air is drawn in from outside until the two pressures are equal, when the cycle starts again.

The result is a vibration of air in and out of the aperture of the resonator. The restoring force is the excess pressure in the sphere when it contains excess air. Increasing the volume of the sphere increases its capability to hold excess air for a given excess pressure. It therefore follows that increasing the volume of the resonator lowers its frequency of vibration.[24] The frequency also depends on the size of the aperture and the length of the neck (if any). These two factors affect the acoustical mass of the air in the neck: the larger the acoustical mass, the lower the vibration frequency.[25]

The acoustical mass is not the same as the actual mass. Lengthening the neck increases the actual mass, so the force needed to move the air increases, resulting in a lower frequency. The acoustical mass is therefore proportional to the length of the neck. However, by increasing the size of the aperture the actual mass is also increased, but the air within the neck now requires less force to move it, resulting in a higher frequency. The effective mass is therefore inversely proportional to the size of the aperture.

Neck length and aperture size also affect the resonance amplitude of the resonator. Lengthening the neck results in more force being required to move the air, and hence a lower amplitude is produced, but with a longer period of decay. With a large aperture the air within the neck requires less force to oscillate, due to reduced friction. This results in a larger amplitude but a shorter period of decay. Helmholtz however states that, when using his form of resonator with an ear-piece for detecting a particular frequency, "Resonators with a very narrow opening generally produce a much more considerable reinforcement of the tone, but then there must be a much more precise agreement between the pitch of the tone to be heard, and the proper tone of the resonator. It is just as in microscopes; the greater the magnifying power, the smaller the field of view."[26] However, this is not the case when using a spherical resonator to amplify the tone of a sound source (excited close to the aperture, as in an African xylophone) to the outside medium.

In the case of the Helmholtz resonators, which were originally made of glass and later of brass, the surface is very smooth. When the interior surface of the neck is smooth there is little friction operating against the oscillating air, and a large amplitude results. A resonance curve can be drawn to show the response in amplitude of a Helmholtz resonator to an external sound source of variable pitch - see figure 154. As the pitch of the source approaches the resonant frequency of the sphere, the amplitude at first rises gradually, progressively rising more dramatically until the two pitches are the same, at which point the maximum amplitude is produced. As the sound source continues to rise in pitch the amplitude drops quickly at first and then more gradually until there is no response.

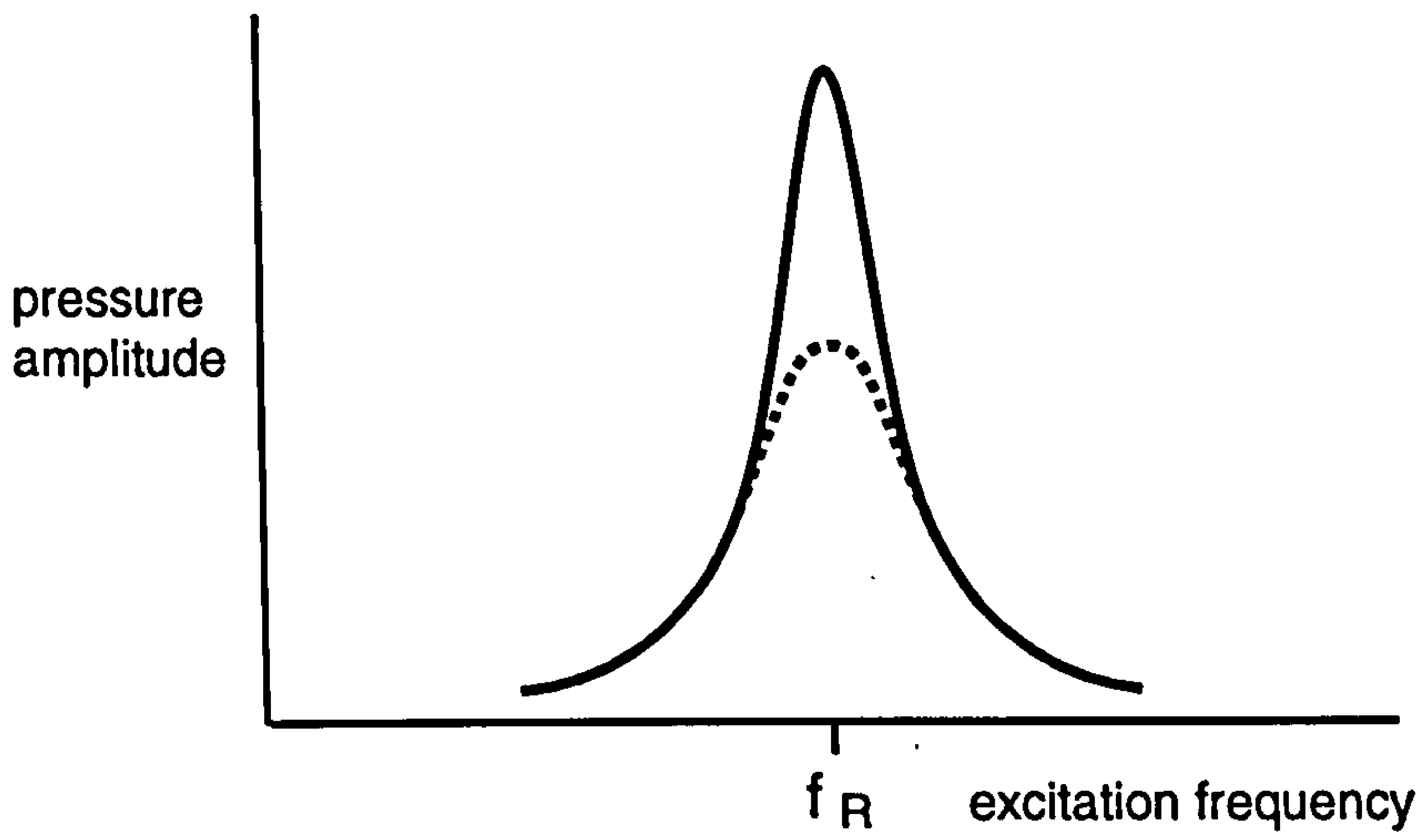


Figure 154 Resonance curves for high and low resistance spherical resonators. Source: Backus, J., *The Acoustical Foundations of Music*, p.81.

The spherical calabash used for African xylophone resonators do not have smooth interior surfaces. There is therefore more friction operating against the air in the neck. The amplitude produced at resonance is less than that for a smooth-necked resonator, due to frictional energy losses. The resonance curve for a rough-necked sphere is broadened by increasing the resistance as shown by the dashed line in figure 154. This means that a high-resistance resonator gives a weaker response, but over a wider frequency range. Practically, this means that a xylophone with rough-necked resonators will produce a slightly lower maximum amplitude than one with smooth necks, but will be less susceptible to ambient temperature changes which affect the pitch of the resonators to a greater extent than the pitch of the bars.

The effect of mallet hardness

The hardness of a beater head determines which modes of vibration are excited when it is used to strike the bar. Striking a low-pitched bar with a hard-headed beater may fail to excite the fundamental; the resulting tone will be composed only of high partials. On the other hand, too soft a beater used on a high-pitched bar will hardly excite any response at all. Understanding the control that the type of beater has over tone is important for the player of tuned bar idiophones. The players of most African xylophones use beaters of differing hardnesses in each hand for this reason.

The correct weight of beater for a particular bar is also important. Fletcher and Rossing [27] explain the relationship between the beater and bar thus: "A mallet whose mass nearly equals the dynamic mass of the struck vibrator (typically about 30% of the total mass for a marimba bar in its fundamental mode) transfers the maximum amount of energy to the vibrator." A heavy beater remains in contact with the bar for a relatively long period, which tends to damp out the higher modes, whereas a lighter beater rebounds after only a short contact time.[28]

EXPERIMENTAL WORK

A series of tests has been undertaken in order to:

1) examine the modes of vibration of bars of uniform thickness but of different shapes;

2) examine the effect of undercutting bars and the method for tuning upper partials;

3) analyse tone characteristics of African-type xylophone bars coupled with resonators of different types;

4) assess the effect of mirlitons on tone and the effect of mirliton material.

Modes of vibration of bars

The theoretical frequencies of the first three transverse normal modes of vibration of a rectangular bar, as given in table 15, are f_1, 2.76 f_1, and 5.404 f_1. This standard acoustic theory probably relates to orchestral percussion bars, where the ratio of the bar's length (L) to width (W) is between 5:1 and 7.5:1.[29] Some African xylophones have bars with a much lower length to width ratio. An extreme example of this ratio occurs in the bass bars of the Venda *mbila* from Northern Transvaal; Kirby[30] measured one bass bar as "14 inches [355mm] long and 5½ inches [140mm] wide"; a ratio of 2.5:1.

For the purpose of comparison, three test bars, 22mm thick, were made from straight-grained, quarter sawn padauk (*pterocarpus angolensis*). These were of three distinct bar shapes: LoDagaba *gyil*, Venda *mbila* and Azande *manza*. The Azande *manza* bar was of the spear pattern shown in figure 141, while the other two were rectangular. The first three modes of vibration were measured using a Conn strobotuner. The dimensions of the bars and their mode frequencies are shown in table 17.

Table 17 Mode frequencies of three test bars.

Bar type	dimensions (mm)	ratio of length to width	mode	frequency (Hertz)	ratio to f_1
			1	328.7	1
Kogyil	573x78x22	7.3:1	2	883.6	2.69
			3	1646	5.01
			1	752.1	1
Mbila	370x153x22	2.4:1	2	1968.7	2.62
			3	n/a	n/a
			1	473.2	1
Manza	485x87x22	5.7:1	2	1205.6	2.55
			3	2262.4	4.78

The ratios of the second and third modes to the first mode for the *kogyil* bar (2.69:1 and 5.01:1) approximate to the theoretical ratios of 2.76:1 and 5.40:1. The ratios of the second and third modes to the first mode for the *manza* bar are appreciably lower than the theoretical values. To confirm this a second *manza* bar was made, with plain tapered ends (as opposed to the more complicated spear-shaped ends), measuring 360mm long and 50mm wide at the centre, narrowing to 25mm at the ends. The frequencies of the first and second modes of this bar were 508.4 Hertz and 1286.92 Hertz respectively, giving a ratio of second to first modes of 2.53:1, very close to that given for the *manza* bar in table 17. It appears therefore that tapering the ends of a bar lowers the upper partials.

It was not possible to hear or register on the strobotuner the frequency of the third mode of the *mbila* bar. This was probably due to this bar's fundamental being higher than the other bars' (a rough calculation using the theoretical value of 5.404 f_1 would put it at 3844.8 Hertz). The frequency of the second partial was audible (although considerably fainter than the other bars tested). The ratio of the second to first mode frequencies was calculated as 2.62:1, lower than the theoretical 2.76. The ratio of length to width of the *mbila* bar is very low (2.41:1), from which it appears that increasing the width of a bar lowers the frequency of the second partial. To further examine the effects of the length to width ratio a second, larger bar (made from the same plank as the bars in table 17) was tested. The bar was cut to the dimensions 770 by 185 by 22. The frequencies of the first and second modes were measured, and the bar was then divided longitudinally into two, giving bars 153 and 31 wide. These were tested, and then the wide bar was reduced in length by 100mm intervals, down to a final length of 335. The results of this experiment are shown in table 18.

Table 18 The effects of the length to width ratio of a bar on the ratio of the frequencies of the first to second modes of vibration.

bar number	dimensions (mm)	ratio of length to width	mode	frequency (Hertz)	ratio to f_1
1	770x185x22	4.2:1	1 2	179.7 484	1 2.69
2	770x153x22	5.0:1	1 2	179.21 483.2	1 2.70
3	770x31x22	24.8:1	1 2	185.5 503.94	1 2.72
4	670x153x22	4.4:1	1 2	234.4 630.2	1 2.69
5	570x153x22	3.7:1	1 2	322.4 860.9	1 2.67
6	470x153x22	3.1:1	1 2	474.3 1238.8	1 2.61
7	370x153x22	2.4:1	1 2	752.0 1968.7	1 2.62
8	335x153x22	2.2:1	1 2	909.5 2383.5	1 2.62

As the ratio of length to width decreases, so does the ratio of the frequencies of the second and first modes. The effect of the bar's width is however remarkably slight: when the ratio of length to width is at its greatest (bar 3; 24.8:1), the ratio of the frequencies of the first two modes is 2.72:1, and when the length to width ratio is smallest (bar 7; 2.2:1) the ratio of the first two modes is only reduced to 2.62:1. In fact, the ratio of the frequencies of the first two modes of bar 7 (with the the lowest length to width ratio) is higher than that for bar 6. It should be noted that the theoretical frequency of mode 2 ($2.756f_1$) was never reached.

The effect of undercutting bars on modes of vibration

The aim of the test was to tune the second to first partial to the ratio of 4:1, ie. that for the orchestral marimba. The *kogyil*-type bar was chosen for this because it resembles most closely the shape of an orchestral marimba bar, the tuning of whose partials is regarded as very important. There are a number of reasons why the exact tuning of partials for low pitched orchestral bar percussion instruments is more important than for African xylophones:

1) Orchestral style mallets are too light and often not soft enough to excite the fundamental pitch, whereas African xylophone beaters are generally heavier and softer, using natural rubber for the beater head[31].

2) The orchestral-style of playing using four mallets, two in each hand, requires a very exact technique to hit the centre of each bar[32]. The position at which the bar is hit dictates which modes are excited; hence a bar with an inharmonic partial will be very noticeable if it is not struck at its centre. MacCallum[33] notes: "'Octave tuning' [tuning the second partial to the double octave of the fundamental] is in keeping with the high standards of marimba manufacture . . . With octave tuning the bar will sound harmonious wherever it is struck."

3) Orchestral marimba bars are insufficiently undercut to raise the second partial well above the double octave of the fundamental, in the way we find in the low pitched bars of the Venda *mbila* and Pende *madimba*[34]. The degree of undercutting of orchestral marimba bars usually leaves the second partial slightly sharp of the double-octave required, hence the need to lower this partial by carving a secondary tuning arch close to the node of the first mode of vibration.

Methodology and results

After testing the three bars in table 17 for their modes of vibration with constant thickness, the pitch of the *gyil* bar was lowered in stages to a final pitch 110 Hz. (A_2), by undercutting. This pitch was chosen because it is the usual bottom note of the orchestral marimba, and also approximately the lowest note of the *gyil*. The results of the following tests are given in both Hertz and cents (the latter for ease of comparison). The frequencies of the first three modes of vibration were found using the strobotuner. The *gyil*-type bar tested measured 573x78x22, and with constant thickness produced a fundamental of 328.68 Hertz (E_4 - 5). Its pitch was lowered by 695 cents to 220 Hertz (A_3), by cutting an arch, symmetrically into its underside, between the nodes of the first mode of vibration (see fig. 155).

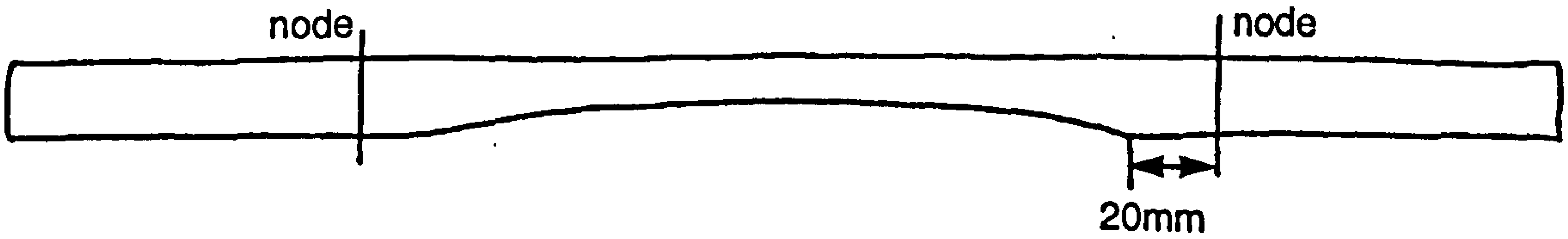


Figure 155 Shape of test bar at 220 Hertz.

At 220 Hertz the bar produced the following pitches:

Mode	Hertz	note	cents (above C)
1	220	$A_3 + 0$	900
2	779.0	$G_5 - 11$	689
3	1512.8	$F^{\#}_6 + 38$	638

The frequency ratios of second to first and third to first modes are 3.54:1 and 6.88:1 respectively. The second to first mode ratio here is approximately midway between the preferred ratios for the orchestral xylophone (3:1) and marimba (4:1).

With the same bar at 220 Hertz an experiment was carried out removing wood from various parts of it and noting changes in the frequencies of the first three modes (f_1, f_2, and f_3) in order to ascertain methods for tuning upper partials. Grooves, approximately 14mm wide and 2mm deep, were gouged out across the bar's width at the positions shown in figure 156. This experiment was carried out on the same bar because of the impracticality of making eight bars with exactly the same dimensions and pitch, and also because wood is not a homogenous material, ie. one bar will always be slightly different to the next. The change in frequency produced by each successive groove is shown in table 19. The grooves were cut in the following order: 8, 1, 3, 5, 7, 2, 4, and 6. Since each groove was only shallow (2mm) it was thought that previous ones would have a negligible impact on the effect of successive ones, ie. the change in pitch caused by a small groove is more or less independent of others.

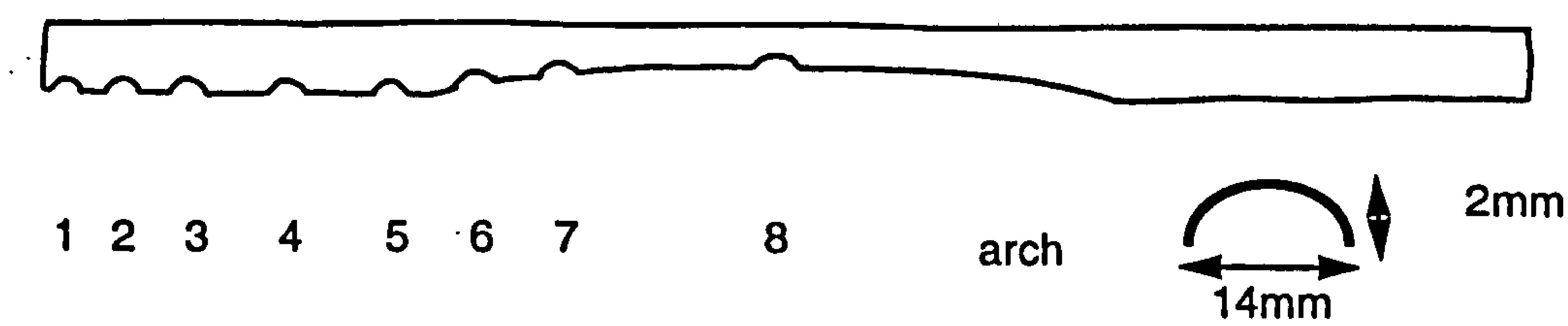


Fig. 156 Position of hollows on bar, numbered 1 to 8.

Table 19 Effects on frequency of removing wood from eight positions on a bar at 220 Hertz.

	Centre of hollow to end of bar, (% of bar length in brackets)	Mode	Change in pitch (cents)
1)	7mm (1.2%)	1 2 3	+10 +5 +5
2)	30mm (5.2%)	1 2 3	+9 +5 0
3)	60mm (10.5%)	1 2 3	+3 0 -10
4)	100mm (17.5%)	1 2 3	-2 -15 -25
5)	135mm (23.6%)	1 2 3	-3 -13 -25
6)	160mm (27.9%)	1 2 3	-4 -19 -15
7)	205mm (35.8%)	1 2 3	-12 -22 0
8)	centre of bar (50%)	1 2 3	-102 -6 -28

Table 19 shows that in order to raise the frequency of the fundamental mode (f_1), removing wood from the end of the bar has the greatest effect. The effect of carving the hollows reduces as they approach the node of the fundamental mode. Removing timber from the centre of the bar lowers the fundamental by the largest degree. It is interesting to note that even at position 4 (17.5% of the bar's length, theoretical nodes 22.4%L) the removal of wood lowers the fundamental.

The frequency of the second mode of vibration (f_2) is raised by removing wood from the end of the bar, although the rise is small at only five cents. At position 3 (10% of the bar's length) removal of wood has no effect on f_2. This position is close to the second mode's node (13.2%L). The frequency of mode 2 starts to be lowered at position 4, the effect increasing until it reaches its maximum at position 7 (35.8% of the bar's length). The hollow is here almost centred upon the second mode's antinode (35.6%L). Removing timber from the centre of the bar (position 8), also a node of the second mode, has a relatively small effect on the frequency of mode 2.

The frequency of mode 3 (f_3) follows the same pattern; the frequency can only be raised by removing wood near the ends of the bar and removing wood near one of that mode's nodes has very little effect on pitch. The frequency of mode 3 is lowered by the largest degree between positions 4 and 5 (between 17.5% and 23.6% of the bar's length; to either side of the antinode at 22.5%L) and at position 8 (50% of the bar's length, also an antinode for mode 3).

In summary, the frequency of a particular mode can be raised by removing wood from that mode's end-of-bar antinode. Lowering the frequency of a particular mode is achieved by removing wood at that mode's central antinode, or in the cases of modes 2 and 3, at any of the two and three central antinodes respectively.

When the frequency of the second partial of a bar is required to be in the ratio of 4:1 to the fundamental, a large amount of undercutting is necessary so as ideally to raise the second partial slightly above the 4:1 ratio. This is necessary because it is not possible to raise the frequency of the second partial without raising the fundamental by a larger degree (see table 19, positions 1 and 2).

With the ratio slightly above 4:1, the frequency of the second partial can be lowered by a significant amount with only a small change to the fundamental. This is achieved by carving two secondary tuning arches slightly closer to the centre of the bar than the nodes of the fundamental, in order to lower f_2 (see fig. 157).

In practice the third partial is rarely tuned. In order to do this, positions on the bar must be found where the removal of wood has a smaller effect on the first two partials than on the third (see table 19, positions 3 and 5), or where the removal of wood changes the first two partials but not the third (positions 2 and 7 in table 19).

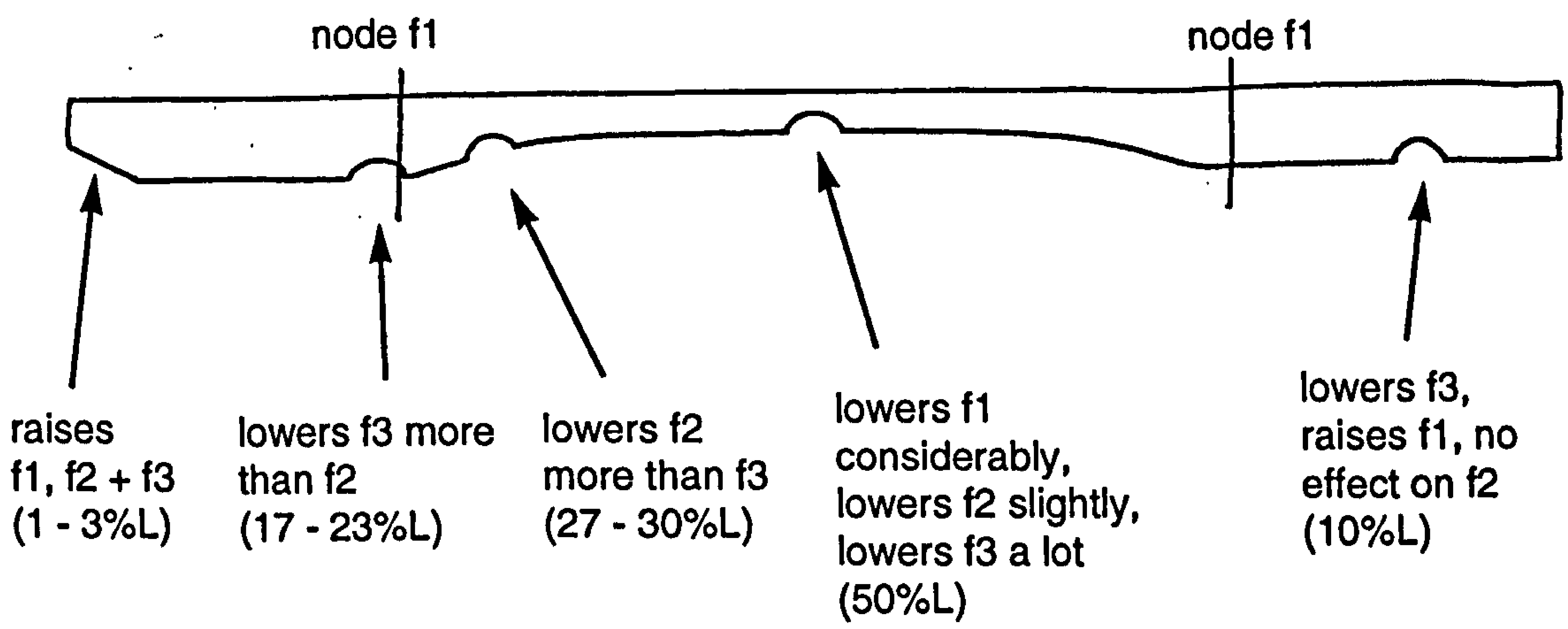


Fig. 157 Tuning arches for modes 1, 2 and 3.

The fundamental of the same test bar was next lowered in pitch by another 700 cents to 146.8 Hertz (D_3), at which pitch the bar produced the following mode frequencies:

Mode	Hertz	note	cents (above C)
1	146.8	$D_3 + 0$	300
2	604.5	$D_5 + 50$	350
3	1357.1	$E_6 + 50$	450

These frequencies give the ratios of second to first and third to first frequency modes as 4.1:1, and 9.2:1 respectively. With the fundamental at this pitch the second partial is an ideal relationship to it for double-octave tuning: it is an easy matter to lower f_2 by 50 cents to give the 4:1 ratio. However, if third partial tuning was required (ratio 10:1) it would not be possible with the bar at 146.8 Hertz, because f_3 would have to be raised to 1468 Hertz, an unattainable rise of 136 cents. Attempting to do this by removing timber from the ends of the bar would would raise the fundamental approximately twice as much as the third partial (see table 19, position 1).

The fundamental pitch of the test bar was then lowered by a further 478 cents to 110.4 Hertz (A_2 +22 cents), just sharp of the intended final pitch of 110 Hertz. This was achieved by increasing the amount of undercutting uniformly between the nodes for the first mode of vibration. The deep arch (the bar was now 7mm thick at the centre) caused the nodes of mode 1 to move toward the ends of the bar, at 21%L. At 110.4 Hertz the bar produced the following mode frequencies:

Mode	Hertz	note	cents (above C)
1	110.4	A_2 + 22	922
2	506.9	B_4 + 45	1145
3	1266.3	$D^{\#}_6$ + 30	330

These frequencies give the ratios of second to first and third to first frequency modes as 4.6:1, and 11.5:1 respectively. The frequency of the second partial was then lowered by extending the arch to the new position of the nodes of mode 1 (21%L), and cutting deeply into these nodal areas. It was soon apparent that f_3 was falling in pitch too quickly in relation to the fall of f_2, because mass was being removed very close to the inner antinodes of f_3 (22.5%L). In order to lower f_2 more than f_3 the position for removing mass was moved towards the centre of the bar, to approximately 30%L (approximately position 6, table 19). Removing wood from the region 30 to 40%L is quite critical; it was noted that removing material at 35%L (node for f_3) caused f_1 to fall in pitch, such that it would be difficult to raise it again.

In summary, tuning both f_2 and f_3 in the correct ratio to f_1 required the careful removal of wood from two areas:

1) around 21%L to lower f_2 more than f_3, and

2) around 30%L to lower f_3 more than f_2.

Whilst tuning upper partials it is important to remove only small amounts of wood at a time, and to check the change in frequencies regularly.

Tuning the upper partials on the test bar caused the fundamental to fall to 107.2 Hertz (45 cents flat of A); f_1 was then restored to 110 Hertz by removing wood from the ends of the bar. This in turn caused f_2 and f_3 to rise, but by only 15 cents, an amount easily corrected by the procedure described above.

TONE CHARACTERISTICS OF AFRICAN-TYPE XYLOPHONE BARS

Xylophone bars of five designs were made, representing the following African xylophones:

1) LoDagaba *gyil* (north-west Ghana),
2) Venda *mbila* (Northern Transvaal, South Africa),
3) Pende *madimba* (south-west Zaire),
4) Azande *manza* (north-east Zaire),
5) Birom *kundung* (northern Nigeria).

For ease of analysis the bars were all tuned to the note A in two or three octaves. All of the bars were made of *pau rosa*, a dense timber which produces a very resonant tone. This timber is similar to *pterocarpus erinaceu* as used for the bars of the LoDagaba *gyil*. Table 20 gives the tuning and dimensions of each bar. The five bar-types are shown in figure 158.

Table 20 Tuning, dimensions and nodal positions of African-type test bars

bar type	frequency (Hertz)	dimensions (mm)	thinnest part of bar at centre of arch (mm)	nodal positions
gyil	110	570x75x22	5	0.213L, 0.787L
gyil	220	505x65x22	9	0.220L, 0.780L
gyil	440	445x55x22	15	0.224L, 0.776L
mbila	110	355x140x33	3	0.177L, 0.833L
mbila	220	330x94x33	4	0.185L, 0.815L
mbila	440	303x76x33	7	0.208L, 0.792L
madimba	110	378x95x52	2.5	0.151L, 0.849L
madimba	220	330x78x50	4	0.161L, 0.839L
madimba	440	280x60x49	7	0.165L, 0.835L
kundung	220	354x49x18	3	0.206L, 0.794L
kundung	440	316x48x19	7	0.218L, 0.782L
manza	220	370x66x18	3	0.249L, 0.751L
manza	440	370x66x18	8	0.265L, 0.735L

Analysis methodology

The dimensions of the *gyil* bars in table 20 were taken from instruments I studied in Ghana. The dimensions of the *mbila* bars were taken from Kirby[35] and from a Venda *mbila* I studied at the Pitt Rivers Museum, Oxford. The dimensions of the *madimba* and *kundung* and *manza* bars were taken from instruments I studied at the Musée de l'Afrique Centrale, Brussels. *Kundung* and *manza*-type bars tuned to 110 Hertz were not made because they are not usually tuned below approximately 200 Hertz.

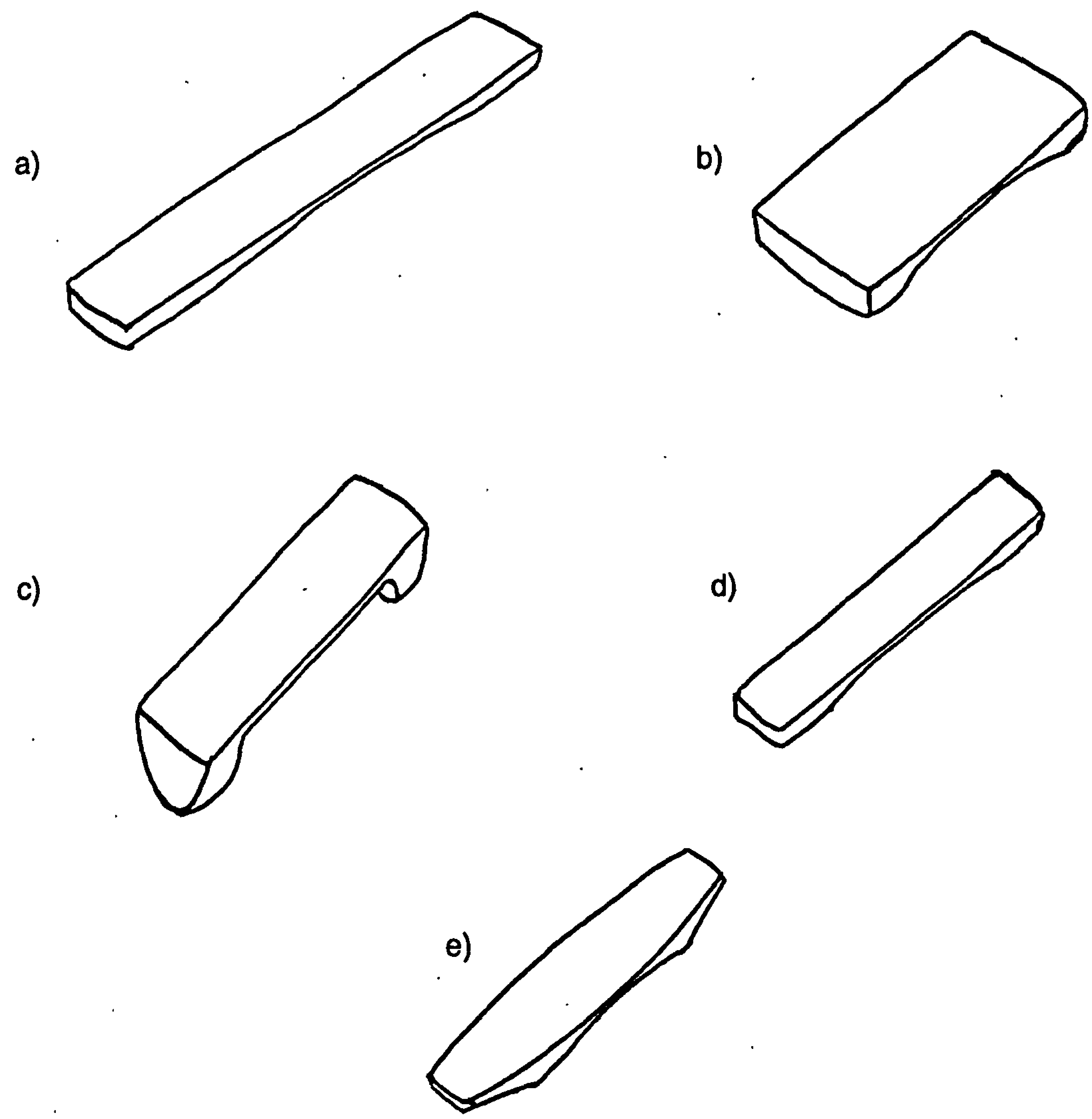


Fig. 158 Bar-types made for the tests: a) *gyil*, b) *mbila*, c) *madimba*, d) *kundung*, and e) *manza*.

To my knowledge the exact tuning of the second partial of African percussion bars is rarely undertaken. For this reason the test bars were tuned without paying attention to the second partial. The sound of each bar was first tested without a resonator in order to assess how bar shape and dimensions affected tone and sustain (rate of decay).

Each bar was then tested with the type of resonator (spherical calabash, elongated calabash, or ox horn) traditionally associated with it. The test resonators were fitted with mirlitons where appropriate. Two types of material for mirliton membranes were used: a) spider's egg sacs (collected in Ghana) and b) the diaphragm of small rodents (collected in C.A.R.). The aim of testing the bars with these resonators was to reproduce as closely as possible the sound of each African xylophone listed in table 20.

In order to establish the effects of resonator type and mirliton upon tone and sustain, one type of bar, the *gyil* was tested with each form of resonator and mirliton listed.

In all thirty-six examples were recorded and analysed. The sounds were recorded on digital audio tape (DAT) using a Casio machine and AKG microphone. The recording levels were constant for all examples.

The recorded signals were digitised using a Cambridge Electronic Design 1401 Digital Transient Recorder on to a PC. The signals were then analysed using Matlab software. The analysis was carried out by Ashdown Environmental Ltd.[36] 'Waterfall' analysis was used to produce sound spectra which could be plotted to show four points in the progress of the note: on initial impact of the beater (t=0s) and half a second (t=0.5s), one second (t=1s), and two seconds (t=2s) later. In addition to these four sound spectra, a separate graph showing each signal in its entirety in the form of time against amplitude is included, the numbers on the these graphs show the analysis time slices. The results are given in Appendix 3 which is bound separately from the main volume as Volume II. An audio tape of the results is also included.

Analysis results

The combinations of bar and resonator whose sounds are analysed are listed below. Numbering relates to the plots in Appendix 3.

A1) *Gyil* 110 Hz. without resonator.

A2) *Gyil* 110 Hz., with spherical calabash resonator, without mirliton.

A3) *Gyil* 110 Hz., with spherical calabash resonator having three 12mm diameter spider's egg sac mirlitons.

A4) *Gyil* 110 Hz., with spherical calabash resonator having three

22mm diameter spider's egg sac mirlitons.

A5) *Gyil* 110 Hz., with long (marrow-shaped) calabash resonator, without mirliton.

A6) *Gyil* 220 Hz. without resonator.

A7) *Gyil* 220 Hz.,with spherical calabash resonator having three 12 mm diameter spider's egg sac mirlitons.

A8) *Gyil* 440 Hz. without resonator.

A9) *Gyil* 440 Hz., with spherical calabash resonator having three 12 mm diameter spider's egg sac mirlitons.

A10) *Manza* 220 Hz. without resonator.

A11) *Manza* 220 Hz., with long calabash resonator, without mirliton.

A12) *Manza* 220 Hz. and 440 Hz. (played together), with long calabash resonators, without mirliton.

A13) *Manza* 220 Hz., with long calabash resonator having one 12mm diameter mirliton (rodent diaphragm) on the side near the bottom of the resonator. This combination represents the *kalangba* sound.

A14) *Manza* 440 Hz. without resonator.

A15) *Manza* 440 Hz., with long calabash resonator, without mirliton.

A16) *Manza* 440 Hz., with long calabash resonator having one 12mm diameter mirliton (rodent diaphragm) on the side, near the bottom of the resonator (again representing the *kalangba* sound).

A17) *Manza* 220 Hz. and 440 Hz. (played together), with long calabash resonators having one 12mm diameter mirliton (rodent diaphragm) on the side, near the bottom of each resonator (again representing the *kalangba* sound).

A18) *Madimba* 110 Hz. without resonator.

A19) *Madimba* 110 Hz., with long calabash resonator incorporating one 12mm diameter mirliton (spider's egg sac) on the side, near the bottom.

A20) *Madimba* 220 Hz. without resonator.

A21) *Madimba* 220 Hz., with long calabash resonator incorporating one 12mm diameter mirliton (rodent diaphragm) on the side, near the bottom.

A22) *Madimba* 440 Hz. without resonator.

A23) *Madimba* 440 Hz., with long calabash resonator incorporating one 12mm diameter mirliton (rodent diaphragm) positioned on the side, near the bottom.

A24) *Mbila* 110 Hz. without resonator.

A25) *Mbila* 110 Hz. with long calabash resonator having one 12mm diameter mirliton (spider's egg sac) on the side, near the bottom.

A26) *Mbila* 220 Hz. without resonator.

A27) *Mbila* 220 Hz. with long calabash resonator having one 12mm diameter mirliton (rodent diaphragm) on the side, near the bottom.

A28) *Mbila* 440 Hz. without resonator.

A29) *Mbila* 440 Hz. with long calabash resonator having one 12mm diameter mirliton (rodent diaphragm) on the side, near the bottom.

A30) *Kundung* 220 Hz. without resonator.

A31) *Kundung* 220 Hz. with ox horn resonator having one 12mm diameter mirliton at the end of the resonator.

A32) *Kundung* 440 Hz. without resonator.

A33) *Kundung* 440 Hz. with ox horn resonator having one 12mm diameter mirliton at the end of the resonator.

A35) *Gyil* 220 Hz., with ox horn resonator having one 12mm diameter mirliton at the end of the resonator.

A39) *Gyil* 220 Hz. with long calabash resonator having one 12mm diameter mirliton (diaphragm of rodent) on the side, near the bottom.

A40) *Gyil* 220 Hz. with long calabash resonator having one 12mm diameter mirliton (spider's egg sac) positioned on the side, near the bottom.

EXP. 1 EFFECT OF BAR SHAPE ON TONE AND SUSTAIN

The results of the sound signals produced by the bars alone are discussed first, in ascending order of pitch.

Exp. 1.1 - Bars at 110 Hertz

Only three of the bar types were appropriate to this pitch:

a) *gyil* (A1),

b) *madimba* (A18),

c) *mbila* (A24).

The *gyil* produces the largest amplitude and also the longest sustain (approximately 2.5 seconds). The *madimba* and *mbila* bars produce notes of similar amplitude and duration (approximately 1.5 seconds), although both values for the *mbila* bar are slightly greater than for the *madimba* bar. This agrees with aural experience, the *gyil* bar sounding the loudest with the longest sustain. Looking at the frequency distribution over time for the three bars, it is surprising that second partial of the *gyil* bar (at 499 Hertz) does not appear on plot A1. Exciting the second mode of this bar during aural tests produced the strongest amplitude of all three bars. For the *gyil* bar at t=0s, the dominant frequencies are the fundamental and the third mode (measured at 1216 Hz.). At t=0.5s, 1s and 2s the fundamental alone dominates.

Initial excitation of the *madimba* bar (A18) at t=0s shows that all of the first three modes (at 110, 510 and 1126 Hz.) are present. At t=0.5s the second partial is still quite strong but the third partial has almost disappeared (at just a little over 20 dB). At t=2s the second partial has decayed almost completely.

The *mbila* bar (A24) at t=0s produces strong first and second modes (at 110 and 602 Hz.). During aural tests the third mode of vibration was extremely faint and difficult to excite, and no measurement of this mode was possible: on the sound spectra plots for the *mbila* bar the third mode does not appear. Its frequency is most likely above the 1500 Hertz limit of the plot scale.

In order to investigate the reasons for the different levels of amplitudes of the second modes of the three bars, the nodal positions of these modes were found. This was done by sprinkling sand on the bars, and then, whilst holding the bars at their centres (50%L, this node for mode 2, theoretically, should not change), exciting the second modes. The nodal positions are shown in table 21:

Table 21 Nodal positions for modes 1 and 2 of 110 Hertz test bars.

bar	nodal position for mode 1	nodal position for mode 2
gyil	21.3%L	13.7%L
madimba	15.1%L	11%L
mbila	17.7%L	14%L

The nodal positions for modes 1 and 2 of the *gyil* bar approximate to the theoretical values as given in table 16 (22.4%L and 13.2%L respectively). Mode 2 of the *gyil* bar is therefore damped very quickly (or not excited at all) because its antinodes lie close to the supports (see page 220). The effect of the large amount of undercutting on the *madimba* and *mbila* bars has brought the nodal positions of the two modes of each bar closer together; therefore the antinodes of mode 2 are no longer close to the supports and these modes will not be damped in the same way.

Summary

The *gyil* bar produced by far the longest sustain, and marginally the largest amplitude for the fundamental mode of vibration. The *madimba* and *mbila* bars both produced stronger upper partials and shorter periods of sustain than the *gyil* bar. The strong upper partials of the short bars result from the large amount of undercutting which moves the nodal positions for modes 1 and 2 closer together, thus reducing the damping caused by the supports. Short bars which require a very large amount of undercutting to lower the fundamental produce a shorter sustain than long bars. The tuning and playing style of the *madimba* and *mbila* instruments are similar; both are tuned to a heptatonic scale and the music played on them is characterised by very fast passages in the low registers of the instruments. It is therefore necessary for these instruments to have bars with a short sustain so that the notes of the heptatonic scales do not overlap. The *gyil*, however, is tuned to a pentatonic scale, and the style of music played upon it is characterised by slower passages in the bass register (the beaters used are much heavier than those of the *madimba* and *mbila* producing a greater amplitude but making very fast passages difficult) so fewer dissonances result.

Exp. 1.2 - Bars at 220 Hertz

All five types of bar are represented at 220 Hertz:

a) *gyil* (A6),

b) *manza* (A10),

c) *madimba* (A20),

d) *mbila* (A26),

e) *kundung* (A30).

The spectra of the *gyil* bar shows it to produce the strongest fundamental with the longest sustain, but the weakest second mode. The *manza* produces the next strongest fundamental and length of sustain, but differs significantly from the *gyil* by having a strong second mode. The combined effect of tapering the ends of the *manza* bar and reducing its thickness on the ends has a dramatic effect on the nodal positions of mode 2 moving them to 21.6%L (see table 22), whilst the nodal positions of mode 1 are are very close at 24.9%L.

Table 22 Nodal positions for modes 1 and 2 of 220 Hertz test bars.

bar	nodal position for mode 1	nodal position for mode 2
gyil	22%L	14.25%L
manza	24.9%L	21.6%L
madimba	16.1%L	11%L
mbila	18.5%L	12.7%L
kundung	20.6%L	12.2%L

The *madimba* (A20) and *mbila* (A26) bars have short periods of sustain but strong second modes. In fact, at initial excitation (t=0s), the amplitude of the second mode of the *madimba* bar is greater than that of the fundamental. At t=0s for the *mbila* bar, the amplitude of the second partial is also very large (approximately 84dB) but quickly dies away (approximately 48dB at t=0.5s).

The frequencies of the second mode of the five bars were measured as:

gyil: 839 Hertz,
manza: 984 Hertz,
madimba: 838 Hertz,
mbila: 1202 Hertz,
kundung: 999 Hertz.

These figures are similar to those at 110 Hertz, in that the second modes of the *gyil* and *madimba* are close to one another, but the second mode of the *mbila* is considerably higher. It is surprising that the second modes of the *gyil* and *madimba* bars are so close to each other because the degree of undercutting is quite different for each: the *gyil* bar has relatively little arching, leaving the central part 9mm thick, whereas the *madimba* bar is undercut more deeply, the centre being only 4mm thick (see table 20). It seems reasonable to expect that because the *mbila* bar is the same length and has the same amount of undercutting as the *madimba* bar, it should be these two bars that have similar frequencies for the second mode, yet this is not the case. It appears that the peculiar shape of the *madimba* bar, with very thick ends, has the effect of lowering the frequency of the second mode.

Looking at the plots it can be seen that the shorter bars, with a necessarily large amount of undercutting (*madimba* and *mbila*), produce second partials of greater amplitude than longer bars with less undercutting. However, when measuring the frequency of the second partials of the bars (holding the bars centrally and striking at about 30%L, antinode for mode 2), the amplitude of mode 2 was much greater for the longer bars than for the shorter.

The *kundung* bar (A30) has a large amount of undercutting and the frequency of its second mode is consequently relatively high.

Summary

The *gyil* bar produced the largest amplitude for the first mode of vibration, and produced the longest sustain. The *madimba* and *mbila* bars had the strongest second modes of vibration. These results follow the pattern observed at 110 Hertz.

Exp. 1.3 - Bars at 440 Hertz

All five types of bar are represented at 440 Hertz:

a) *gyil* (A8),
b) *manza* (A14),
c) *madimba* (A22),
d) *mbila* (A28),
e) *kundung* (A32).

At 440 Hertz there is less discernable difference between the sound spectra of the bars. The *gyil* bar still has the greatest sustain, but the *manza* bar now surpasses it in having the largest amplitude for the fundamental pitch. The frequency of the second mode of vibration for each bar was measured as:

gyil: 1298 Hertz,
manza: 1523 Hertz,
madimba: 1356 Hertz,
mbila: 1765 Hertz,
kundung: 1606 Hertz.

The second mode of vibration of the *gyil* bar does not show up on the plot, and those of the *manza*, *mbila* and *kundung* bars are too high to register on the scale of the plots. The only bar whose second mode of vibration registers on the plots is the *madimba*. At t=0s it is quite prominent, but at t=0.5s it is barely perceptible.

EXP. 2 - THE EFFECT OF RESONATORS ON TONE, AMPLITUDE AND SUSTAIN

In this section the sounds produced by the coupling of bars and tubular and spherical resonators are analysed.

The *gyil* bar tuned to 110 Hertz was chosen for this comparison because of its long sustain and large amplitude.

The spectra produced by the *gyil* bar coupled with a spherical calabash (A2) and the spectra produced by the same bar coupled with a long (tubular) calabash resonator (A5) have greater amplitudes than the *gyil* bar alone (A2). In all three spectra the fundamental and third mode are featured, but the *gyil* bar with spherical calabash is the only one which features the second mode.

The spectra of the two resonated bars (A2 and A5) exhibit similar general amplitude levels and sustain periods. At t=0s the amplitude from both couplings is over 100dB, and continue to be so until t=2s. The two events differ, however, in how quickly maximum amplitude is reached after initial excitation. With the tubular resonator, maximum amplitude is reached almost immediately (after approximately 0.07s), as it is for the bar alone (A1), but with the spherical resonator there is a noticeable swelling after initial excitation until maximum amplitude is reached at approximately 0.2s.

The sound spectra produced by the *gyil* bar alone (A1) and the tubular resonated bar (A5) are very similar. At t=0s in both events it is the fundamental and third partial (1216 Hz.) that dominate, with no response from the second mode (measured as 499 Hz.). At t=0.5s, 1s, and 2s, the third mode diminishes considerably, leaving just the fundamental. The spectra for the *gyil* bar with the spherical resonator are quite different: at t=0s and 0.5s the second mode features strongly (at approximately 70 dB and 60 dB respectively). For event A2 at t=0.5s an approximation to the harmonic series results with the spherical resonator.

EXP. 3 - THE EFFECT OF MIRLITONS ON TONE, AMPLITUDE AND SUSTAIN

This section examines and compares the sounds of the different African xylophones which the author has attempted to reproduce using traditional designs and materials. The distinctions between these xylophones' resonators and mirlitons are explained below:

1) *Birifor gyil* and *Sisaala jengsi* (see Chapter IX). These instruments use spherical calabash resonators *each with three mirlitons* (typically 12mm diameter) in the low register and two in the high register. This instrument is represented by events A3 (110 Hz.), A7 (220 Hz.), and A9 (440 Hz.).

The LoDagaba *gyil* is very similar in design to the Birifor and Sisaala instruments but it uses larger mirlitons (typically 22mm diameter) which produce a significantly different sound. This type of xylophone is represented by event A4 (110 Hz. only).

2) Pende *madimba*. The Zairaian *madimba* uses long calabash resonators with one mirliton on the side, near the bottom. This instrument is represented by events A19 (110 Hz.), A21 (220 Hz.), and A23 (440 Hz.).

3) Venda *mbila*. This instrument uses very similar resonators and mirlitons to the *madimba*. The *mbila* traditionally has the resonators suspended obliquely under the bars with the mouth of each resonator cut off at an angle (parallel to the plane of the bar) so that the vibration of the bars is communicated optimally into the resonator.[37] The resonator used with the test bar was not cut off at an angle because it was suspended vertically under the bar. The *mbila* is represented by events A25 (110 Hz.), A27 (220 Hz.) and A29 (440 Hz.).

4) Azande *manza* (see Chapter XI). This instrument uses long calabash resonators but never with mirlitons. The *manza* is represented by events A11 (220 Hz.), A12 (220 and 440 Hz.) and A15 (440 Hz.). A xylophone of similar construction to the *manza*, but incorporating mirlitons, is used by the Banda, Linda and Sabanga peoples in C.A.R. The latter instrument is sometimes also known as *manza*, but more often as *kalangba,* and is represented by events A13 (220 Hz.), A16 (440 Hz.), and A17 (220 and 440 Hz.). To reproduce the *kalangba* sound, the same *manza*-type bars were used, in order to demonstrate precisely the effect of mirlitons without having to take into account variations in the bars.

Though of similar form, real *kalangba* bars are generally narrower and somewhat shorter, and therefore tend to notes of slightly shorter sustain. In order to avoid confusion, the combination of *manza* bar and resonator with mirliton is called *kalangba* here.

5) Birom *kundung*. This instrument uses ox horn resonators with one mirliton at the end of each. It is represented by events A31 (220 Hz.) and A33 (440 Hz.).

Bars tuned to 110 Hertz are examined first, followed by 220 Hertz and 440 Hertz.

Exp. 3.1 - Bars with resonators and mirlitons at 110 Hertz

The four couplings of bar and resonator at this pitch are the Birifor *gyil* (A3), the LoDagaba *gyil* (A4), the Pende *madimba* (A19), and the Venda *mbila* (A25).

The effect of the mirlitons on the two gyil (A3 and A4) is immediately striking. Initially, at t=0s, the second mode (499 Hz.) is quite prominent in both, but by t=1s the second mode has died away leaving the fundamental which, by exciting the air in the sphere, generates a very strong harmonic series. This effect is the greater for the LoDagaba *gyil* (A4) which has the larger mirlitons. The amplitude levels for both types of *gyil* are noticeably higher than those of the *madimba* and *mbila*. The *gyil* bars also have a much longer sustain than the *madimba* and *mbila* bars (2 seconds as opposed to 1 second), governed by the sustain of the bar itself, rather than by the type of resonator.

The effect of the mirlitons on the long resonators of the *madimba* and *mbila* bars is far less noticeable than the mirlitons on the spherical resonators of the *gyil* bars. This is due in part to the use of only one mirliton on the tubular resonators, but is also to the lower efficiency of the tubes compared to the spheres. At t=0s the second mode of the *madimba* bar is quite powerful (approximately 80dB). By t=0.5s the amplitude of the first mode has fallen slightly, but the second mode has fallen considerably (approximately 60 dB). At this stage it is possible to see the effect of the mirliton shown by the small but regular peaks, which approximate to an harmonic series.

It is surprising that the spectrum plots for the *mbila* bar with resonator and mirliton (A25) do not show the second mode of vibration (602Hz.) since this is very prominent for the unresonated *mbila* bar (A24). This does however back up the aural impression of the sound because the *mbila* bar gives a stronger sense of the fundamental than does that of the *madimba.*

Exp. 3.2 - Bars with resonators and mirlitons at 220 Hertz

The couplings of bar and resonator at this pitch follow the patterns of the Birifor *gyil* (A7), *madimba* (A21), *mbila* (A27), *manza* (A11), *kalangba* (A13) and *kundung* (A31). In addition to the above six, the spectra of the two *manza* bars an octave apart played together (A12), and of two *kalangba* bars played together (A17) are are included in this section.

The sound spectra of the *gyil* are quite different from those of the other bars types coupled with resonators using mirlitons. Both the amplitude of the fundamental of the *gyil* and its period of sustain exceed those of all the other bars tested at 220 Hertz. At initial excitation, the second mode of the *gyil* is weaker than that of the *madimba* and *mbila,* but in the latter instruments it dies away more quickly than in the *gyil.*

For the *gyil,* the peaks produced by the mirlitons at t=0.5s form an approximate harmonic series, as do those of the *madimba* and *mbila* bars. However the first harmonic, 2f, is much stronger for the *gyil* than for the other two. That the peaks produced by the mirlitons for the *madimba* and *mbila* bars at t=0.5s and t=1s are stronger than those of the *gyil* is probably due, in part, to the thinner mirliton material used for the *madimba* and *mbila* bars at 220 Hertz (see experiment with *gyil* bars using different resonators and mirliton materials, Exp. 4.2). The peaks produced by the mirlitons of the *madimba* and *mbila* bars are very even, rising slightly in amplitude as frequency rises at t=1s. The opposite is true for the *gyil* at t=1s. The troughs between the peaks of the *madimba* and *mbila* spectra are much deeper and more jagged than those of the *gyil*, especially at t=1s.

The spectra produced by the *kalangba* bar resemble those of the *madimba* and *mbila*, but the *kalangba* bar sustains a little longer, and the amplitude of its second mode (relative to the fundamental) is smaller than the second mode of both the *madimba* and *mbila.*

The *kundung* bar coupled with the ox horn resonator and spider's egg sac mirliton (A31) produces a very powerful sound as shown in the spectra. These spectra are very different to those of the *madimba*, *mbila* and *kalangba*. Initial excitation (t=0s) of the *kundung* bar results in many high amplitude peaks. The reason for this is that the mirliton is at the end of the resonator and so is immediately excited at t=0s. The peaks include the fundamental and second mode (999Hz.) of the bar, but also the peaks produced by the mirliton which approximates to an harmonic series.

At t=0.5s the peaks produced by the mirliton of the *kundung* are very high (almost reaching 80dB). They differ from those produced by other bar/resonator/mirliton combinations by being uneven, the peaks of the fourth and sixth harmonics being considerably higher than those of the second, third, and fifth. It is also noticeable that the troughs are smoother than those of the other bars with mirlitons.

It is very unusual for African xylophones with individual resonators not to have mirlitons.[38] The *manza* is the only xylophone tested here that does not have them. The spectra for the *manza* bar (A11) show a powerful fundamental but no other peaks are recognisable, even at t=0s. It is surprising that the second mode (985 Hz.) does not feature in the spectra, because it is relatively strong in the spectra for the unresonated *manza* bar at t=0s and 0.5s (event A10). As two bars, an octave apart, are always played together on the *manza*, event A12 shows the spectra of the *manza* bars at 220 and 440 Hertz played together. At t=0s and 0.5s, the second mode of the 220 Hertz bar is clearly present at 985 Hertz, whereas it was not in event A11. At initial excitation in event A12 the amplitudes of the two fundamentals are approximately equal, but as time elapses, the amplitude of the 440 Hertz peak gets progressively smaller compared to the 220 Hertz peak, due to the longer sustain of the latter frequency.

Event 17 shows the spectra of the two *kalangba* bars played together. At t=0s the second mode of the 220 Hertz bar is present, although this mode fades quickly, and by t=0.5s the approximate harmonic series set up by the two mirlitons is established. Compared to the single *kalangba* bar (A13, t=0.5s), the second mode of the 220 Hertz bar in event A17 fades quicker. This is probably due to the combined effect of the two mirlitons vibrating at the same frequencies (880 and 1100 Hz.) either side of the second mode of the 220 Hertz bar (985 Hz.). It appears therefore that tuning the partials of each bar of the *kalangba* is not important because the two mirlitons provide a complete harmonic series at greater amplitude than the second modes of the two bars.

Exp. 3.3 - Bars with resonators and mirlitons at 440 Hertz

The six test bars with resonators at this pitch are the Birifor *gyil* (A9), the *manza* (A15), the *kalangba* (A16), the *madimba* (A23), the *mbila* (A29), and the *kundung* (A33). Apart from the *manza*, all of these have mirlitons, yet their effect is only noticeable on the spectra of the *gyil* and the *kundung*. Again it is the *kundung* which has the highest mirliton peaks, at their greatest amplitude at t=0s. Even though the amplitude of the fundamental of the *kundung* is less than that of the *gyil*, the *kundung*'s mirliton peaks are still greater in amplitude than those of the *gyil*.

It appears therefore that at 440 Hertz the use of mirlitons is most effective in conjunction with ox horn resonators: less so with spherical calabash resonators and least of all with tubular calabash resonators. Traditionally the *kalangba* does not use mirlitons on the highest four or five resonators because they are not effective at the higher frequencies. This is reflected in the spectra for the test *kalangba*.

The *madimba* bar (A23) has the strongest second mode (1356 Hz.) at approximately 65dB at t=0s, although this decays rapidly so that by t=0.5s it has disappeared from the spectrum. The sustain of all the bars is short at 440 Hertz, the *gyil* being slightly the longest. This is due to the *gyil* bar rather than the spherical resonator.

EXP. 4 - EXPERIMENTS WITH 220 HERTZ GYIL BAR USING DIFFERENT RESONATORS AND MIRLITON MATERIALS

The aims of these experiments are firstly, to assess how the first two modes of the bar are affected by resonator and mirliton type and secondly, to assess how the amplitudes of mirliton harmonics are affected by the type of mirliton material and resonator. The 220 Hertz *gyil* bar was coupled with:

a) spherical calabash resonator with three mirlitons (12mm diameter) made of spider's egg sacs (A7),

b) ox horn resonator with one mirliton (12mm diameter) made of a spider's egg sac positioned at the base of the horn (A35),

c) tubular calabash resonator with one mirliton (12mm diameter) positioned at the side, near the base, made of the diaphragm of a rodent (A 39), and

d) tubular calabash resonator with one mirliton (12mm diameter) positioned on the side, near the base, made of a spider's egg sac (A40).

Exp. 4.1 - The effect of resonator type on the amplitude and sustain of the fundamental and second modes with the 220 Hertz gyil bar

The ox horn resonator produces the strongest fundamental, followed closely by the spherical calabash. The responses from the two tubular calabash resonators are noticeably weaker. The tubular resonators produce maximum amplitude almost immediately at t=0s, whereas with the spherical calabash maximum amplitude is reached slightly after initial excitation. The swelling of amplitude after initial excitation is greatest with the horn resonator (see Vibration Analysis Module for event A35).

The frequency of the second mode of vibration of the *gyil* bar was measured as 839 Hertz. The approximate amplitude levels at t=0s and 0.5s are given below:

resonator type	amplitude at t=0s	amplitude at t=0.5s
spherical calabash (A7)	70 dB	55 dB
horn (A35)	73 dB	58 dB
tubular calabash (A39)	65 dB	40 dB
tubular calabash (A40)	83 dB	57 dB

Event A40 is anomalous: it is likely that the exceptionally high level of amplitude given above for the tubular calabash at t=0s with the spider's egg sac mirliton (A40) is due to the bar having been struck slightly off centre when recording, and not to the egg sac mirliton. This explanation is arrived at because the amplitudes of the other bar/tube combination (A39) are much lower, and because at t=0.5s the second mode amplitude of A40 has decayed by a greater degree than that with both the spherical and conical resonators.

Disregarding event A40, the spherical and conical resonators give approximately equal responses to the second mode, while the tubular resonator gives a lower response. The low response of the tube is the result of the frequency ratio of the second and first modes of the bar being 3.8:1, and the fact that closed tubes produce a series of only odd harmonics (ie. for the tube to respond well, the frequency ratio of the second to first modes of the bar would need to be in the region of 3:1). Conical tubes produce an approximation to a complete harmonic series, so the horn responds better to a second to first mode ratio of 3.8:1 than does the tube.

The Vibration Analysis Modules for the four events show the duration of the fundamental mode produced with the spherical calabash and horn to be approximately equal, both being longer than those with the tubular calabash.

Exp. 4.2 - The effect of mirliton and resonator combinations on amplitude, tone and sustain with the 220 Hertz gyil bar

As already established, the sympathetic vibration of mirlitons creates an approximate harmonic series. This section aims to show how the amplitudes of these harmonics are influenced by the type of mirliton material and the type of resonator.

Looking at the four events (A7, A35, A39 and A40), the mirliton harmonics of largest amplitude are produced with the horn resonator. The second largest are produced with the tubular calabash fitted with the rodent diaphragm mirliton (A39). It is very noticeable that the same resonator fitted with a spider's egg sac mirliton produces peaks of lower amplitude. This is because the rodent material is thinner than the spider's egg sac, and so vibrates more easily (due to less damping) and at a higher amplitude. The amplitudes of most of the peaks produced by the mirliton of the spherical resonator and tubular resonator (using the same spider's egg sac material) are comparable.

The spherical calabash is the only resonator which produces a peak of high amplitude for the second harmonic (2f=440 Hz.). Both the conical and tubular resonators favour the upper harmonics.

Plot A35 shows that of the harmonic peaks produced by the conical resonator the fourth and sixth harmonics (4f=880 Hz. and 6f=1320 Hz.) are the most prominent. This response is evident also in the spectra produced by the *kundung* bar when coupled with the horn resonator (A 31). As would be expected, the tubular resonators favour the odd harmonics, so the highest peaks are for the third and fifth harmonics (3f=660 Hz. and 5f=1100Hz.).

CONCLUSIONS

Effects of bar shape on tone, amplitude and sustain

The most powerful low pitched fundamentals were produced by the *gyil*, followed closely by the *mbila* bar. Ghanaian xylophone makers strive to produce as loud as possible a fundamental, which has a long sustain. The strength of the *mbila*'s fundamental was more apparent when the bar was played than the plots reveal. These two bars are very different in shape; the *gyil* being very long and the *mbila* very short and extremely wide. The *madimba* bar, which is also short, produced a less powerful fundamental. The strong fundamental of the *mbila* therefore appears to result from this bar's width.

The unusual shape of the *madimba*-type bars, with the very thick ends and large amounts of undercutting, produced a number of characteristics:

a) the fundamental was reasonably powerful but decayed more quickly than that of any of the other bars tested;

b) they gave the strongest second mode at initial excitation although this mode decayed quickly;

c) the frequencies of the second mode were surprisingly low, considering the very thick ends of the bars and the deep undercutting (see page 243); and

d) the nodes of the fundamental of these bars ranged between only 15%L and 16.5%L.

The design of the bars of the *madimba* are the most unusual of all the test bars made. Considering the tools traditionally available to the African xylophone maker (an adze, an axe and some scraping knives), they are some of the most difficult to make. There must, therefore, be strong reasons why this design has been developed by the Pende xylophone makers. Unfortunately the author was unable to study the manufacture of the *madimba* (see page 149) and so cannot give the makers' own account for the unusual design. One of the aims of this series of experiments was to attempt to explain the reasoning behind traditional bar designs from an objective point of view using spectra analyses. This has been done for the *madimba*, but the results are incomplete without knowledge of the Pende makers' aims: for instance it is not known whether upper partials are tuned on the *madimba*.

The 110 Hertz *mbila* bar, although very thin at its centre, produced a strong fundamental because of the bar's width (see table 20). Wide bars produce a stronger fundamental, but it is not known by the author whether *mbila* bars were made wide for this, or any other reason, since the Venda *mbila* tradition appears to have died out.

Tapering and thinning the ends of a bar (as in the *manza*) brings the nodes of the first and second modes closer together which reduces the damping of mode two by the bar's supports. The Nzakara xylophone maker, Dengba, said that the bars were tapered at their ends because of their method of stringing; the bars rest on cord stretched between support bars which would come into contact with the bars, if they were rectangular (see page 197). Dengba said that the bars were thinned at their ends for appearance (see page 195), although he stressed that this was also done to adhere to tradition. Since the development of the *manza* is not known (such a sophisticated instrument is likely to have taken centuries to develop), it is impossible to say whether the bars were originally made this way to produce a certain tone, or whether bars were tapered as a consequence of their method of support.

Effects of resonator type

The choice of resonator form, spherical or tubular, for African xylophones may appear, at first glance, to be guided by suitability to the type of frame used on the instrument; closed frame xylophones (of west African origin such as the *gyil* and *jengsi*) have resonators suspended in a wide frame which sits on the ground, favouring spherical resonators because of their shorter length (compared with tubes of the same pitch), whereas xylophones with an open frame and centre-board, which are held off the ground (of central African origin such as the *manza* and *kalangba*), have tubular resonators which can be positioned in a more or less straight line. However, the Venda *mbila* and Pende *madimba*, which rest on the floor during performance, both use tubular calabash. This seems to point to the fact that the specific form of resonator used was chosen for a good reason, but, since most African xylophones use mirlitons, it is necessary, when assessing the choice of resonator type, to consider the sound produced by the resonator in conjunction with the mirliton.

Bars coupled with tubular resonators produce maximum amplitude almost immediately, whereas the amplitudes produced by the coupling of bars with spherical and conical resonators swell to a maximum some time after initial excitation. A very fast tempo xylophone style, such as that of the *madimba* and *mbila*, would probably demand maximum amplitude at initial excitation, and the choice of tubular resonators could, therefore, possibly be a determining factor. However, it must be remembered that there are always a number of considerations as to the choice of resonator type: frame design, availability, effect of resonator with mirliton, and tradition. The Chopi xylophone playing style is also very fast, as is that of the Mandinka *bala*, but both these instruments use spherical calabash. These two instruments are played both on the ground and suspended off it, so the choice of spherical resonators may perhaps be due to this factor.

Tubular resonators produce a tone favouring odd harmonics, in particular the third and fifth. Conical and spherical resonators both produce an approximate harmonic series.

The tests have shown that the three resonator types produce different amplitudes. The levels of amplitude produced by tubes varies with resonator pitch; tubes are less efficient at low frequencies (110 Hz.) than at higher ones (220 Hz.). Levels of amplitude produced by spheres and cones are more consistent over frequency. Cones are not practical as low frequency resonators due to the excessive length needed (see page 224), and so are not generally used below 220 Hertz on African xylophones. Conical tubes produce slightly higher levels of amplitude than spheroids, resulting in the longer period of sustain for spheroids. The large amplitude produced by ox horns is probably in part due to its dense, reflective material, although since cones of different materials were not made, the effects of material upon the efficiency of resonators are not precisely known.

The effect of mirlitons

Mirlitons are forced into vibration when the air in the resonator is excited by striking a sympathetically tuned bar. Mirlitons act upon the fundamental of the bar and resonator to produce an approximate harmonic series. The amplitude of these harmonics is so strong that the upper partials of the bar are usually effectively drowned out almost immediately. Although the mirliton always produces a complete harmonic series, the choice of resonator type dictates which harmonics are enhanced in preference to others:

a) tubes (closed) favour the odd harmonics, in particular the third and fifth, and notably with very little response to the first;

b) cones enhance all harmonics, but favour the fourth and sixth;

c) spheres enhance all harmonics, favouring the lower ones; they are the only resonator type to produce a strong first harmonic.

The thickness of mirliton material affects the level of amplitude:

a) thinner membranes, such as the diaphragms of rodents, produce higher amplitudes;

b) thicker membranes, such as spider's egg sacs, produce lower amplitudes.

The size of mirlitons affects both amplitude and the relative prominence of the harmonics:

a) membranes of larger diameter produce higher amplitudes, which are greater at lower frequencies;

b) smaller membranes produce lower amplitudes, and favour higher harmonics.

In many African xylophone cultures instrument makers and musicians consider the choice of mirliton to be extremely important in determining tone. The material used for the membrane, and its size, have a dramatic effect on tone. The *kalangba* instruments in C.A.R use thin membranes, such as rodent diaphragms. These are far more difficult to obtain than spider's egg sacs which are easily available (I collected many in C.A.R. during field work) and are generally used throughout Africa. I asked *kalangba* makers and musicians why they did not use spider's egg sacs (which are also more durable) but they always stated that the thicker material did not produce the sound they wanted; they were not loud enough, and did not cut through the singing, handclapping, and sound of the other instruments to the same extent.

In northern Ghana the sound of the LoDagaba *gyil* is very different from that of the structurally similar xylophones of neighbouring peoples. The main difference is the large size of mirlitons used by the LoDagaba, which produce a louder buzz (compare A4 and A3). The Sisaala and Birifor consider the sound of the LoDagaba *gyil* to be too harsh and grating, finding it unpleasant to listen to. Likewise, the LoDagaba consider the sound of other xylophones to be inferior to their own.

Chapter XIII has attempted to show how xylophone design affects tone, and it is hoped that this work will form the basis for further research. Further work suggested by the author would include:

1) studies of the manufacture of other African xylophones to include, amongst others not yet documented, a) Pende *madimba*, b)

Chokwe *njimba*, c) Birom *kundung* and d) the Azande *manza* in north-east Zaire;

2) a study of the effects of resonator material (density and surface properties);

3) a study of the effects of beater weight and hardness;

4) investigation of the tuning of upper partials in African xylophones.

NOTES

Notes to Chapter I
1) Tracey, H., *Chopi Musicians, their Music, Poetry and Instruments*, (Oxford, 1948, rep. 1970).
2) Boone, O., *Les Xylophones du Congo Belge*, (Tervuren, 1936).

Notes to Chapter III
1) Kunst, J., *Music in Java: Its History, Its Theory and Its Techniques*, 2nd. ed., 2 vols., (The Hague, 1949). 3rd.enlarged ed., edited by E Heins, 1973.
2) Jacobson E., and van Hasselt, J.H., *De Gong-Fabricatie te Semarang*, (Leiden, 1907). A complete translation of this book, together with additional notes by the translator, A. Troth, was published in *Indonesia*, vol. 19, (1975), pp. 127-152. Since original copies are extremely rare, all page numbers given in the text relate to the translation.
3) Pak Resowiguno still runs a gongsmithy several miles outside of Solo, in the village of Wirun, Mujolaban, Sukoharjo, Solo. Troth, op. cit., writes in footnote 24, p.149: "This gongsmith is at present (May 1969) the leading manufacturer of gongs in Central Java, working both privately, as well as on a commission basis for the Leppin Karya Yasa, the recently organised gamelan industry associated with the Mangkunegaran of Surakarta."
4) Kunst, J., op. cit., pp. 139-140.
5) Ibid., p. 140.
6) Hood, M., *The Ethnomusicologist*, (New York, 1971), p. 364.
7) Ibid., p. 365.
8) Ibid., p. 366, although not mentioned by name by Hood, I assume the gongsmith to be Pak Resowiguno in the village of Wirun.
9) Jacobson and van Hasselt, op. cit., p. 132.
10) Pak Tentrem Sarwanto, Ngepung Rt. 02 Rw. II, Semanggi, Solo.
11) Pak Tentrem made the Gamelan Sekar Pethak, commissioned by York University, between September and November 1981.
12) A *pendopo* is part of a palace or nobleman's house where guests are met. The *pendopo* may be used for public entertaining, such as dance performances. The pendopo is a large, open-sided building with a cool marble, or tiled floor, and a large tiered roof.
13) See further Kunst for list of names assumed, and their role, op. cit., pp. 138-139.
14) Concerning the origin of the gong see Kunst, 'A hypothesis about the origin of the gong', *Ethnos* nos. 1-2, (1947), and Kunst, 'Once more, a hypothesis about the origin of the gong', *Ethnos*, no. 4, (1947).
15) Jacobson and van Hasselt noted the following names for the four *pemalu* (smiths): 1. *malu ngarep*, 2. *malu nempong*, 3. *malu ngalap*, 4. *malu nulup*, and 5. *nulup*, the helper who is used by the smith only if a large gong is being made, op. cit., p. 130.
16) Jacobson and van Hasselt use the term *malu ngalap* for the third smith, and do not mention the *pengalap* as a specific job. This may be because in Semarang it was the third smith's job to carry the workpiece to and from the hearth, ibid., p. 130.
17) Jacobson and van Hasselt use the term *ngaroni* for the bellows operator, ibid., p. 130.
18) Ibid., p. 130.
19) See revival history, note 6.
20) Jacobson and van Hasselt, op. cit., p. 132.
21) Gongsmiths in Thailand use a metal retaining hoop during the casting

of the plate. The casting of *kong wong* was seen by the author in Bangkok, Oct., 1990.
22) Jacobson and van Hasselt note the term *luluh* for this clay substratum. He also mentions that according to local smiths " their colleagues in Solo use sand instead of loam for the *luluh*, and this is said to be less suitable". This is extremely dubious since sand would inevitably embed itself in the bronze, something many precautions are taken to avoid, op. cit., p. 138.
23) Ibid., p. 136.
24) Ibid., p. 142.
25) Many drums, such as those in Burma, Thailand, and Zaire and Zambia use a tuning paste in the centre of the skin to lower the pitch. This also has the effect of giving a fuller, more rounded tone, where the function of the drum is both melodic as well as percussive.
26) Clay placed in the *pencu* of a kempul, *ombak* will result.
27) Jacobson and Hasselt, van, op., cit., note the term *awon* for these bronze shavings and that, as a by product, they are kept by the *tukang kikir* and sold back the foundry owner. He adds that *awon* "constitute a very well-known means of poisoning. For this purpose it is crushed to a very fine powder and regularly added in small amounts to daily meals. The gong-makers claim that they have had constantly repeated inquiries about this *awon* from other natives and Chinese (mostly women), and in a few cases, even from Indian ladies. The gongsmiths themselves, however, are not fully convinced of the harmfulness of *awon* to health. It is further believed that the *banyu plandan*, the dirty, muddy water from the pit (plandan) in which the gongs are cooled, is an antidote to *awon* poisoning."

Notes to Chapter V
1) The problem of bamboo splitting is much worse in a temperate climate where humidity is low. The gamelan given to the South Bank Education Centre by the Indonesian Government in 1991 had bamboo gender resonators, most of which split upon arrival in London. Bamboo can be prevented from splitting by removing the hard skin which is high in silica and holds most of the tension within the culm.
2) Pak Mulyadi received an order for a set of bamboo gender barung resonators during March 1989. The difference in tone was most notable in the lower pitched bars, especially the low 6, 1 and 2, where the bamboo resonator seemed to strengthen the normally weak fundamental.
3) Pak Diran runs a frame building and carving workshop in Solo, see chapter on frame building and carving.
4)Bamboo resonators tend to rattle slightly if they are loose in the frame. The problem is worse with loose zinc resonators since the thin metal of the tubes is set into vibration when its corresponding bar is played. Bamboo resonators do not tend to vibrate as much because of the greater stiffness of the material.
5) Reducing the size of the aperture also reduces the efficiency and therefore the loudness of the resonator. Since the aperture of the lowest-pitched resonator of the gender barung is often only 15mm in diameter, this results in an uneven response in the bass register of the instrument. This would be unacceptable in an African xylophone, but since the playing style of the gender barung rarely requires the use of the lowest note, combined with the fact that this note is repeated in the slenthem which has much larger resonators with larger apertures, the low volume of the lowest note of the gender barung notes is not thought important.

6) The saron used in Gamelan Degung in Bandung, West Java also has a tunable, partially closed trough resonator. Information from Simon Cook in Bandung, November 1991.

Notes to Chapter VI

1) Address: Bapak Diran, Joyotaitan RT.03/V, Ke. Serengam, Solo, Central Java.

2) Iron gamelan often have frames made of a cheaper timber, along with the more simple carving styles/motifs to reduce costs. Many of the iron gamelan orchestras coming over to British schools are of this type, currently being made in Jogyakarta by Bapak Hirdjan.

3) Mulyadi, & Dalijo D., *Pengenalan Ragam Hias Jawa 1B*, (Jakarta, 1983) pp 30 - 54. This publication, *An Introduction to Javanese Decorative Styles*, gives examples of the styles cited in the text.

4) Turner, H., *Manual of Traditional Wood Carving*, ed. Paul, N.,(New York, 1977) This book is a re-issue of H. Turner's *Cassel's Wood Carving*, as originally published by Cassel and Company Limited, London, in 1911. Solonese carving style is similar to carvings from the early part of the European Gothic Perpendicular Period (1375-1536). Turner writes, p. 88: "The characteristic features of this period are: 1) A use of natural forms as elements of design, such as oak leaves and acorns, maple leaf, the vine leaf and grapes, ivy, and similar forms. 2) A very natural treatment of these forms, which is conventional enough to fulfil the requirements of natural art." Fig. 314, page 136 shows an example of a carved panel in Gothic style, very similar to present day Solonese style.

5) The process of setting in before 'outlining ' or 'wasting away' is considered bad practice by European carvers due to the risk of splitting the timber. Turner, H , op. cit., pp. 62 - 63 writes: "When the design has been successfully placed, the first thing to do is to cut away the wood to form the ground. There are three ways in which this can be done: a) By setting in along the outline first; b) by cutting a 'V' trench about 1/8" away from the outlines, and then setting in; and c) by wasting away the wood with quick gouges up to about 1/8" of the outlines, and setting in. The first method is often employed, but it is unsuitable because by this method thin stalks, and other parts of the design, nearly always get broken and dislodged, owing to the lateral pressure due to the rapid driving in of the tool. This must be so, as the first blow does not cause any cutting away of the wood...This transmission of lateral pressure cannot occur without some result."

6) Good quality carving tools are not available in Solo. They are forged from vehicle leaf springs, by specialist tool makers in Semarang. A set of thirty-four chisels in 1989, cost 80,000 rupiah (approximately £30). Carvers have to buy their tools, and the cost is equivalent to a carver's salary for one month. Gouges are made by a process of forging and then filing the back of the tool to the required sweep (curvature). The top of the gouge is flat, unlike the European gouge, and the internal bevel is filed.

7) Information from interview with Pak Diran on 11 June 1989.

8) *Pahat col* are very similar to the standard English straight gouge, in that the sweep of the chisel runs along the length of the blade to the shank.

Notes to Chapter VII

1) For further information on Balinese bamboo ensembles see: McPhee, C., *Music in Bali*, (London, 1966).

2) *Joged* instruments use a light coloured bamboo known as *tiing tamblang*. *Jegog* are made from one of the largest bamboo species in Bali, which is also light in colour, known as *tiing petung*, see *Peralatan Hiburan dan Kesenian Tradisional Daerah Bali*, (Jakarta 1987).
3) Address: Tamiardji, Desa Gerduren, Purwojati, Banyumas, Central Java.
4) Information from: Marden, L., 'Bamboo, the Giant Grass', *National Geographic*, Oct. (1980), pp. 502-530.
5) *Bambu wulong* is the same as *awi wulung*, which is the preferred variety for angklung in West Java, see Wijaya, E.A., 'Botani Ekonomi Bambu Musik Jawa Barat', Fakultas Ilmu Pasti dan Pengetahuan Alam, (Bandung, 1983), p. 39.
6) Bamboo culms reach their final height in the first year of growth. Further growth is limited to the thickening of the culm walls.
7) For the higher pitched bars, the depth of the cutaway is only made to the equivalent of one third of the diameter, so that a tongue with a large cross section is produced that will give a high pitch.
8) It would be possible to lower the the pitch of the air chamber by only partially breaking through the node, but this method would result in a reduction in volume (efficiency) of the bar.

Notes to Chapter IX
1) Goody, J., *Death, Property and the Ancestors*, (Stanford University Press,1972), *The Social Organisation of the LoWiili*, (Oxford, 1967), *The Myth of the Bagre*, (Oxford, 1972).
2) Labouret, H., *Les Tribus du Rameau*, (Paris, 1931).
3) Mensah, A. A. 'Musicality and Musicianship in Northwest Ghana', *Research Review*, II(1), (1965), pp. 42-45. 'Further Notes on Ghana's Xylophone Traditions', *Research Review*, III(2), (1967), pp. 62-65.
4) Godsey, L., 'The Use of the Xylophone in the Funeral Ceremony of the Birifor of Northwest Ghana', PhD. dissertation, (U.C.L.A., 1980).
5) Strumpf, M., 'Ghanaian Xylophone Studies', (Legon, 1970), 'The Dramatic Elements of the LoDagaa Funeral Ceremony', M.A. dissertation, (Legon, 1975).
6) Seavoy, M., 'The Sisaala Xylophone Tradition', PhD. dissertation, (U.C.L.A., 1982).
7) Goody, J., *The Social Organisation of the LoWiili*, (Oxford, 1967).
8) Ibid., p. 19.
9) Ibid., p. 20.
10) Ibid., p. 20.
11) Ibid., p. 21.
12) Ibid., p. 25.
13) Godsey, op. cit., p. 33.
14) Goody, op. cit. 1967, p. 21.
15) Op. cit., p. 43.
16) Op. cit., 1975, p. 106.
17) Ibid., p. 106.
18) Goody, op. cit., 1962, p. 102.
19) Goody, op. cit., 1967, p. 21.
20) Goody, op. cit., 1962, p. 80.
21) Strumpf, op. cit., 1975, p. 106.
22) Goody, op. cit., 1967, p. 21.
23) Ibid., p. 21.
24) Ibid. p. 19.

25) Godsey, op. cit., p. 21.
26) Goody, op. cit., 1967, p. 12.
27) Ibid., p. 12.
28) Ibid., p. 14.
29) Goody, op. cit., 1967, p. 25.
30) Op. cit., p. 39.
31) Op. cit., 1962, p. 79.
32) Op. cit., 1975, p. 86.
33) Ibid., p. 87.
34) Mendonsa, E., *The Politics of Divination* (London, 1982), p. 32.
35) Ibid., p. 38.
36) Ibid., p. 39.
37) Ibid., p. 42.
38) Ibid., p. 46.
39) Seavoy, M., 'The Sisaala Xylophone Tradition', Phd. dissertation, (U.C.L.A., 1982).
40) Discussions in Silbelle.
41) Discussions in Sorbelle.
42) Discussions in Kowie and Silbelle.
43) Discussions in Kowie, Pulima and Sorbelle.
44) Discussions in Pulima. It was said in Kowie that although medicine used to be painted on to the tree in the form of a cross, this is no longer adherred to unless the maker knows that the tree is bad.
45) Discussions in Silbelle and Sorbelle.
46) Discussions in Kowie and Pulima.
47) Discussions in Silbelle.
48) Discussions in Kowie.
49) Discussions in Silbelle.
50) Op. cit., p. 291.
51) Ibid., p. 273.
52) Ibid., p. 184.
53) Ibid., p. 38.

Notes to Chapter X

1) Jalla, A., *Litaba za Sicaba sa Malozi,* (London, 1959)
2) Mainga, M., *Bulozi under the Luyana Kings*, (London, 1973)
3) Clay, G.C.R., *History of the Mankoya*, (Lusaka, 1945)
4) Binsbergen, van, W., *Tears of Rain, Ethnicity and History in Western Zambia*, (London, 1992)
5) Brown, E., 'Drums of Life - Royal Music and Social Life in Western Zambia', Phd. thesis, (Washington, 1984).
6) Jones, A.M., 'African Music in Northern Rhodesia and some other places', Rhodes Livingstone Institute, (Lusaka, 1948).
7) Mensah, A.A., 'Principles Governing the Construction of the Silimba, a Xylophone found among the Lozi of Zambia', *Review of Ethnology*, 3/3, (1970), p. 19.
8) His Royal Highness the Litunga, Ilute Yeta IV, Limulunga, Western Province, Zambia.
9) Mainga, op. cit., p. 21.
10) Ibid., p. 47.
11) Ibid., p. 35.
12) Ibid., p. 30.
13) Ibid., p. 33.
14) Ibid., p. 65.

15) Op. cit.
16) Clay, op. cit., p. 2.
17) Ibid., p. 2.
18) Ibid., p. 9.
19) Ibid., p. 20.
20) Mainga, op. cit., notes "The *maoma* royal and war drums, which came to feature so significantly in the installation rituals and ceremonies (installation rituals are always completed with the king sitting on one of the *maoma* drums)..", p. 33.
21) Information from discussions with the Litunga, 12/11/91.
22) Musicians of the Litunga, Limulunga.
23) Information from discussions with the Litunga, 12/11/91.
24) Ibid.
25) Brown, op. cit., p. 400.
26) Information from discussions with the Litunga, 12/11/91.
27) Boone, O., *Les Tambours du Congo Belge et du Ruanda Urundi*, (Tervuren, 1951),p.56.
28) Information from discussions with the Litunga, 12/11/91.
29) Ibid.
30) Brown, op. cit., p. 398.
31) According to Brown, op. cit., p. 397, during his research "all Luyana instruments were made at Lealui, the northern capital.", since the present Litunga has not resided at the dry season palace for a number of years, Luyana instrument making now takes place in Limulunga.
32) Gluckman, M., 'Notes on the Social Background of Barotse Music', quoted by Jones, A.M., in 'African Music in Rhodesia and some other places', 4, (Lusaka, 1948), p. 38.
33) See Dechamps; R., 'Note préliminaire concernant l'identification anatomique des espèces de bois utilisées dans la fabrication des xylophone de l'Afrique Centrale', *Africa-Tervuren,* XIX (3), (1973), pp. 61-66. This study of 149 xylophones in the collection of La Musee de l'Afrique Centrale, Tervuren, shows 71% of xylophones with bars made of *pterocarpus. Pterocarpus angolensis* constituted 10% of fixed bar type xylophone.
34) Information from discussions with the Litunga, 12/11/91.
35) Ibid.
36) Such small intervals are uncommon in African instruments. I am unaware of any other African xylophones with intervals of less than 100 cents, although the LoDagaba funeral xylophone does have one very small interval which has a mean of 121 cents. Research by Paul Berliner (*The Soul of Mbira,* (London, 1981) pp. 62-68) shows that intervals of 100 cents or less do exist among lamellophones in Zimbabwe.
37) Brown, op. cit., pp. 396.
38) During Brown's research, op. cit., all instruments were made in Lealui. Since Limulunga is now the permanent residence of the King, instruments are now made here.
39) Information from discussions with the Litunga, 12/11/91
40) Again, this is very similar to the *Dza Vadzimu,* see Berliner, op. cit., p. 66.
41) During research at Le Musée de l'Afrique Centrale in 1987 I studied two *madimba* xylophones (mus. nos. 34666, and 34667) of the Bena Kanioka in south west Zaire (centred around the town, Mutombo Mukulu). These xylophones use the same method of adjusting the height of the calabash (see fig. 123).
42) This method of fine tuning resonators would not work with bottle-

neck calabash since they work on the principle of a Helmholtz resonator, producing one fundamental pitch irrespective of the proximity of the sound source.
43) Spiders' egg sacs, as used in West Africa, are thicker and produce a more mellow buzz. By comparison, the thinner membranes produce a loose, thin sound. These tend to be used more often in conjunction with elongated calabash.
44) Brown, op. cit., p. 363.
45) Ibid., p. 363.
46) Ibid., p. 127.
47) Ibid., p. 128.
48) Boone, op. cit., p. 56.
49) Ibid., p. 55.
50) See Brown, op. cit., p. 363.
51) The *silimba* players in a compound in Mongu (shown in fig. 128) were paid 150 *Kwacha* (in 1991 200 Kwacha = £1) for each drum consumed. Usually only one oil drum of beer is sold in one day. With such low wages it is understandable that most of the musicians playing at such places are children.
52) The volume a resonator produces is related to the size of the aperture; the larger the aperture, the less the friction, and the greater the ease of movement of air.
53) Brown, op. cit., p. 360.
54) Ibid., p. 366.

Notes to Chapter XI
1) Boone, O., *Les Xylophones du Congo Belge*, (Tervueren, 1936). This book does not cover Nzakara instruments since their territory only slightly overlaps into Zaire from C.A.R., and it is therefore unlikely that instruments would have been collected to represent such a small section of the peoples of the Uele region. I found the book extremely useful as an instrument maker and have made many *manza* type instruments over the last six years.
2) Le Musée de l'Afrique Centrale, Tervueren, Brussels, Belgium.
3) Arom, S., *Polyphonies et polyrythmes instrumentales d'Afrique Centrale - structure et méthodologie*, 2 vols., (Paris, 1985).
4) I don't know whether the Banda-Linda and Sabanga previously used their ten-keyed xylophones for court music.
5) Evans-Pritchard, E.E., *Witchcraft and magic among the Azande*, (Oxford, 1937).
6) Dampierre, de, E., *Un Ancien Royaume Bandia du Haut Oubangui*, (Paris, 1962).
7) The Bapende 17 bar *madimba* is equally finely made.
8) It was not possible to get the necessary research documents.
9) Baxter, P.T.W. and Butt, A., *Ethnographic survey of Africa, East Central Africa, Part IX, The Azande and related peoples of the Anglo-Egyptian Sudan and the Belgian Congo*, (London, 1953).
10) The Banda are the main ethnic group in the central region of C A R.
11) Cordell, D., *History of Central Africa,* ed., Birmingham, D., and Martin, P., (London, 1983), p. 53.
12) Ibid.
13) Ibid., p. 55.
14) Evans-Pritchard, E. E., 'The Organisation of a Zande Kingdom', *Cahiers d'études africaines*, I, (1960), pp. 5-37.

15) Op. cit., p. 23.
16) Ibid.
17) Baxter and Butt, op. cit., p. 38.
18) Dampierre, op. cit., p. 167.
19) Ibid., p. 169.
20) Cordell, op. cit., p. 53.
21) Ibid., p. 57.
22) Ibid.
23) Ibid.
24) Ibid., p. 58.
25) Baxter and Butt, op. cit., p. 23.
26) Ibid., p. 24.
27) Life expectancy of Europeans was very short before quinine was discovered as an effective treatment for malaria.
28) Information from discussions with Dengba, Banguiville, 6/4/90.
29) Discussions with Sano in Vougba, 1/4/90. These two instruments were made to be played together, and were almost certainly made by the same maker; the design on the bars of each xylophone are identical.
30) *Mami kpaningbo* literally translates as breast xylophone. It is interesting to note that the Nzakara still use the vou Kpata word, *kpaningbo* to name the various parts of the xylophone they now call *nzanzangoula*.
31) I tried to obtain seeds in every village I visited, but since this type of calabash is not used for any purpose other than xylophone resonators, it was not possible to find any.
32) Op cit.
33) Op. cit., pp. 101 - 104.
34) Ibid., p. 129.
35) The Chopi xylophones from Mozambique use a similar method, but with one support bar between every two keys. See Tracey, H., *Chopi musicians, their Music, Poetry and Instruments*, (Oxford, 1948, rep. 1970).
36) Boone, op. cit., p. 132.
37) Dechamps, R.,'Note préliminaire concernant l'identification anatomique de espèces de bois utilisées dans la fabrication de xylophones de l'Afrique Centrale', *Africa-Tervueren*, XIX- 3, (1973).
38) Ibid., p. 66.
39) Discussions with Dengba, 11/4/90.
40) Ibid. As a general rule, timber takes one year for every 25mm of thickness to air dry in northern Europe. Dengba mentioned allowing four months, although he said it was often dry within two months.
41) Discussions with Dengba, 4/4/90.
42) These are produced by repeatedly scraping the surface with a metal blade, the annual growth rings in the timber being more dense resulting from *pterocarpus* being deciduous, losing its leaves for two months. The bars of this instrument are made of *pterocarpus ossum*.
43) Boone, op. cit., p. 120: "Le *manza* est un instrument relativement rares, et d'une façon générale, il est réservé aux chefs et aux notables. Le plus souvent, on utilise deux ou trois instruments en même temps: tons hauts, tons moyens, tons bas. Chez les Ngbandi (the Bandia are an Ngbandi clan), le premier se nomme *nyini* (enfant), le deuxième est dénommé *tani* (femelle) et le troisième est le *toni* (mâle)."
44) Arom, S., op. cit., p. 62.
45) See Dampierre, op. cit., chapter III, 2, 'Le culte des ancêtres.', pp. 191-210.

46) Ibid., p. 418.
47) ibid., p. 199.
48) I was told this by a number of people in Zemio.
49) I have not been able to identify this timber.
50) Playing the bars with sticks on sapwood produces a more mellow and melodic sound than playing on the harder heartwood; this would produce a more percussive sound. Whereas soft beaters are used with xylophones with hardwood bars, log xylophones played with sticks require the struck point of the bar to be of softwood so that the lower modes of vibration are excited - see pp. 217 and 227 - 228). The bar must therefore rest with the sapwood uppermost. The purpose of carving the arch on the top of the bar, thus leaving the heartwood intact, is to produce a louder note with a longer sustain. In order to achieve a melodic tone with a log xylophone the sticks must strike the bars at approximately 45 degrees to the horizontal bar; striking the bars with sticks held close to the horizontal results in a percussive rather than tuneful tone.
51) The Banda are the main ethnic group in C A R. There are many subgroups of the Banda, including the Linda (Banda-Linda).

Notes to Chapter XIII
1) See page 120 - the introduction of the Birifor *kogyil* to the LoDagaba.
2) Godsey, L., 'The Use of the Xylophone in the Funeral Ceremony of the Birifor of Northwest Ghana', PhD. thesis, (UCLA, 1980), p. 79.
3) Backus, J., *The Acoustical Foundations of Music*, London, 2nd. ed. 1977, vibrating air columns, see pp. 63 - 72
4) Askill, J.,*Physics of Musical Sounds*, New York, 1979, percussion intruments, see pp. 153 - 162.
5) Campbell, M., and Greated, C., *The Musician's Guide to Acoustics*, London, 1987, vibrating air columns, see pp.195 - 201, and percussion instruments, see pp. 429 - 441.
6) Fletcher, N. and Rossing, T., *The Physics of Musical Instruments*, New York, 1991.
7) Moore, J.M., 'Acoustics of Bar Percussion Instruments', Phd. thesis, Ohio State University, 1970.
8) Ibid., p.136.
9) Ibid., pp.15-18 & 66-83.
10) Askill, op. cit. pp. 164-5.
11) Ibid., p. 166.
12) Tracey, H., *Chopi Musician's, their Music, Poetry and Instruments*, (Oxford, 1948, repr. 1970), p. 141.
13) Campbell and Greated, op. cit., p431
14) Askill, op. cit., p.162. Ibid.
15) Campbell and Greated, op. cit., p. 438.
16) Moore, op. cit., p. 79.
17) Ibid., p.81.
18) It should be noted that these nodal and antinodal positions are for a bar of uniform thickness and will change when a bar has been undercut.
19) Campbell and Greated, op. cit., p. 438.
20) Ibid.
21) Brown, op. cit., p. 101-110.
22) The Javanese xylophone, gambang, which has a range of four octaves, has bars ranging in thickness from 10mm to 45mm.
23) Helmholtz, H., *On the Sensations of Tone*, 1885, 2nd. English ed.,New York, 1954, p. 372.

24) Backus, J., op. cit., p 79.
25) Backus, J., op. cit., p 79.
26) Helmholtz, H., op. cit., p. 374.
27) Fletcher, N. and Rossing, T., op. cit., p. 547.
28) Ibid.
29) These figures are typical for the shortest and longest bars of orchestral bar percussion instruments.
30) Kirby, P R, *The Musical Instruments of the Native Races of South Africa*, Oxford, 1934, p. 51. Kirby mentioned the Venda *mbila* as being extremely rare in the 1930s so it is likely that this xylophone is no longer in use.
31) See Wood, op. cit., p. 133, regarding the effect of mallet hardness.
32) Venda xylophone playing style does however also require the use of two beaters in one hand playing the low register of the instrument (held so they cross in the palm of the hand at 90 degrees to one another) while only one beater is used in the higher register. Kirby notes, op. cit., p 53, "The necessity for two left-hand beaters arises from the fact that the deepest notes are produced by wide slabs of wood; and the distance to be covered in jumping, say, an octave would be too great for a single beater to accomplish in the required time".
33) MacCallum, F K, *The Book of the Marimba*, New York, 1969, p.90.
34) Both these instruments have bars much shorter in relation to their pitch than orchestral marimbas, so a far greater amount of undercutting is required to lower the fundamental. This raises the second partial to such an extent (at least 500 cents) that it does not create a dissonance with the fundamental.
35) Kirby, op. cit., p. 51.
36) Ashdown Environmental Ltd., Hartfield, Sussex.
37) See Kirby, op. cit., plate 17A.
38) The only other African xylophones with multiple bars and individual resonators that do not use mirlitons that I am aware of is the other instrument very similar to the *manza*, the Nzakara *nzanzangoula*, and the Chokwe *njimba* from the Angolan/Zairian border region.

APPENDIX 1 Glossary of Javanese words connected with the manufacture of bronze gamelan.

A *abu* - charcoal
aling-aling - screen used to protect against heat of work-piece
ancer - small indentation in boss
angell - tool rest (for *penyukat*)

B *bahu* - sidewall of gong, refer to fig. 7, p. 25
besalen - workshop, smithy
bilah - bar or key of instrument
blimbingan - particular shape of gender bar

C *cakrak bubutan* - hand operated lathe used for cleaning up groove at base of boss
cekeh - support for overhead bellows (*congklok*)
cemengan (gong -) - gong with only boss polished
colok - flame torch, length of wire, dipped in paraffin and set alight
congklok - overhead bellows

D *dodogkan* - stone anvil used to make bonang
dongo - hearth, when cold/not in use
dudu - part of gong, refer to fig. 7, p. 25

E *endak* - process used in voicing/tuning *pencon gandhul*
entol - long wooden beam used in *metak* process

G *gangsa* - bronze
ganjel - clay support used in instrument forging
geblog - small metal hammer, similar in weight and shape to a club hammer
gecakan - a test used to assay the quality of bronze

I *impes* - process of voicing/tuning *pencon gandhul*

J *jati* - teak (*kayu* -) teak wood, *kayu* = timber
jleberan - stage (process: *njleber*) workpiece assumes during early forging of *pencon gandhul*
jongko - dividers for measuring
jugil - mattock
jujutan - test (process: *njujut*) to assay quality of bronze alloy
juluk - process used in voicing/tuning *pencon gandhul*

K *kancing* - process used in voicing/tuning *pencon gandhul*
kayu - timber
kempel - the sound of a well voiced *pencon gandhul,* ie a strong tone with a long decay
kempul - hanging gong (small) type instrument tuned to a single fundamental (no *ombak*) note in the scale
kentheng - process used in voicing/tuning *pencon gandhul*
kesik - scraper
kikir - file, *kikir besi* - iron file, *kikir patar* - dread-nought-type file
klontong - shape *pencon* assumes during forging after *lakaran*

klowong - iron hoop used to retain the shape of *pencon* during the *ngelem* (quenching) process
kreweng - old, broken up bronze instruments that are remelted

L *ladok* - anvil, *ladok mendan* - vertical stone anvil set in ground, *ladok tandhes* - horizontal iron plate anvil set in the ground
laga - (or *logo*) large wooden hammer
lakaran - *pencon gandhul* in early stages of forging
lakarwo - small poker-like tool used in *nyingeni* process
lambe - rim of *pencon,* see fig. 7, p. 25
lambung - outer flutes on gender bar
lamus - bellows
lanang - male (style/shape of *pencon*)
laras - scale, tuning
lempung - clay
lilin - wax
loloan - part of gong, opening, see fig. 7, p. 25
luk - curved shape of metallophone bar

M *malam* - wax
mapak - process of forging *pencon gandhul,* smoothing out *rai* and *recep*
masoni (*di* -) - process of forging *pencon gandhul,* forming *pasu*
mbesot - process, melting bronze
mencu - process of forging *pencon gandhul,* hammering out the boss
menda - process of forging *pencon gandhul,* smoothing out the sidewall (*bahu*)
metak - process of cold hammering *pencon gandhul*
munuk - process of making bonang *recep*

N *ndekung* - process of making the *bahu*
ngelem - process, quenching red-hot *pencon* in cold water
ngucik - process of making *lambe*
njereng - process of making *uceng*
njleber - see *jleberan*
njujut - see *jujutan*
nyangoni - process of adding more tin to a molten bronze alloy
nyingeni - lost-wax method of repairing cracks in bronze instruments
nyolok - process of adding more copper to a molten bronze alloy

O *odo-odo* - ridges on gender type metallophone bar
ombak - the beating of two close pitches, of a gong

P *paesan* - end of gender bar
padi - rice husks
pahat col - wood carving gouge with external bevel
pagol - wooden stake used as an anvil
pagolan - timber post set vertically in ground, see fig. 33, p. 43
pancal - process of voicing/tuning *pencon gandhul*
palu - hammer, *palu alang*: hammer used to forge *pasu,* *palu besi:* steel hammer, *palu laga:* large wooden hammer, *palu mendan:* hammer used to form sidewall of *pencon*

palu penunjut: hammer used to forge the *pencu* (boss),
palu ucikan: large hammer used to forge the *lambe*

pasu - part of *pencon,* see fig. 7, p. 25
pelamus - see *lamus*
pemalu - smith (hammerer)
pencon - collective term for all types of gong pot instruments,
pencon gandhul: hanging instrument,
pencon pangkon: cradled instrument
pencu - boss or knob, part of *pencon,* see fig. 7, p. 25
pendopo - traditional style Javanese open-sided building
pengalap - worker in forge, carries workpiece to and from the forge
pengider - worker in forge, turns workpiece
penglaras - tuner, see *laras*
penguku - wood carving gouge with internal bevel
penyilat - wood carving chisel, flat
penyingen - mould for bronze casting, *penyingen bunderan*: mould for *pencon* type instruments, *penyingen jujutan*: test casting mould
penyukat - large (1.8m) poker-like tools used to move *pencon gandhul* around in the forge
planden - large water basin
polos - particular style of saron bar

R

rai - part of *pencon,* see fig. 7, p. 25
recep - part of *pencon,* see fig. 7, p. 25

S

selet - process of cold hammering *pencon gandhul* to smooth out undulations
supit cocor - small clasping tongs
supit klowong - medium sized clasping tongs

T

tatah - set of Javanese wood carving chisels
tikel - part of *pencon,* see fig. 7, p. 25

U

uceng - early stage of forging *pencon*
umbul - short, stout piece of timber used to exert pressure on surface of *pencon gandhul* during *metak* process

W

wadon - name used to describe the 'female' or flat style of *pencon*
wanngkil - carving tool used to cut away the ground in relief carving
wegang - scraper chisel used to clean up the groove at the base of a *pencon;* used in conjunction with a lathe
welon - shape *pencon* assumes during forging
widengan - groove at base of *pencu* (boss)

APPENDIX 2, Sisaala villages

Kowie

Dinwia Nanchua (father, xylophone maker, musician)
Malik Dinwia (son, musician)
Alidu Nandzo (son)
Siedu Dinwia (son)
Mumuni Gomina (grandson, musician)
Salifu Luaru (grandson, musician)

Pulima

Dimmie Gomina (landlord, jengsi custodian, musician).
Luri Gomina (musician).
Alfred Luriwie Gomina (musician).

Silbelle

Tayilu Tormia (chairman of the village development commitee)
Kasugu Willa (xylophone maker)
Kerimu Kasim (xylophone maker)

Sorbelle

Felwia Nabila (landlord)
Nmanvasa Monto (chief)
Jha Mula (chairman of the village development commitee)
Gbene Nansia (xylophone maker)
Jakbui Hor (xylophone maker)

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