Steel Pan Tuning

This book is dedicated to
the rhythmic people of Trinidad and Tobago
and their master tuners

Steel Pan Tuning

A Handbook for Steel Pan Making and Tuning

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Preface

When I first started to write this book three years ago, my intention was to update Peter Seegers book about steel pan making from 1964. I was trying to understand and learn how to tune steel pans as a part of my research in the acoustics of the steel pan, and it seemed suitable to document what I was learning. But, during my research project I realized that the art of steel pan tuning has now reached a degree of crafting refinement that makes it impossible to teach a novice how to do it properly from a reading book only – if it ever was. In fact, I believe that it would be easier to make a working violin from just reading a handbook than to make a steel pan. Still, as a scientist I wanted to document what I was learning and felt that a building description could serve as a written guidance to the basics of steel pan making.

The main purpose of this handbook is thus *not* to teach novices how to tune steel pans. The making and tuning of good steel pans is a crafting art that must and should be taught practically by a skilled panmaker. But the methods have hitherto been passed on completely through oral tradition. Therefore, a handbook like this one can, seen as a complementary aid, facilitate the teaching of pan making. The documentation is also intended to serve as a basis for a discussion of existing and emerging new tuning techniques.

The aim of this book is *not* to promote a standardization of the crafting process. It is rather to present major steps of the process and gather the tricks, specialities and results of some different methods so we can have an open discussion of their usefulness. In this way the community of panmakers can join the information society and start to develop the steel pan instrument through the same methods as used by manufacturers of high-tech instruments, such as pianos, violins, saxophones, etc.

As a researcher in acoustics I want to bring my measurements and theories to the skilled tuners to see if the marriage of practical crafting knowledge and scientific theory can bring the steel pan further in its evolution towards a matured instrument. The aim is to promote a fruitful feedback between theory and practice – to try to make a ”reference work” both for skilled panmakers and newcomers in the field.

You may argue that the panmakers have managed very well without any theory or written documentation through the first fifty years of the steel pan history. This is perfectly true, but the future development of the instrument can be facilitated and speeded up by providing written documentation and theories. This has been realised by individuals and organisations in Trinidad. A paper from Pan Trinbago (the national organisation for steel pan music in Trinidad & Tobago) from 1980 states the following about the need for technical research: ”Today, however, there is a need to carry this development to a higher plane and to marry the rich practical experience of the individual panmaker with the theory of engineering science”.

I do not claim to be anyone who knows very much about steel pan making and tuning. I don’t even know how to keep my own tenor pan in tune, when it comes to practice. But, as I am eager to learn the practical methods and have access to tools for measurements and theoretical models, this book can be seen as a first step towards a thorough documentation of the instrument and the tuning techniques.

The book is divided into four main parts:

I – a practical section with a brief description of the crafting method.

II – a documentation of various inventions and trends for the future development of pan.

III – a theoretical section with a discussion of the acoustical aspects of the steel pan and a documentation of research results, gained in projects during the years 1989 and 1990.

IV – appendices with data and measurements on some common steel pan models and tools.

This handbook is intended to be published in a step-wise refined procedure. This means that the first edition is to be revised when a sufficient amount of new findings and data are at hand. Therefore, if you find something that seems faulty or poorly described, please report it to me to have it altered in the next edition. In this way the handbook can serve as an evolving reference work for the art of steel pan making and tuning in the future.

Stockholm, December 1991.

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I also want to thank the crew who has helped me with the production of the book: Bob McAllister for proof-reading, Elisabeth Gunnarsdotter, Linus Torell and Johan Larsson for helping me with the pictures, and Lars Lundbom for layout, typography and cover design.

Steel pan history

The steel pan, the tuned steel drum, is one of the few genuinely novel acoustic instruments invented in the twentieth century. Its origin is believed to be dustbins, used as rhythm instruments by the traditional Carnival bands of Trinidad & Tobago in the 1930's. During its 50-year history the steel pan has evolved from a multi-pitched percussion instrument to the mellow-sounding melodic-harmonic instrument of today.

The history of the steel pan is a story of prohibitions and compulsion. Its invention was in fact induced by the ruling colonialists trying to suppress the strong rhythmic heritage of the black Africans. Here are some milestones in the history of the pan:

1883	The use of drums in street parades was outlawed since the colonialists feared that passing of secret messages by means of drumming might become the impetus for social unity and revolt among the black. Riots and conflict between the natives and the authorities led to the banning of drum processions after the carnival this year.
1900-1934	The ban of drums led to the use of tuned bamboo sticks in street parades. During the 1930's biscuit tins were included as rhythm instruments in the Tamboo Bamboo bands.
1934	Tamboo Bamboo bands were forbidden due to street clashes among rival groups.
1935-1938	A gradual change to steel instruments in street bands.
1938-1939	Are considered to be the "birth" years of the steel drum. Tamboo Bamboo bands finally switching over to steel. Alexander's Ragtime Band, led by pioneer Carlton Forde, is said to have been the first known band with an ensemble exclusively consisting of steel instruments.
1942	Carnivals forbidden during World War II for "security reasons", which gave people more time for acoustic experiments with the emerging "steel drum".
1939-1945	The first melody pans with three to eight tones was introduced. The pan crafting process was improved by sinking, grooving and tempering. Sticks damped with rubber tubing were starting to be used. The

instruments were grouped into categories as iron, boom, dudup, ping-pong.

1945 In a spontaneous Carnival at the end of the war there were several bands consisting of only steel pans – the first real steelbands.

1946 The Invaders steelband, led by Elliot ”Ellie” Manette, was reported to be the first steelband to participate in organised ”mas”.

1947-1949 The last years of the small melodic steel pan; in 1948 the 55 gallon oil drum finally replaced the biscuit tin as main raw material. The first fourteen-note steel drum with chromatic tones was developed.

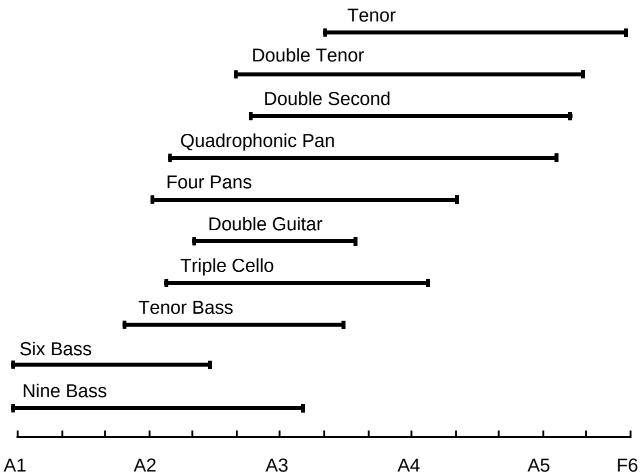
The early rhythm steel drums were usually made from paint tins or biscuit tins, one foot in diameter and two feet long. It was discovered that bulges of different sizes in the bottom of a tin could produce sounds of various pitches. Some of the more inventive players started to tune the tins and play melodies on them. Several sources point out Winston ”Spree” Simon as the inventor of the first melodic steel pan.

An oil industry as well as an U.S. naval base had been established on the island of Trinidad. Leftover oil drums were often cut in two and used as dustbins. These dustbins successively replaced the biscuit tin as the raw material for pan making. The bottom of the dustbin was hammered outwards to a convex shape (i.e., the opposite to a modern steel pan) and then small dents for the different notes were made in it. In the later part of the 1940’s, pan tuner and arranger Elliot ”Ellie” Manette changed the design to concave with convex note-dents and increased the number of notes in the pan.

Through the fifty years following the second world war, the steel pan has been further developed by panmakers through sophisticated experimentation with the physical parameters of the metal, using intuition, trial and error experiments and a good musical ear. The development is still in progress; refinements are made and new crafting techniques and constructions are tested. A number of pan types with different layouts have evolved from this experimentation. Some problems that have not yet been finally resolved are the standardization of the note layout on the various pan types and the evaluation of the effectiveness of the different existing crafting techniques.

The steelband

In the traditional Trinidad carnival steelband all the melodic and harmonic functions are held by steel pans – the only other instruments that participate are percussion instruments. A steelband can consist of up to 100 players, forming about ten to twelve different instrument groups, ranging from bass to soprano line, together covering a tonal range almost equal to a grand piano.



Graph of tonal ranges for the most common steel pan models. Total range of scale corresponding to that of a grand piano, less one octave at the bottom and 1.5 octave at the top.

The following is a list of the most common steel pan models, together with their usual tonal range and a suggestion for a ”tonal

Trinidad name	"Range" name	Tonal range	No. of drums
Tenor	Soprano	D4 - F6	1
Double tenor	Alto	F3 - C6	2
Double second	Tenor	F#3 - B5	2
Quadrophonic pan		B2 - Bb5	4
Four pan		Bb2 - C#4	4
Guitar pan		D3 - F4	2
Cello pan	Baritone	B2 - Bb4	3
Tenor bass		G2 - D4	4
Six bass		A1 - D3	6
Nine bass		A1 - B3	9

range" name:

The rhythm section of the steelband is usually comprised of a regular drum-kit, a pair of congas (usually played with rubber-tipped sticks) and the important "iron" – several people playing with metal rods on brake drums from old cars.

Methods for steel pan making

Nowadays, steel pans are mostly made by a team, consisting of specialized "sinkers", doing the tough sinking and crafting work, and the expert tuner, doing the intricate tuning of the pan. Almost every pan tuning team has its own method for making and tuning steel pans, using special, sometimes secret, tricks and handicraft methods to get a good result.

The techniques described and discussed here are based on the methods used by the tuners Lawrence "Egar" Mayers and Rudy Smith and their respective crafting teams. Data for the description of the methods has been gathered by the author during tuning sessions, research projects and discussions with the tuners in Sweden from April to June 1989. The manuscript was revised after a visit to Trinidad in the spring of 1990. The pictures were taken in Trinidad 1990 and in Sweden 1991.

The documentation of the crafting method is fully the responsibility of the author, and none of the involved tuners should be held responsible for any faulty statements made here, due to possible misconceptions. However, the functionality of the described methods is fully credited to the tuners.

I. PRACTICAL SECTION

Making and Tuning a Steel Pan

Panmakers' working methods are usually learned during a long time as apprentice of a respected master. The methods may later be changed and formed by the tuner's own personal preferences. In crafting, the same result can often be accomplished in several ways and things can be done in different orders. The intended result may be the only common denominator of the different working methods.

It is hard to describe handicraft work in writing. To describe the crafting and tuning work, I have chosen to report the various steps of *one* method to make functioning steel pans. I have tried to emphasize what I believe is the desired result of each step, rather than the exact working process. It is up to the reader to judge if he wants to work in this way or use some other method to get the required result. A skilled panmaker often omits some of the steps described here, because the precision of his work usually makes them redundant.

Each chapter in the practical section is structured according to the following; first, a brief description of *what* is to be done, second, *why* it is done and third, *how* it is done. For the sake of clarity I have been forced to dissect the work of the panmaker into discrete pieces. The many small steps described here are often interlinked with each other in a continuous flow of work that can be very hard to penetrate. When you do the actual work you will often find it hard to separate the steps from each other.

The main stages in the making and tuning process, together with a rough estimate of the used time for a professional panmaker, are:

- Choosing the drum
- Sinking 2 hours
- Marking of notes 30 min.
- Backing 1 hour

• Grooving	1 hour
• Levelling	1 hour
• Cutting	30 min.
• Tempering	30 min.
• Coarse tuning	2-4 hours
• Making holes for hanging	30 min.
• Fine tuning	
• Finishing	
• Blending	

The making of a steel pan set is usually about two days of work for a tuning team: The first day the sinker does the sinking, backing, grooving, levelling and the tempering. The second day the tuner does the tuning. The blending – the last fine tuning – is done after the chroming and has to be repeated later when the pan gets out of tune.

The description of the crafting process involves many terms that are special to steel pan making and also many measures. Before continuing, it may be appropriate to take a look at appendix E for a definition of the terms used for the various parts of the steel pan. In the beginning of appendix A there is an explanation of the measures and a conversion table between inches and millimetres.

1. Choosing the drum

The drums used for steel pan making are ordinary, new or used steel barrels. The volume of the standard steel drum is 208 litres (which equals 45.8 imperial gallons or 55 U.S. gallons, respectively). The drums are 59.5 cm (23 inches) in diameter and 88.3 cm (24.8 inches) long. See appendix D for more details on drums.

Panmakers usually prefer drums that have a rim with a flat side and a square cross-section; a so called "flat fold". A new method to join the side and the bottom of the drum is to make a round fold, see fig. 1.1. Some panmakers avoid drums with this round rim, because they claim that it will not withstand the stretching forces during the sinking. However, recent tests (done by a tuner and myself) indicate that the round

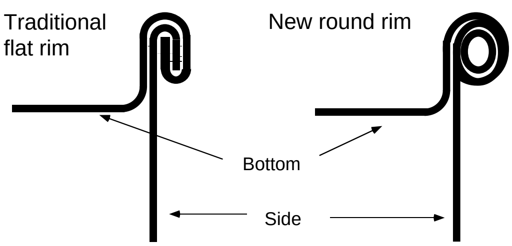


Fig. 1.1 Cross-section of the traditional flat rim and the new round rim.

rim is as durable as the flat rim. Acoustically, the result seems to be acceptable too. On Trinidad, backline instruments are often made out of round-rim drums nowadays, but the round rim seems to be avoided in front line instruments, I belive, mostly for aesthetic reasons.

The thickness of the metal is of vital importance. Generally, it seems to be better the thicker the metal is, especially for the lower tuned instruments, such as bass, cello and guitar pan. But if you use a thick metal for the higher pans, such as the tenor and the double tenor, the small high notes might be difficult to tune. The thickness of the steel in the bottom of the most commonly used drums is 1.2 mm (18 gauge). The side of the drum can be either 1.2 mm or 1.0 mm (20 gauge) thick. It is unclear which is the best; a side with 1.0 mm thickness seems to be most common. The thinner skirt will probably give the sound of the pan a better ”ring” than the thicker one.

The thickness of the metal in the bottom of the drum can not be measured directly without destroying the drum, so you have to use some tricks to determine it. The thickness of the metal in the bottom and the top can be assumed to be the same. The thickness of the top can be measured with a tool that is put in through the tap. The weight of the drum and the sound that is emitted when you tap on it can also be used as clues to the thickness of the metal. See appendix D for data on the weight of different drums. Drums with less than 1.0 mm (more than 20 gauge) thickness in the side are often corrugated for additional strength. Try to avoid those for pan-making because the bottom of these drums is probably too thin (1.0 mm or less).

The material of the drum should be mild steel. Steel drums with a galvanised iron coating can not be used for steel pans – the coating definitely spoils the tone. The quality and homogeneity of the steel are important. Poor metal may have spots where the carbon content is more concentrated. These spots are harder and may burst when stretched during the sinking.

The condition of the drum is also of great importance. A little light rust here and there on the surface doesn’t matter, but try to avoid drums with sharp dents and spots of rust that seems to be going deep. Such spots tend to crack when the metal is stretched during the sinking. Text that is grooved on the bottom of the drum will usually not affect the result as it will be smoothed out during the sinking. But if the text is deeply grooved and has sharp edges, try to find another drum, at least if you are about to make a pan that is to be sunk deeply.

Some drums are ”re-conditioned”, which means that they are cleaned and used a second time. The drum is often burned clean during the reconditioning process and this affects the metal in an unfavourable way. Try to avoid these drums. Re-conditioned drums can be detected by scraping off the paint at a spot and looking at the metal surface. If the metal is clear and shiny, it is a new drum. If it is grainy and without lustre, it is re-conditioned.

2. Sinking

The sinking is the first part of the panmaking. During the sinking the panmaker lowers the bottom of the drum into a concave kettle where the notes later are hammered up as convex dents. The whole sinking process can be seen as consisting of four steps; marking, lowering, shaping, and smoothing.

There are several reasons for doing the sinking: First, the bottom is lowered to remove the tone of the bottom of the drum – otherwise it would interfere with the sound of the notes. As the bottom is sunk you can hear its tone rise from a low pitch up to a very high. Second, the bottom is stretched to enlarge the surface to make enough space for all the notes. Third, the metal is made thinner in the middle where the highest notes will be situated. Fourth, the sinking is intended to make a suitable overall curvature for the notes of the different pan types. There seems to be a certain (still unrevealed) relationship between the size of the notes and the needed overall curvature of the pan – small notes; deeper sinking – large notes; a more shallow sinking.

If the bottom rim has some indentions you have to start by making sure that the rim is circular. This is done by hitting the rim with a sledge-hammer from the middle of the bottom surface and outwards. If the side of the drum has some large indentions it is best to open the drum in the top and remove the dents by hammering from the inside. Otherwise they might affect the sound of the outer notes.

Begin the sinking process by opening the drum to make it possible for the air to come out when you are hitting the bottom. This can be done either by removing the whole top

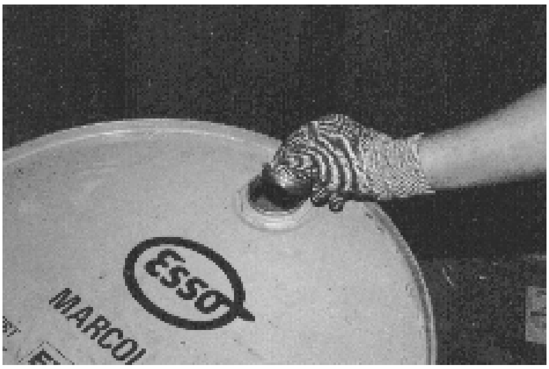


Fig. 2.1 Remove the plug to let the air slip out during the sinking.

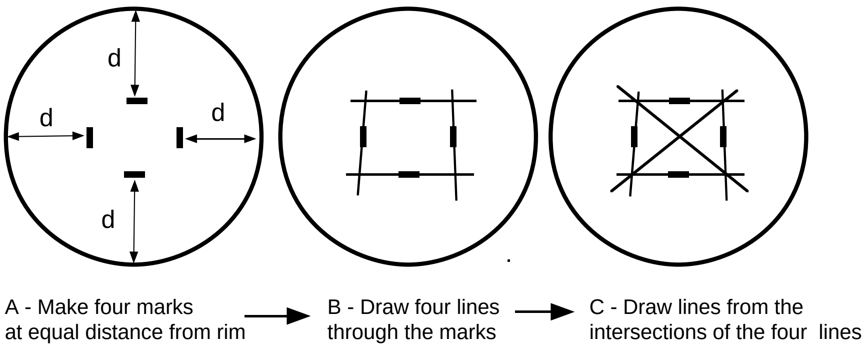


Fig. 2.2 Method to find and mark centre.

or the plug, see fig. 2.1. Then turn the drum upside down and place it steadily on the ground. A few strokes on the top before turning the drum may make the top concave and help the drum stand better.

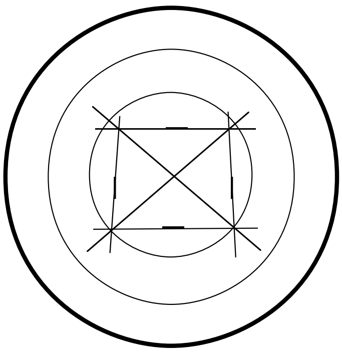


Fig. 2.3 Concentrical circles drawn to see the shape of the bottom better while doing the sinking.

MARKING

The panmaker often starts by drawing a pair of concentrical circles on the bottom surface to make it easier to see the shape of it while it is lowered. To draw the circles, the middle of the bottom has to be found and marked. This is usually done by making four pencil marks on the bottom at equal distance *d* from the rim. Draw straight lines through the marks and then two lines between the opposite corners of the formed rectangle, see fig. 2.2. The crossing of the two later lines represents the centre of the drum. Another method to find the centre is to measure the distance 26.6 cm, which equals the radius (half the diameter) of the drum, from the rim towards the centre several times at different rim positions.

Two concentrical circles are made by using a compass. The inner circle is drawn with a radius of approx. 1/3 (10 cm) of the

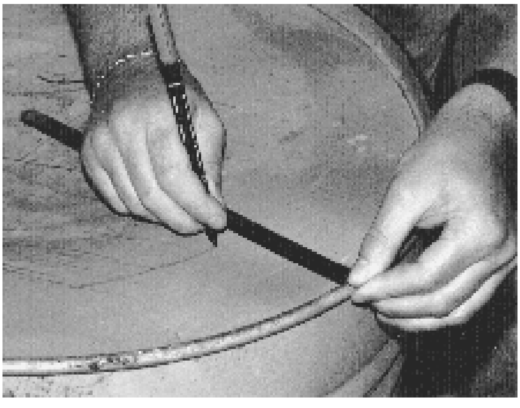


Fig. 2.4 Method to make concentrical circles.

drum radius and the second with a radius about 2/3 (20 cm) of the whole radius. The result is that the drum radius is divided into three equal parts, see fig. 2.3. The two circles may also be drawn by moving a ruler round the bottom of the drum in circular movements, drawing two lines at constant distances from the rim, see fig. 2.4

LOWERING

The lowering of the drum bottom is done using a sledge-hammer with a smooth, rounded head and a short, specially formed handle. The handle of the sledge-hammer should be long enough to enable you to hold it with both hands.

A better, more elaborate method to do the sinking is to use a 5 kg cast iron ball, most often a shot-put or a cannon-ball. The ball is dropped or thrown at the bottom and caught when it bounces up again. The round ball will make fewer marks in the metal than the sledge-hammer, but it will be harder to work on the steep sides near the rim. For the inexperienced panmaker the shot-put may also cause difficulties in hitting the right spot and catching it when it bounces back.

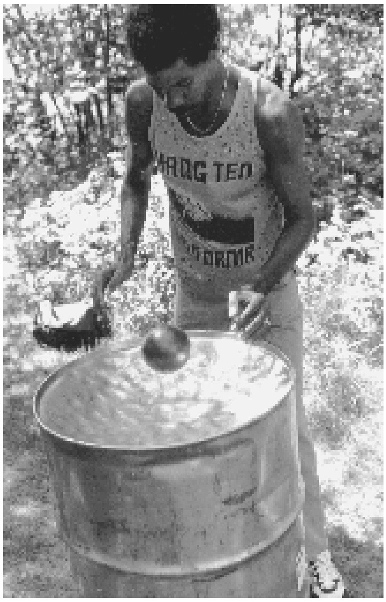


Fig. 2.5 Sinking with a shot–put.
Photograph by Linus Torell.

It is important that the surface of the sledge-hammer or the ball is very smooth, otherwise it will create impressions that later will cause small cracks in the stretched metal. For more detailed information on the sinking sledge-hammer and the shot-put, see appendix B.

The first strokes should be placed near the outer circle. Work around the drum along that circle. If the head of the sledge-hammer is well rounded and you keep it perpendicular to the surface when you hit, you may use all your strength at this point. Using a shot-put, its weight alone will supply enough force, you just have to lift it and let it fall.

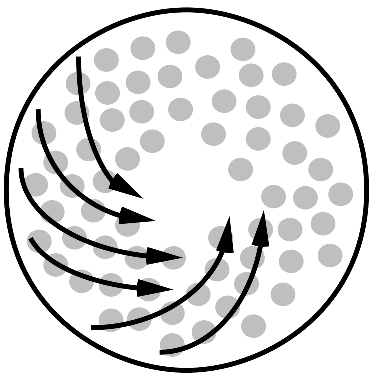


Fig. 2.6 Sinking method.

After the first circular work-around you start to place the strokes closer to the centre, thus working towards the middle in a spiral-

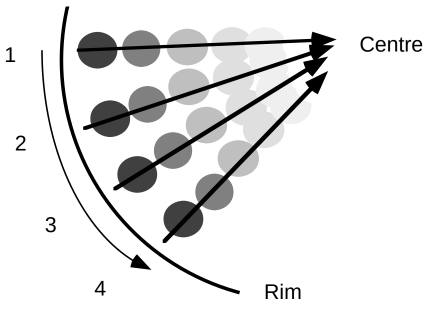


Fig. 2.7 Working from rim towards centre.

like manner, see fig. 2.6.

During the sinking, the drum should be standing on a flat, semi-soft surface, like a carpet or directly on the ground if you are outdoors. This will make it easier to keep the drum in a fixed position while you are hitting. It might also be beneficial to have someone to hold the drum to prevent it from jumping around.

When you are working near the edge it is usually better to use one hand for hitting and the other one to support the drum. But keep the thumb of the supporting hand on the outside to prevent yourself from hitting it with the ball or the sledge-hammer. Best is to place the supporting hand a bit away from the hitting point. Protective gloves (and something to shield your ears from the noise) are also recommended.

After the first spiral movement towards the centre you start again, this time further out, a bit closer to the rim. Now work the metal by, so to speak, "driving it from the rim". This means that you first hit the surface hard near the rim, then move towards the centre, hitting a bit softer each time, see fig. 2.7. This working pattern is repeated time after time, while moving slowly round the drum.

It is more important to have a good feeling for how the surface is shaping, than it is to work systematically. There should not be any large fluctuations anywhere – if an "edge" is coming up in the metal, lower it right away. Keep your eye on the concentrical circles – the best way to control the sinking is to move slowly backwards while you are working. In this way you can see the formerly sunk surface to keep the newly sunk levelled with it. It is also beneficial to rotate the drum now and then to prevent the light and the shade from fooling you to make a non-symmetric sink.

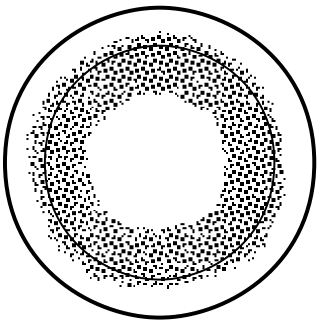


Fig. 2.8 Region where most of the effort in sinking should be concentrated.

To be able to shape an evenly curved sink, it is important to keep the middle part level (like the bottom of a bowl) with the rest of the surface. Do not hit too much in the middle, though, because the metal will easily get too stretched there. A couple of strokes when it is beginning to come up as a dent and starts to emit a resonant sound (like the one from a big note) is usually enough to keep it down.

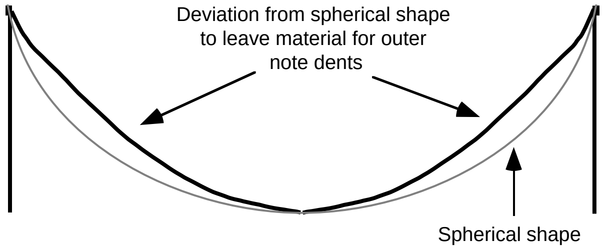


Fig. 2.9 Cross-section of drum after sinking. Note the deviation from spherical concave shape near to the rim.

Keep working around the drum according to the above pattern, inwards from the rim, thus shaping the surface to a smooth bowl. Most of the effort in sinking should be concentrated to the region between 1/3 and 2/3 of the radius of the drum. This is where the inner end of the outer notes will be later on, see fig. 2.8 for an overview.

After the sinking the basin in the bottom should have a straight or slightly convex part near the rim. This part is later going to form the outer note dents. Its shape and height should be different for different pans – longer and more convex the larger the notes are going to be. It is important that the shape of this part is right, otherwise the notes will not rise properly when the backing is done. As a rule of thumb, the shape of the basin should be almost as if it was a pan with a continuous ring of outer notes, without any groove indentions between them. This means that the height of the deviation from the spherical should be about the same as the height of the future note dents.

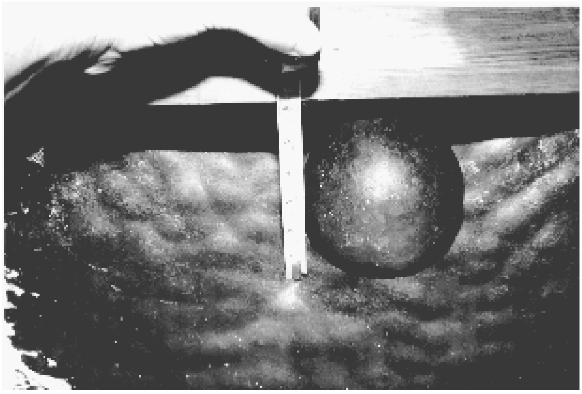


Fig. 2.10 Measure the depth at even intervals. Figure shows a double second at the depth of six inches.

If you are a beginner in pan making you will probably have to read the sections about backing, grooving, levelling and tuning to understand the intent of this shaping. In fig. 2.9, a cross-section of a sunk drum is shown. Moulds for the overall shape of the different pans and their sinking depths are given in appendix A.

When you are beginning to reach the final depth you should check

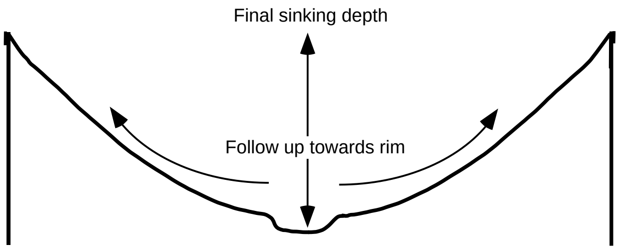


Fig. 2.11 A trick for the last sinking. Hit down the surface in the middle to the right depth and follow this up towards the rim. Not recommended for beginners.

the depth at even intervals, see fig. 2.10.

A fast (and somewhat risky) method to do the last sinking is to lower the drum to the appropriate depth in the centre and then "follow it up" on the rest of the surface, see fig. 2.11 for an explanation.

HANDLING OF HOLES

If the surface bursts during the sinking you have to decide how to handle the situation. The holes can be divided into two main types; small unevenly shaped holes and longer cracks.

The first type of hole is caused by defects such as rust or harder parts of the metal where the carbon content is higher. These holes are usually no problem if they are not close enough to grow into a big crack. Try later to position the notes between them. If that is not possible, consider the possibility to weld the holes before continuing. If there are more than five holes you have probably chosen a bad drum. The best thing might be to discard the drum and start on a new one. I have, though, seen working (but not good-looking) pans with small holes in the note areas, so it might still be worth a try.

The second type of hole, the cracks, is either caused by text grooved in the metal or by too much stretching of the metal in certain regions, or a combination of these. They will show up as small slits and grow as you sink and stretch the surface further. If they show up before you have reached 70-80% of the final sinking depth there is a risk that they may grow up to a length of 5 cm or more, making the drum unusable. The cause of the crack can be one of several; the drum is bad, the sledge-hammer is not smooth, or you are doing the sinking in an incorrect way. Your best choice might be to stop here and start on a new drum.

If there are no more than two or three cracks in the middle, try to place the inner notes between them. At a later stage, welding of the cracks might be considered. If a crack is starting to grow you might decide to stop the sinking at a depth 2–3 cm less than the recommended, and place the notes closer to each other. This might be preferred rather than spoiling the whole drum.

Welding can be done either with gas or by electrical methods. The weld should be made as neat as possible and a smoothing of it may be necessary before continuing. Welds in the drum surface should preferably be placed between notes or inside note sections, but not on a groove, because of the risk of cracking when the grooving is done later. Presumably, there are also acoustical implications of disturbing the isolating effect of the groove. Welds in the note area of small notes can be quite disastrous for the sound, but in larger notes they do not seem to influence the sound particularly.

SHAPING

The shaping is the part of the sinking in which the drum basin is adjusted to its final shape. When you reach 90% of the final depth it is time to change tool to the backing sledge hammer, which is roughly the same as the sinking sledge hammer, see fig. 2.12. It has a shorter handle and is held in one hand for more control, see the specification in appendix B.

Now the marked circles are probably gone together with most of the paint in the middle of the bottom. If so, mark the centre in the same way as before and re-draw the two concentrical circles before continuing with the next step.

Fig. 2.12 Shaping the sunk surface with the backing hammer.

Now you start hitting softly, thereby adjusting the shape and smoothing the rather uneven surface at the same time. The only direction the surface can be adjusted is downwards, so it will keep on sinking while you are shaping. Measure the depth at even intervals.

If the surface on one side of the basin is coming up while you are hitting on the opposite side, you are either hitting too hard, or the metal is too thin. Try hitting more softly. If this doesn't help, there is a risk that you eventually will have to discard the drum.

The best method for doing the shaping is still by working the metal ”towards the centre”, i.e., first hitting near the rim and then going inwards in the same way as described for sinking. When 100% of sinking depth is reached the surface should be smooth and evenly shaped.

SMOOTHING

It is important that the surface of the drum is smooth. Any unevenness in the metal will affect the overtones and make the tuning harder. If the surface still is rough when the shaping is finished, this is the best time to even out the part of the surface that later will become the note areas. During the rest of the crafting they will be left as unaffected as possible, until it is time for the tuning.

Fig. 2.13 Smoothing the sink with the backing hammer.

The smoothing is done by hitting down the surface in places where it is dented upwards. The tool used for smoothing is usually the backing hammer, see fig. 2.13. Use good light to see the reflections in the metal; working outdoors is the best. Avoid hitting the surface in places where it is dented inwards, work around them instead. As the metal is thicker near the rim you will notice that you have to hit much harder to remove the roughness there.

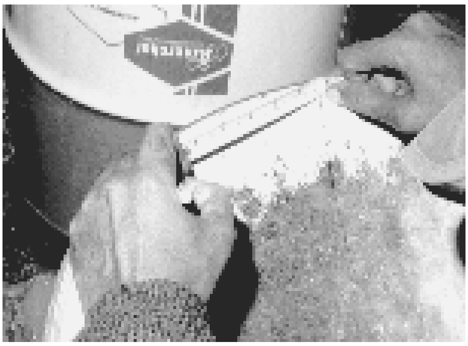


Fig. 3.1 The length of the outer notes along the rim is measured with a ruler. Here the tuner uses a straight ruler. If measures in appendix A are to be used, the ruler should be curved along the rim.

While you are examining the surface for unevennesses, try to locate spots of potential trouble. Examples of such are; sharp indentions caused by remainders from welding or lumps in the painting and corrosion (rust) that seems to be going deep into the metal. Mark those places and try to avoid them when you are positioning the notes later. The most hazardous thing to do is to make a groove across such a spot. The weak metal could easily burst when it is hit with the sharp metal punch.

A skilled panmaker often omits this extra smoothing step because he has smoothed the surface enough during the shaping. If there is any roughness left, he smooths the surface later with the backing hammer at the same time as he is doing the backing.

3. Marking of notes

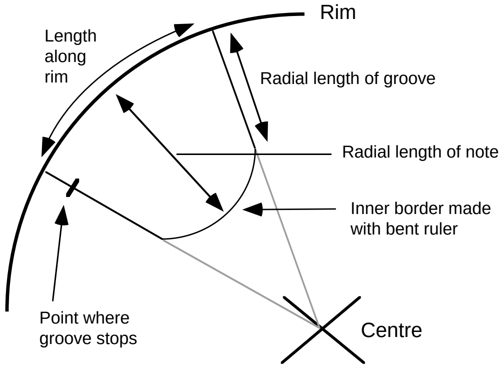


Fig. 3.2 Details of an outer note.

Marking is the process in which the bottom basin is divided into the sections that later will form the different notes. The tuner usually does the marking by copying measures for the outer notes from previously made pans and by using templates for the inner notes. The marking can be quite tricky, especially if you have holes to watch out for.

MARKING OUTER NOTES

Once again, begin by locating the centre of the bottom in the same way as shown in fig. 2.2. The next step is to mark the length of the outer notes along the rim, see fig. 3.1. Measures and positions of notes for different pans are given in appendix A. Details are explained in fig. 3.2. Lengths of outer notes in appendix A are measured along the rim, not with a straight ruler.

Fig. 3.3 Drawing the radial lines of the outer notes. Note the centre marking.

When arranging the layout, the side welds on the drums are usually positioned to face the player, i.e., in the middle between the two marked positions of the hanging strings in the layout diagrams in appendix A. This is done purely for aesthetic reasons, so if you have problems avoiding holes when positioning the notes, feel free to twist the drum.

When you have worked around the drum, you will probably find that the last mark does not match the first one. If the discrepancy just is a question of millimetres, go backwards and adjust the note positions slightly. If it is more than that, redo it. A ribbon marked with the note lengths and pasted to the rim may be a good tool for the marking of the outer notes.

Fig. 3.4 Marking the length of the radial groove of the outer notes.

Fig. 3.5 Marking the curved inner border of an outer note with a bent ruler. *Photograph by Linus Torell.*

If you are making a double tenor or a quadrophonic pan in Trinidad style, remember to leave some space (about 1 cm) between the note marks.

The next step is to draw lines from the marks on the rim towards the centre marking, see fig. 3.3. Here a flexible ruler is needed, but a hacksaw blade can serve as a good substitute. Draw lines from the rim down towards the centre and make a mark where the radial groove is to stop, 13–20 cm down, see fig. 3.4. Exact measures are given in appendix A.

After all the radial lines of the outer notes have been drawn, their inner borders are marked. To make a smooth inner ending of the note region, bend a ruler so that it extends 2–6 cm inwards from the end marks on the radial lines. To do this, two persons are needed, one holding the bent ruler in a smooth curve with two hands, and one drawing the line, see fig. 3.5. See appendix A for measures on the total radial length of the outer notes.

Fig. 3.6 Spread out the templates of all the inner notes to check space and positioning before marking.

MARKING INNER NOTES

The inner notes are usually marked with templates. Shapes and measures for the templates are given in appendix A. Use the patterns in appendix A to make templates by making as many copies of the page as there are notes. Then cut out the shape of a specific note from each copy with a pair of scissors and paste it on to some sturdy material, such as linoleum. Last, cut the stiff template to its right shape with a knife.

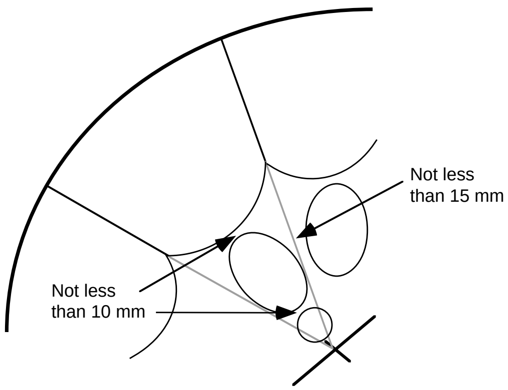


Fig. 3.7 Position of inner notes.

Fig. 3.8 Marking the four notes in the centre of a tenor.

Begin the layout work by spreading out the templates for the inner notes in their positions before you do any marking, see fig. 3.6. This makes it possible to adjust the positions to utilise the precious space in an optimal way.

The elliptical notes are usually oriented with their length axis pointing towards the centre, see fig. 3.7. Always place an inner note as close to its lower octave counterpart as possible (but not closer than 1 cm). In this way it will be easier to find the octave intervals while playing and they will be able to vibrate together. The distance sideways between adjacent notes should be as large as possible, preferably not less than 1.5 cm anywhere. If you have problems with space, the pan is probably not sunk enough.

Fig. 4.1 Backing.

4. Backing

Backing is the procedure in which the notes are given their arched, convex shape. This is not done by raising the note areas, but by lowering the surface between them. When the backing is finished the note areas should curve outwards, while the rest of the drum surface should be concave. For an explanation of the usage of the terms *convex* and *concave*, see appendix E.

The main reason for doing the backing is presumably to form note dents with a proper arch and internal tensions that later are to be conserved by the grooving. Another reason for doing some of the shaping before the grooving is that the grooves would presumably burst if all this stretching of the metal was done after the grooving.

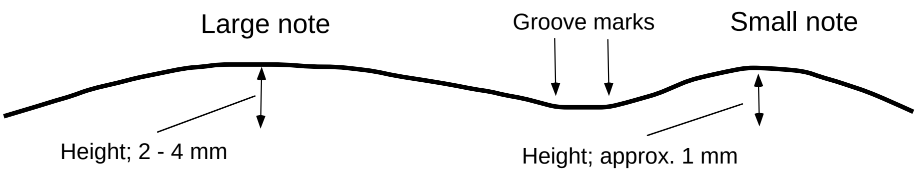


Fig. 4.2 Cross-section of backing result. Heights of dents are exaggerated.

The backing is done with the backing hammer, see fig. 4.1 and appendix B. The size of the head of the hammer makes it impossible to work only between the notes, you have to hit a bit up on the notes, too. This is actually the right thing to do, as the result is meant to be dents with a smooth arch beginning at the groove mark, see fig. 4.2.

During the backing you may notice that the surface tends to move dynamically; when it is hit in one place it comes up elsewhere. The goal in backing is to get the metal down everywhere except in the note areas. A skilled panmaker knows exactly how hard to hit to put the surface at the right level without making it come up elsewhere. He also smooths the surface and adjusts the arch of the notes with gentle strokes while he is doing the backing.

The result of the backing should be smooth note dents that are ”relaxed”, which means that they are able to vibrate more freely than the rest of the surface.

BACKING OUTER NOTES

The outer notes are first backed by hitting on the radial lines going from the rim towards the centre. Begin at the rim and work down at each side of the note, one at a time.

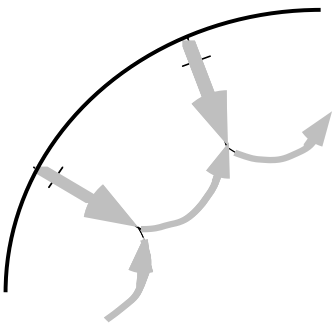


Fig. 4.3 Sequence for the backing of outer notes.

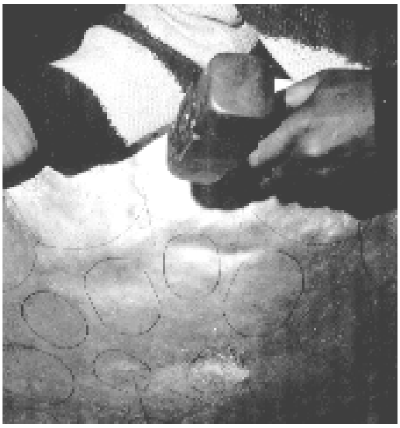


Fig. 4.4 Backing the inner end of an outer note.

You may have to hit quite hard to get the note surface to raise in the right way, especially on tenors. The backing should extend about 2–3 cm in on the note surface, inside the groove mark. After the two radial lines of a note have been backed, its inner border is backed, see fig. 4.3. Here the backing is often done fully on the inside of the marking, i.e., 3–5 cm up on the note, see fig. 4.4.

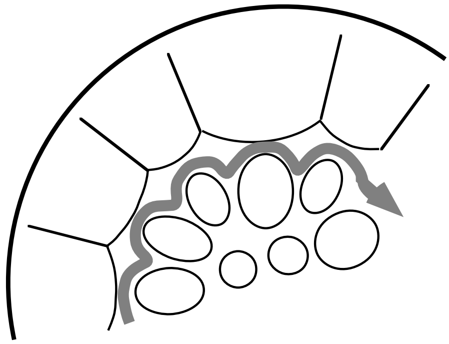


Fig. 4.5 Going round the drum while backing between inner and outer notes.

Fig. 4.6 Backing between inner and outer notes.

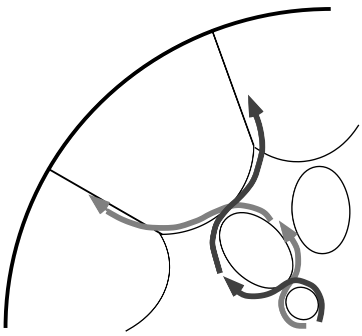


Fig. 4.7 Backing between inner notes.

Lower the borders between the outer notes in this way all around the drum. Watch the height of the dents closely to get them level with each other. If necessary, adjust the arch of the dents by hitting upon them with a couple of soft strokes. The height of the outer notes for a double tenor or a tenor pan should be about 1-2 mm at this stage. Most of the surface inside the marks for grooving should be convex after the backing, but some parts near the rim may still be concave.

BACKING OF INNER NOTES

After the backing of the outer notes, the inner notes are to be treated in the same way. The surface between the notes and the border marks is hit to make the inner note dents raise.

First, work round the pan in the small area between the inner and the outer notes, see fig. 4.5. In practice, this can be seen as an extension of the backing of the outer notes, you just work a bit further in. This will continue to raise the outer notes as well as parts of the inner ones. After the first round, work around the pan a second time and back a bit further down between the inner notes, see fig. 4.6.

Second, hit the surface between the inner notes, working from the centre towards the outer notes, see fig. 4.7. Keep your eye on the rest of the surface all the time, because when you hit in one place it will raise at other places. Try to keep those places down at the same time.

The backing has to be done in a circular manner, because while you are working at one side of the pan, the other side will be affected by stretching forces so that the surface there is raised.

When the backing of the inner notes is done, you may have to go back and adjust the inner borders of the outer notes, as they may have been affected by the backing of the inner notes.

Last, the different notes are adjusted until they are level with each other. If necessary, the overall shape is adjusted again. At this stage you should begin to hear sounds from the notes. If the backing is correctly done, no sound should be heard from the surface between the notes.

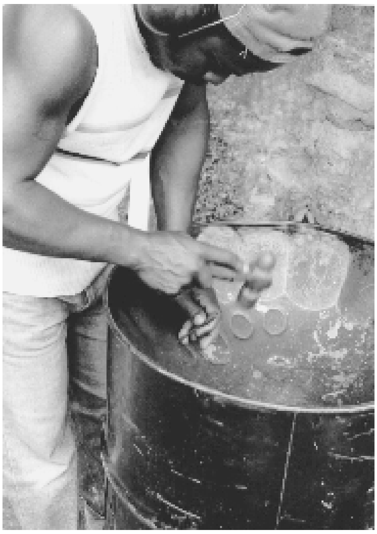


Fig. 5.1 Grooving.

5. Grooving

The grooving is the process in which the note-areas are acoustically separated from each other and the rest of the surface. This is done by hitting the surface with a steel punch along the note borders, making a continuous line of punch-marks in the surface.

The purpose of the grooving is to confine the vibrations that produce the sound of each note to their own sector of the drum surface. The mechanical function of the groove is presumably to loosen up the metal and make a loose "joint". This separates the physical conditions in the note area from the surrounding surface so that the note will be able to vibrate freely. When the crafting is done the note will be a strained buckle of softer metal, while the surrounding metal will be tempered and stiff. A practical function of the groove is also to define the working area for the later tuning.

There is a special model of pans where the groove is complemented with a line of bore-holes. This makes the "groove joint" more flexible and acoustically it seems to work even better than an ordinary groove. See the section about developments for more on this "bore pan".

The tools used for grooving are a shortened nail-punch and a grooving hammer, see appendix B. The head of the punch should have a diameter of 4–7 mm. Some tuners use punches of different size for

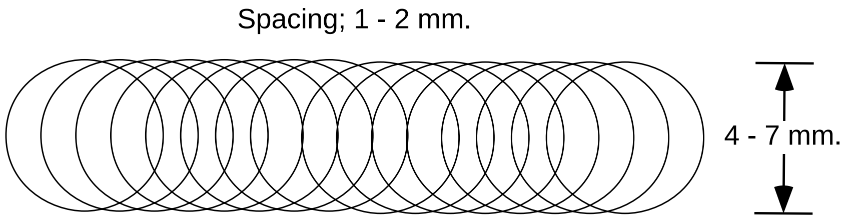


Fig. 5.2 Spacing and width of groove marks.

different notes in the same pan. The edge of the head have to be fairly sharp to make distinct marks in the metal. It is important that the punch has a comfortable length (10 cm is proposed) to enable good control. A longer punch would be hard to control.

The grooving hammer should be a hammer that you are well acquainted with – you must know exactly how hard you are hitting. It is also important that the head is tightly fastened to the handle to get high precision in the hammering. The weight of the hammer should be approximately 0.5 kg.

It is difficult to know how hard to hit while grooving. The indication of a proper grooving is that it leaves a score in the metal that is clearly visible during the rest of the crafting and on the finished pan, without breaking the metal. It should be visible on both the playing side and the backside of the pan, but not more than that. This is because the groove mark is going to define the working area for the latter tuning.

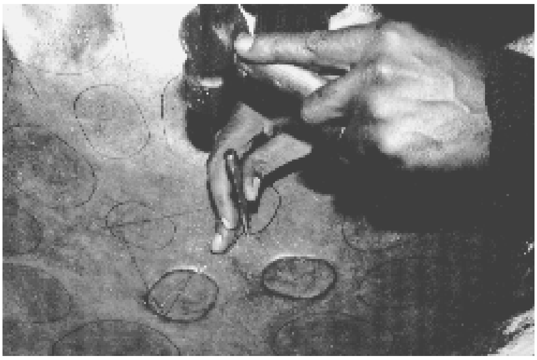


Fig. 5.3 The grooving usually begins with the innermost notes.

It is better to groove a bit too light than too hard, because even if you don't go through the surface right away, the groove might burst at a later stage when the metal is stretched by the levelling. A groove that is too hard will also make the surface unnecessarily rough, resulting in a need for extra levelling work. Exactly what happens if the groove is too soft is still unclear to me, possibly the pan will be hard to tune because of interference between notes.

If you want to practice grooving before starting off, it might be useful to try on the unused top of the drum. But bear in mind that the un-stretched metal in the top is about 30% thicker and harder than the metal in the middle of the sunk bottom of the pan. This means that it can withstand harder grooving than the playing surface.

Fig. 5.2 shows what the groove should look like, when properly done. The width of the groove can vary from 4 to 7 mm. The spacing of the marks is ideally 1 to 2 mm, but can be more as long as the marks still are overlapping. If the punch jumps more than 4 mm between two successive strokes, go back and groove the place over again.

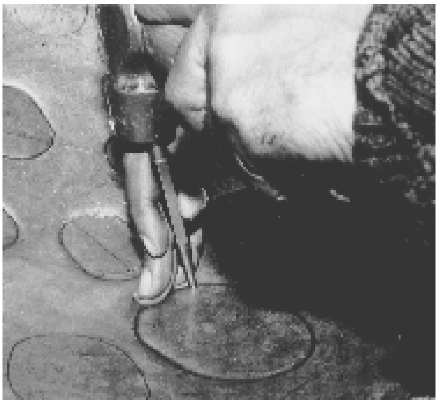


Fig. 5.4 Detail of the grooving of an inner note.

GROOVING OF INNER NOTES

The grooving usually begins with the inner notes, see fig. 5.3. If the surface still seems rough, the region along the lines has to be smoothed before grooving. An uneven surface will make it hard to control the punch, resulting in a winding groove. Such a crooked groove will make it harder (or, at worst, impossible) to tune the note. So, if necessary, start the grooving of each note by using the smoothing hammer to even out the region along the lines. You can check that the surface is even by feeling it with your finger. It is also important that you see the note border lines well, so if they are diffuse after the backing, fill them in again before grooving.

The best place to start grooving on a note is where the line is straight; this will make it easier to make both ends meet when you have grooved around the note, see fig. 5.4. Put the punch on the line, start hitting it about 3-4 times a second, and move it forward with a constant speed while hitting. The speed should be adjusted so that marks are made with 1 mm spacing. The grooving should leave sharp

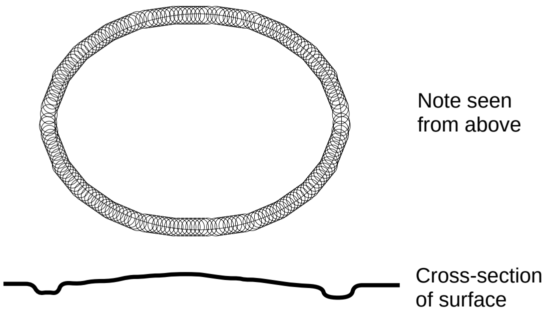


Fig. 5.5 Overview and cross-section of a grooved inner note.

marks in the metal resulting in a continuous canal, about 1/2–1 mm deep, see fig. 5.5 to get an idea of the right result. The drum should be standing steady on the ground to enable good control over the punch, because it will jump back slightly each time you hit it.

Groove all the inner notes in the same way. The grooving of a note will affect the surface of adjacent notes, so remember to smooth the metal along the marking of each note just before grooving.

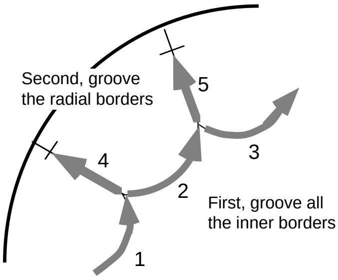


Fig. 5.6 Grooving order for outer notes.

GROOVING OF OUTER NOTES

The grooving of the outer notes is usually done by grooving the innermost borders of all the outer notes first. After this all the radial lines are grooved. See fig. 5.6 for an explanation of the grooving sequence.

The grooving of the inner notes has reshaped the surface and lifted the inner border of the outer notes a bit. So, before grooving, make a round with the backing hammer and put the surface back in its right place again, see fig. 5.7. If necessary, also smooth the metal at the marking of each note with the smoothing hammer before grooving.

Begin grooving at the joint between the straight radial line and the inner curve. Work from one side to the other, see fig. 5.8. Work around all the outer notes in this way.

When the inner borders of the outer notes are grooved, the metal sinks down about 1 mm. It can be hard to make a smooth connection between the groove that is to go up towards the rim and the existing

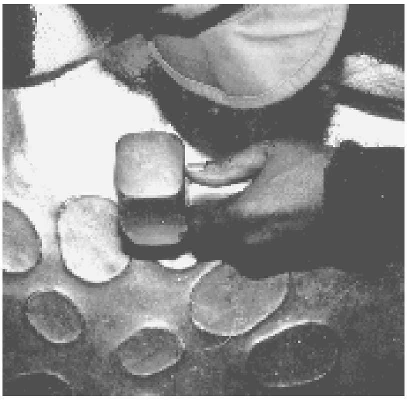


Fig. 5.7 Levelling of inner border before grooving outer notes.

Fig. 5.8 Grooving the inner border of an outer note.

groove if the surfaces are not level with each other. So, before going further, the radial lines may be levelled with the backing hammer. Work around the pan hitting at the inner end of the radial lines to get them level with the existing inner grooves, see fig. 5.9.

The radial lines of the outer notes are grooved from their inner end towards the rim. But they do not go all the way up to the rim. Use the ruler to make marks about 5 cm from the rim on all the radial lines before starting off.

Groove the lines from the point where the radial line meets the inner groove and upwards against the rim, but stop when you reach the mark, 5 cm from the rim. As you are getting closer to the rim, you have to hit harder because of the thicker metal. At the 5 cm mark, hit last hard stroke to mark the end. Work around the whole pan in this way, and the grooving is done.

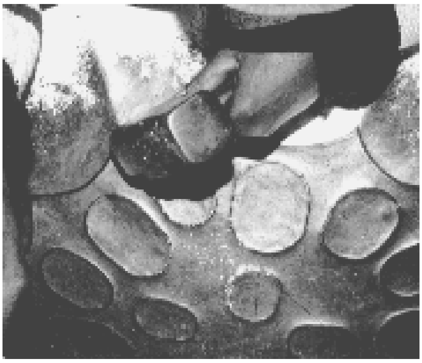


Fig. 5.9 Levelling of the radial border of outer notes before grooving.

6. Levelling

During the levelling the playing surface of the pan is formed to its final shape. The levelling is done with the backing hammer and is quite similar to the backing. During levelling, each octave pair of outer-inner notes goes through four steps that are interlinked with each other:

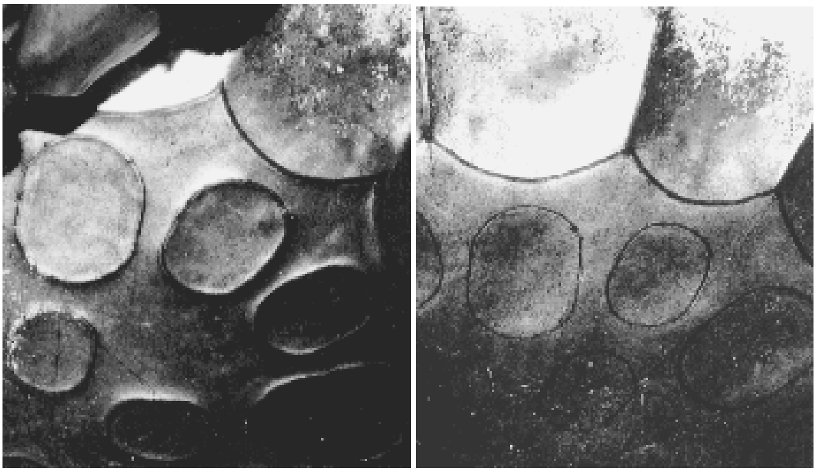


Fig. 6.1 Levelling. Left part of picture showing how the pan looks after the grooving and right part the result after the levelling.

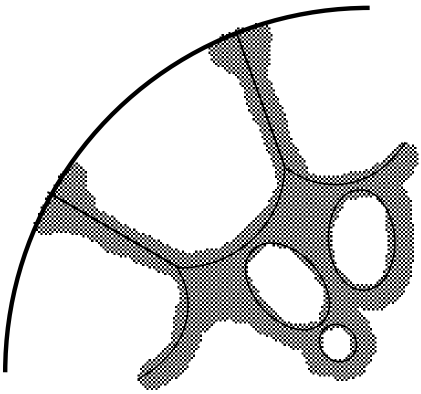


Fig. 6.2 Regions for "taking out the fat".

taking out the fat, flattening the grooves, final shaping, and adjusting the notes to be level with each other. The last step of the levelling is to smooth the surface of the whole pan.

The purpose of the levelling is to put the surface back to the shape it had before the grooving, see fig. 6.1. The levelling can be seen as a continuation of the backing, but it brings the drum further towards a properly shaped steel pan.

Shaping is an important part of the levelling. During the shaping the surface of the notes is formed to soft bulges and the surface between the notes is formed to an evenly curved basin.

"TAKING OUT THE FAT"- FLATTEN THE GROOVES

The grooving has made the surface of the pan look somewhat "swollen", kept down only at the grooves, see the cross-section in fig. 5.5. Now the surface between the notes has to be formed to a smooth concave shape again, leaving the notes standing up as smooth convex dents. This procedure is called "taking out the fat".

Begin working on a note pair, preferably the pair with the largest inner note. Hit the surface near the border of the inner note until it gets down level with the groove. When the surface between the grooves surrounding the inner note is flat, it is time to do the same around the corresponding outer note. Begin hitting down the "fat", first between the grooves of the inner and the outer note, and then gradually work further up between the outer notes. If the outer notes are separated by one groove only, the groove is flattened by hitting right on it and a bit up on each note, see fig 6.2.

When the surface between the notes is smooth, it is time to adjust the grooves down to the level of the surface between them. This is done by hitting a bit up on the note. This lowers the groove and makes it flat. The result of this procedure should be almost invisible grooves, seen only as marks in the metal. This is the critical point where the metal will burst if you have grooved too hard. Work around the pan at least once, adjusting all the grooves to be level with the smooth transition from the convex shape of the note areas and the concave shape between them.

SHAPING OF NOTES

When all the grooves are flat, you start to adjust the shape and height of the inner notes. Hit a bit further up on each note (about 2–3 cm) to shape it to a smooth swelling. Now the note is formed to its final shape and it is important that the result is a smooth surface without sharp indentions or unintended buckles. Small buckles have acoustic resonances that may affect the harmonics in an unfavourable way, thus making the pan difficult to tune. On the larger notes it is extra important to check that the arch is smooth and the dent curve extends over the whole note.

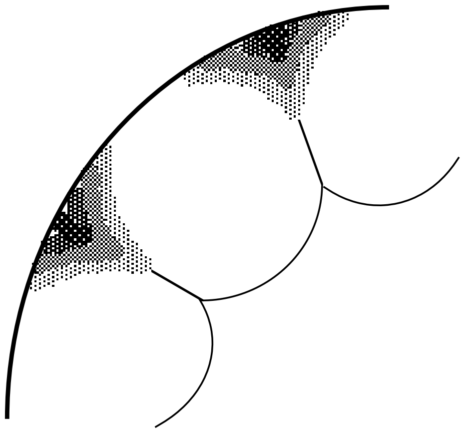


Fig. 6.3 Shaping of outer notes. The lower a part is sunk, the darker it is marked.

After the backing and the grooving, the outer notes will have sharp ”edges” at the rim. The notes look somewhat like a triangle with the top cut-off, pointing at the centre. But the actual sounding note dents in a steel pan all have an elliptical shape, no matter what shapes the note borders have. For an explanation, see the chapter about note shape in the theory section. This means that the outer notes have to be reshaped to something more elliptical.

Fig. 6.4 Shaping an outer note. Note the line defining the working area.

This is done by sinking the part in the small area between the place where the radial groove stops and the rim. Begin by marking the parts that are going to be lowered, see fig. 6.3. Then use the backing hammer to make a smooth curve, ending off the dents softly against the rim, see fig 6.4. The surface should be lowered down to the level of the radial groove.

Work round the pan, shaping one note pair at a time, until the surface between the notes is down level with the grooves everywhere.

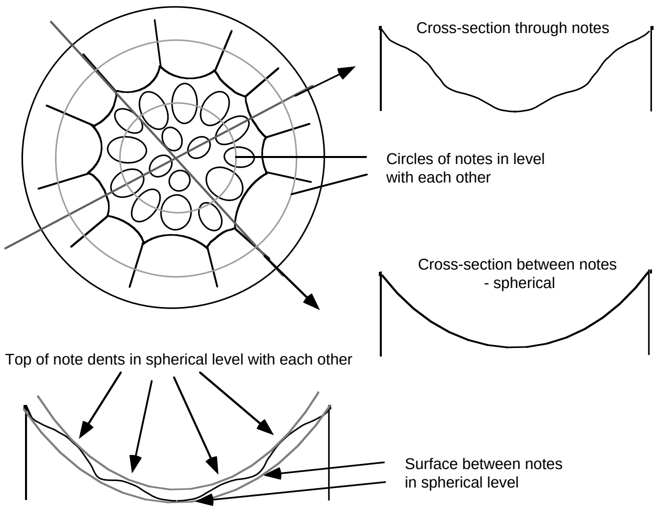


Fig. 6.5 Levelling result. Cross-section and overview.

A skilled panmaker often does this work in one round, because of the precision in his strokes. If the surface is moving at one place when you are hitting in another, you have to work several rounds to get it right. The reasons for this can be one of two:
1 – You are hitting too hard – try hitting looser and adjust the strength in your strokes according to how the surface is reacting. 2 – The surface is too thin or too much worked on – nothing you can do. You have to accept it or (at worst) start working on a new drum.

FINAL LEVELLING

The actual levelling is done in the same way as the shaping, but now more emphasis is put on the relative position of the notes. If the shaping is well done, the final levelling is just a minor adjustment.

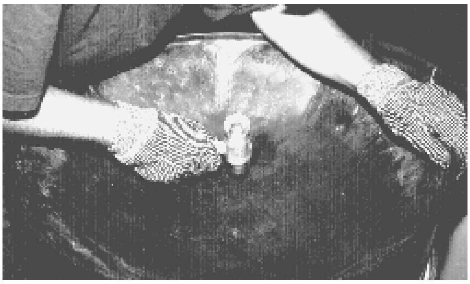


Fig. 6.6 Final smoothing with plastic-headed hammer.

Start the levelling on an outer note and work your way down to the corresponding inner note while checking that the top of each note dent is level with adjacent notes. Work around the pan octave-pair wise, adjusting the notes in the same octave to be level with each other; see circles in fig. 6.5.

This is also your last chance to

mould the overall shape of the pan. Hereafter the surface will be fairly fixed. Hit the surface between the notes softly with the backing hammer. Try to get the surface level everywhere, making an even elliptical curve, except for where the notes are, see fig. 6.5.

The result of the final levelling is very important, because the border of each note has to have a certain curvature in order to get the right geometry to produce overtones that can be tuned to harmonics. See the theory section for more about overtones.

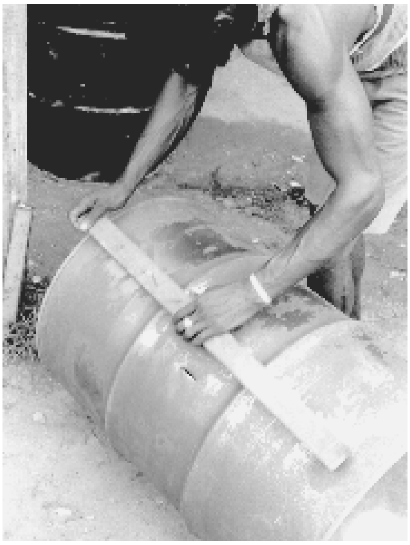


Fig. 7.1 Marking the drum for cutting.

SMOOTHING

The last thing to do before cutting and burning the pan is to smooth it again, if necessary. Work all over the surface between the notes, hitting it softly with the smoothing hammer, examining the surface all the time, see fig. 6.6. The importance of smoothness of the surface at this stage can not be emphasized enough. The smoother the surface, the easier the pan will be to tune and the better it will sound.

Fig. 7.2 Cutting the drum with a cutlass.

7. Cutting the drum

Before the drum is tempered, it should be cut to its proper pan length. The lower the pan is to be tuned, the longer the side of the drum should be. This is to give more resonance to the sound of the lower tuned pans. For common lengths of the different pans, see appendix A.

Before cutting, the side of the drum needs to be marked at the right length. The usual way to do this is to use a wooden stick with two nails driven into it at appropriate distance. While the drum laying sideways on the ground, the stick is pulled around it with one nail resting against the rim. Then the nail at the other end will make a scratch in the paint of the drum, see fig 7.1.

Fig. 8.1 Tempering.

The drum is cut at the mark in the following way: First, hammer on a chisel or an old screw-driver to make a starting hole in the side of the drum. Then use an electrical jigsaw to cut the drum. On Trinidad, this is often done with a cutlass, a cut-off machete, see fig. 7.2. The cutlass is hammered through the metal along the scratch, making a rough cut that later is trimmed with a pair of plate-shears. Last, a file is used to smooth the cut end of the skirt.

8. Tempering

The hammering during the sinking and the backing has made the surface of the pan stretched and soft. The grooving and the backing has also forced local tensions into the metal. Before tuning, the pan has to be hardened and the tensions have to be removed. This is done by first heating the metal and then cooling it. The whole process is called tempering.

The most important effect of the tempering is presumably to remove the local tensions. Uneven tensions in the metal of the notes would presumably make it impossible to tune the pan. As heat is applied, the molecules will be able move and the crystals of the metal will shift positions and rearrange according to the new conditions in the metal. The result will be notes with a homogeneous tension over their whole surface.

A second purpose of the tempering is to harden the surface between the notes and make it stiff, while the metal in the notes areas will be a bit softer, as it later is softened during the tuning. This will make the notes act as fairly independent resonators for the different tones.

There seems to be three different physical processes working during the tempering:

1. Removal of tensions – an *anneal* – by reconstruction of the crystal structure in the metal.
2. *Oxidation* of some of the carbon content of the metal (this is probably why it turns blue) makes the metal more tenacious.
3. *Hardening* by ”freezing” the new crystal structure while cooling.

While the hardening makes the material more stiff, the oxidation seems to make it more stretchable. The amount of heating has to be balanced between these two processes. If the pan is heated too much the metal will become too relaxed – the tuners call it ”slack” – and the pan will be impossible to tune. If, on the other hand, it is heated too little, it will not be hardened enough. See the theory section for a more thorough discussion of the function of the tempering.

The tempering is done by putting the pan upside down on a big fire for a while and then pulling it of and cooling it, either by letting it cool by itself or by the means of putting cold water or oil in it.

On Trinidad, the pan is usually heated over a burning car tyre. The

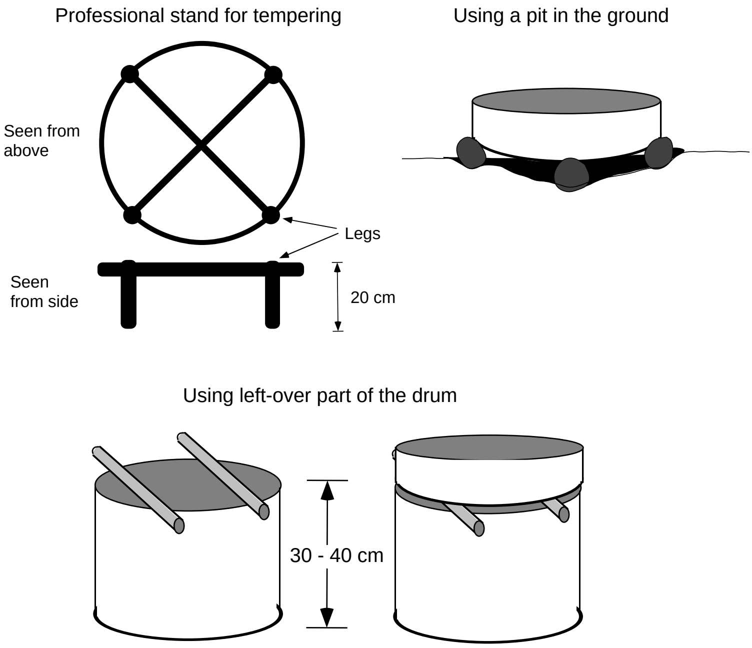


Fig. 8.2 Alternative methods to support the pan over the fire are to use a stand, a pit or the leftover part of the drum.

tyre will burn for about 10 minutes, but 1.5–2 minutes of the excessive heat is often enough for the tempering. If you are afraid that your neighbours or the fire brigade will be alarmed by the large amount of black smoke from the burning tyre, it also works with a large log fire, but the heating will take some more time, about 10 minutes.

Professional panmakers use a special stand to put the drum on while heating it over the burning tyre, see figures 8.1 and 8.2. The legs of the stand are about 15–20 cm long. The stand is often complemented by some shield against the wind to keep the fire burning steady. If you don't have a stand, resting the pan on some rocks works. To do this, dig a pit in the ground with about the same diameter as the pan and put four rocks, about 10 cm high, around it, see fig. 8.2. A third method to make a fireplace is to use the leftover part of the drum to make the fire in, see fig. 8.3. Cut the drum to a length of approximately 30–40 cm.

Light the fire and wait until it is burning with good heat. Then put the pan upside down over it, resting on the stand or the rocks. If you are using the leftover part of the drum as fireplace, you have to put some long logs across the drum to prevent the fire from getting smothered by the pan on top, see fig. 8.3. This will enable the fire to get enough oxygen.

Give the fire enough fuel to keep it burning for 10–15 minutes. Flames should appear all around the pan to make sure that it is evenly heated. If it is windy, you may have to turn the pan during the burning to prevent it from being unevenly heated.

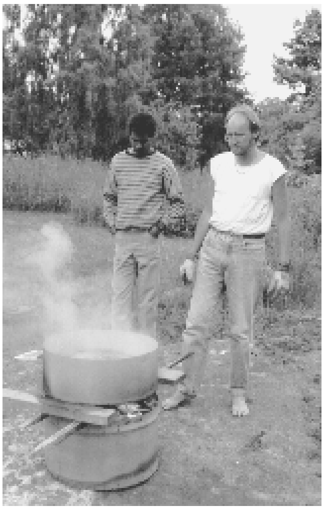


Fig. 8.3 Burning the pan, using the left-over part of the drum as a fireplace.
Photograph by Linus Torell.

The time for burning is very important, because it determines the amount of heat the pan will be exposed to. There is no exact signal for when the pan is sufficiently heated. Experienced panmakers know when the drum is burned appropriately by judging from its colour. The remaining paint on the inside should be crumbled and the rust should be turning from brown to blue-black. If the pan doesn't have any paint on the inside, you can see the metal first turning blue, then black and last greyish. The metal surface should be looking dull when the drum is enough heated.

A documentation of the appropriate temperature and heating time is still lacking. I have heard about many different methods and times: 10–15 minutes on a log fire or 1.5 min on a burning tyre.

One author claims that it takes 35 minutes to temper properly at a temperature of 350 degrees Fahrenheit (Morin, 1988).

After about 1.5 to 2 minutes over the burning tyre or 10 to 15 minutes on the log fire, the pan is pulled out of the fire and hardened by cooling. The cooling can be done either by leaving the pan by itself in the air or by pouring cold water or oil on the surface to temper and cleanse it further. The tempering put in by self-cooling of the pan in the air is often judged to be enough, but the cold liquid will make the metal in the pan even harder. The more the pan is tempered, the longer it will probably stay in tune, but the harder it will be to tune it. Nowadays, the most common tempering method seems to be by self-cooling. Drums with thin metal or drums that are judged to have been burnt too long is sometimes cooled by throwing water into them to remove the heat faster.

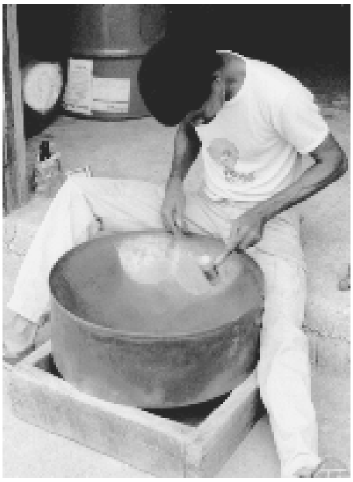


Fig. 9.1 Tuner Lawrence Mayers at work.

As the pan now is black from soot, this might be a good occasion to clean it before doing the tuning. When the pan has cooled down, put some water and soap into it and use a brush to get rid of the rust and the soot from the burned paint.

9. Tuning

The tuning of traditional musical instruments like string, brass and wind instruments is fairly straightforward; you tune the note to the right pitch and it will automatically sound right. The tuning of steel pans is much more complicated, since the pitch and the timbre – the ”colour” of the sound – have to be adjusted independently. This means that the tuner has to control both the fundamental, constituting the playing pitch, and the upper partials (harmonics), producing the timbre, while he is doing the tuning. If the upper partials are not in a harmonic relationship to the fundamental the note will sound harsh and metal-like. See the theory section for more on tone generation and a discussion of partials.

The tuning process can be seen as composed of three main steps:

1. Coarse tuning – the metal of the notes is softened and the notes are put at the right pitch before the fine tuning starts.
2. Fine tuning – adjustments of pitch and timbre while the pan is

hanging in its playing position.

3. Blending – final tuning after the surface has been finished.

TUNING TOOLS

The prime instrument for tuning is your ear; a good sensibility in pitch discrimination is needed to become a competent tuner. An electronic tuning device can be used as an aid for judging the pitch, but when it comes to harmonics, only your ears (or rather, your brain) will do the job.

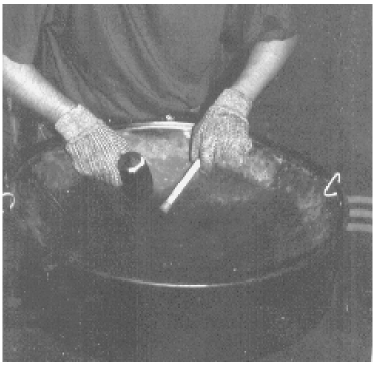


Fig. 9.2 Using hammer and stick to tune.

The tuner alternately taps the notes with a small hammer and a rubber-tipped tuning stick to hear the sound of the note during the tuning. The fundamental – the pitch of the note (the one written in the score) – can usually be heard while hitting the note with the hammer, but as you begin to focus on the upper harmonics you will need the stick.

The type of hammer that is used for the tuning depends on the size of the notes. The following recommendations can be used as a guide for your personal choice: Notes with a length more than 15 cm – a fairly heavy hammer (2 kg) with a large, rounded head. Notes 8-15 cm – a light (less than 1 kg) hammer with a plastic head (usually the same as the smoothing hammer). Notes smaller than 8 cm – an ordinary hammer with a rounded head. See appendix B for further measures on these hammers.

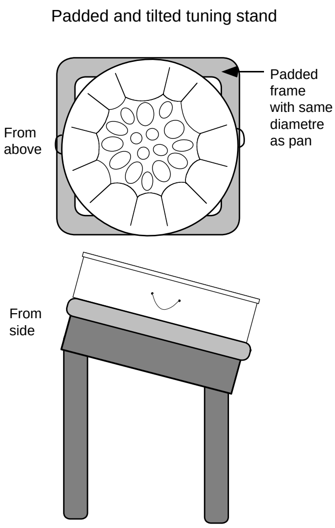


Fig. 9.3 Professional tuning stand.

The reason for using the different hammers is the following: A heavy hammer is needed to produce enough force to tune the larger notes. A hammer with a plastic head will make fewer marks in the metal on the medium sized notes. For the smallest notes a metal head is needed to get enough impact and precision in the positioning of the strokes.

The tuning stick may be a regular playing stick, but often it is better to use a stick that is a bit heavier and harder than the ordinary playing stick. The extra weight can be used to decide if the note is "stable" by hitting it hard and see if the pitch stays the same or changes. If the tuning stick is hard, i.e., has less rubber, it is easier to hear the harmonics – the partials – of the note.

The tuner holds the stick in his left hand and the hammer in his right hand and hits the note alternating with the hammer and the stick, see fig. 9.2. One stroke with the hammer is usually followed by two or three hits with the stick to hear the timbre of the sound clearly.

Fig. 9.4 Temporary tuning stand made from the left-over part of the drum and a car tyre.

The stand used to put the pan on while doing the softening and the coarse tuning has to be designed so the pan can rest on its skirt, leaving the note surface free to vibrate in the middle. This is usually accomplished by using a padded wooden box with the same side length as the diameter of the pan, see fig. 9.3. The box can be mounted on a stand so you can tune standing up, or you can put it on the ground to tune sitting down, see fig 9.1. A temporary tuning stand may also be made out of the leftover part of the drum, putting a truck tyre on top of it to rest the pan on while tuning, see fig 9.4.

It is also practical to have a tuned steel pan or another instrument at hand to "calibrate" your ear at the right pitch of the note you are tuning. A tuning device will be of less use at this stage, because it will be unable to detect the pitch of the harsh-sounding tone. Your ears are probably better at doing this.

To raise the outer notes while doing the softening before tuning, the tuner generally uses a bent iron (like a specially made crowbar), see appendix B. A new tool that is getting more common for raising the outer notes nowadays is specially shaped wooden wedges. See fig. 9.6 and section II for more about this development.

GENERAL STEPS IN TUNING

The first, coarse tuning of each note may be seen as consisting of several different steps, but they are interlinked with each other, so when you see a tuner working it can be hard to realise what he is doing.

The result of the first part of the tuning should be an independent-sounding note with a definite pitch and a steel pan-like timbre. The steps towards this are: softening of the metal, tuning of fundamental and octave tuning (adjustment of timbre).

The softening of a note and the tuning of the pitch is actually done at the same time. While the tuner softens the note he listens to the pitch and tries to get the metal adequately stretched. When the metal is soft enough and he starts to concentrate on the pitch, he also involves the third step of the tuning. This is where he listens to the timbre of the note and adjusts the octave at the same time as he is positioning the pitch. This continuous flow of work is good to keep in mind while reading the step-wise description of the tuning below.

As a rule of thumb, the tuning of a pan should start with the process that affects the metal the most and has the greatest impact on the sound. You then successively move towards finer adjustments. The reason for this is that the stretching of the metal during the tuning will affect surrounding notes as well as the one you are working on. There is no sense in doing fine tuning on one note if you are going to soften and coarse tune the note next to it later.

If a note seems impossible to tune, leave it at the closest pitch you can get and go back to it when you have worked around the pan. The tensions in the metal might be in a more favourable condition then. As you will get tired listening to the banging and concentrating on the pitch, a pause is also recommended when things seem to get impossible.

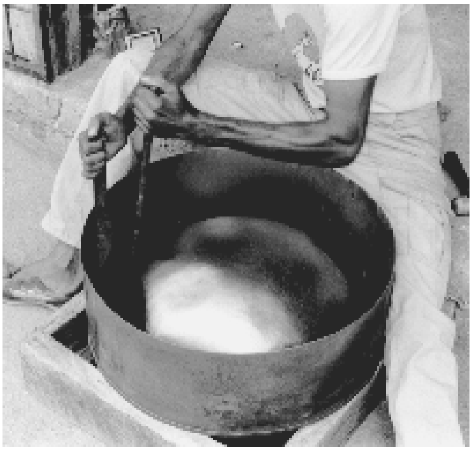


Fig. 9.5 Raising an outer note with a "crowbar" iron. Note the cutlass blade held against the side of the drum as protection.

Sometimes during the tuning, the tuner may decide to listen to another note to "calibrate" his ear. This other note can be either a note with the same pitch in an already tuned pan or a tuned note in another octave of the pan to be tuned.

As the stretching of the metal when tuning one note is affecting the already tuned ones, the tuning has to be done in a circular manner, working round the pan several times. While tuning the outer notes, the inner ones will be affected, so you have to repeat the procedure again, tuning the inner notes and then the outer ones, until everyone is in pitch. A

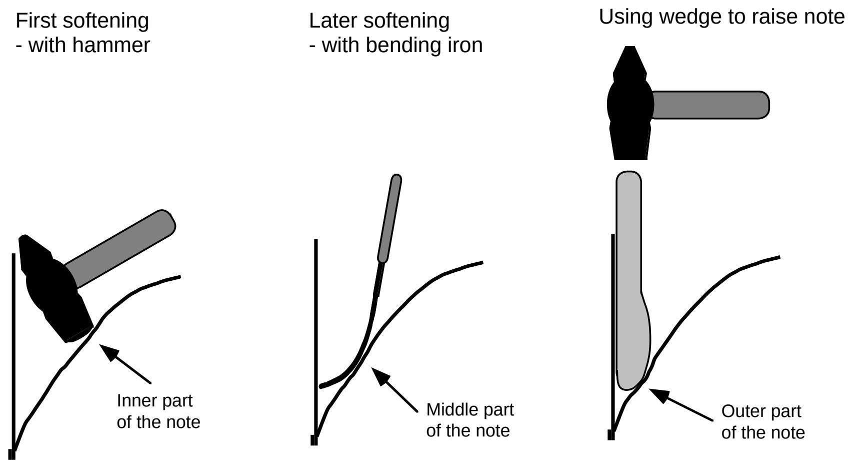


Fig. 9.6 Alternative methods to raise outer notes for softening.

good rule of thumb for this circular tuning is to ”take the worst sounding note and try to make it the best”.

Softening the metal

The softening is the first part of the tuning and it is done by hitting the note up and down several times. The softening effect is included in the tuning of the pitch. You are softening the dent while you are hitting it up and tuning it while you are lowering it again, listening to its sound and pitch.

The purpose of the softening is to ”loosen up” each note and give it a tone that is fairly independent of the surrounding notes. The tempering has made the metal of the note areas stiff. This is the desired effect to some extent, but the notes should not be as stiff as the surface between them. To enable the notes to sound independently, the metal in the dents and the ”joint” at the grooves has to be made softer. This is accomplished by flattening the notes and the restoring them several times. The surface of a note usually has to be hammered up and down again 5–6 times. For the easier notes, such as the inner ones, a couple of times will usually be enough. But some other notes may have to go up and down 10–20 times before they are sounding well.

It is important that the notes get softened over their whole surface, otherwise proper tuning will be impossible. On the smaller inner notes this is usually no problem, but on the bigger outer notes you have to start working at one end and then go over the whole surface. The first time an outer note is raised, the hammer is used on the innermost part (the part nearest to the inner border) of the note. The second time it is raised in its middle, as well as the inner part. The following times you raise the surface closer to the rim each time, but you also make the inner parts come up together with it. A schematic procedure for the raising of outer notes is suggested in fig. 9.6.

When working close to the rim, it can be hard to reach with the hammer and its head may be too big to raise the note properly. The tuner often uses a crowbar-like, bent iron for this work, see fig. 9.5 and appendix B. If the top of the iron is sharp, a blade of a cutlass is held between the tip of the iron and the skirt to protect it from getting marks. A wooden wedge can be also used to raise the outermost parts of the notes. The wedge is put resting against the skirt and hammered upon, see fig. 9.6.

Each time a note is raised, it is lowered again while listening to the pitch, see ”Tuning the pitch” below. The first couple of times a note is lowered, you may flatten it out fully to get it softened faster, but as it starts to sound better you usually leave it convex. For each tuning round, the surface is raised a bit higher. Don't try to do all of the raising at once, because it can easily be to much. It is better to have to do the softening some extra times than to risk to get the metal too slack. It is important to listen to the pitch while raising the note. The pitch should not rise more than about half an octave above the intended final pitch.

The softening is complete when the note seems to have a tone that is relatively independent from its surroundings. It should be easy to hear the pitch and the timbre should be steel pan-like. You may also use your hand to feel when the note is soft enough; it should be ”springy”, without ”buckling” (flapping over to the other side).

Tuning the pitch

When you start the tuning of the fundamental, you concentrate mainly on the pitch to get it low enough. The sound of a note with few upper harmonics is rather dull, so in the beginning it might be quite hard to hear its exact pitch.

The coarse tuning always starts by raising the note and then lowering it, while listening to the pitch, until it reaches its right frequency (or a bit below that). This usually has to be done several times to get the dent softened and the note low enough, see the description below.

The main steps in the procedure for softening and coarse tuning can be concluded in the following list:

1. Hit around the note, on the groove, from above. This is done to ”set” the note – to define the working area. It also strains the metal in the note and insures that the groove is flat.
2. Raise the note by hitting it from underneath, see softening.

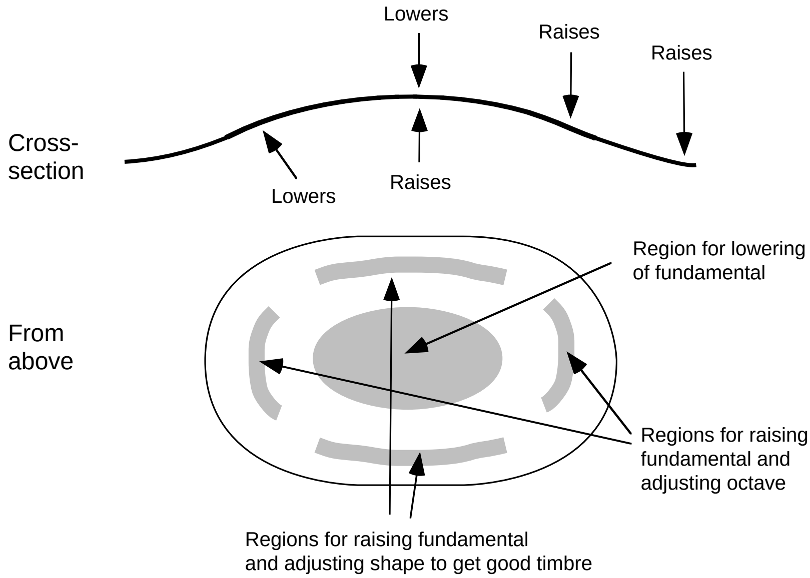


Fig. 9.7 Tuning of fundamental. Overview and cross-section of note.

While this is done, you can hear the fundamental of the note first getting lower, then starting to rise. The note should usually be raised a bit beyond the point where the pitch started to rise.

3. Lower the note, and thus the pitch, by hitting it from above in the middle region. Try to get the fundamental down to the intended pitch or a bit below it. If the pitch starts to rise before it has come down to the right level, the metal in the note is not "slack" enough. Then hit down the dent a bit beyond the point where it started to rise and start over again from point two, this time raising the note a bit more to stretch the metal further.

The process of raising and lowering the note often has to be repeated a number of times before the metal gets slack enough to produce an independent-sounding tone. In a good note, the tone usually comes out after two or three times, but some notes have to be raised ten times or even more.

During the first, softening part of the tuning, the precise pitch of the fundamental is not so important – it is more crucial that the note gets a sound of its own.

When the tuner lowers a note, he gets an indication of how much it needs to be raised the next time. He adjusts the amount of raising to stretch the metal enough to produce a better tone the next time it is lowered. If no partials are heard while a note is lowered, then it probably needs to be stretched further. If, on the other hand, it is raised too far, the metal will get too slack when lowered and the note will lose its sound, thus making it unusable. It is better to stretch the note too little and repeat the process several times, than to risk stretching it too much the first time.

Sometimes during the tuning the note may lose all of its tension and give away a very low tone without overtones. This might be cured by hitting on the groove from above to increase the tension or by raising the note and starting again with the lowering.

When the note has been softened and has a sound of its own, the fundamental is adjusted by changing the ”resonant” size and the height of the dent. Larger dent – lower pitch. Higher dent – higher pitch. To understand this, one must keep in mind that the size of the sounding dent is defined by the shape of the metal surface inside the groove rather than by the boundaries set by the groove. The sounding dent is always a bit smaller than the area delimited by the groove.

There are some rules of thumb for the tuning of the fundamental, see fig 9.7 for an explanation:

- Hitting from above in the middle region lowers the pitch.
- Hitting from underneath in the middle region raises the pitch.
- Hitting from above near the side of the dent raises the pitch (because the dent gets smaller).
- Hitting from underneath near the side lowers the pitch (the dent gets bigger).
- Hitting on the groove from above stretches the metal, and thus raises the pitch. (Don’t hit on the groove from underneath – this might ruin the shape of the note.)

The rules listed above are general, but due to small differences in shape and differing conditions in the metal, each note has its own characteristics and has to be treated in its own way. Sometimes a stroke can have an effect opposite to the intended because of irregularities in the note arch. When lowering the dent, the tuner adjusts the arch towards its final, correct form. The problem is to know exactly which shape this is for each note.

When some notes have been tuned, they may start to interfere with each other. This is usually good, but sometimes the sound of a note can disturb the tuning of another one. In this case, it is necessary to damp notes nearby to hear the harmonics properly.

First, the tuner checks which note is the disturbing one by damping the notes, one at a time, with a finger while hitting the note to be tuned. If the interference disappears when damping a particular note, this is the one causing the trouble. This note may be damped more permanently by pasting something on to the note surface. A sheet of a heavy material stuck on to the note may be used for this purpose. This can be a note template with a sticky backside or a piece of a magnetic plastic sticker for refrigerators or cars. The tuner can also decide to remove the sound of an interfering note totally by hitting it flat to be able to concentrate better on a note that is hard to tune.

It can be seen as a rule of thumb that, if a note is hard to tune, always check surrounding notes to see if they interfering with the note you are working on. If so, damp them before continuing. All pans seem to have at least one note that tunes easily and catches energy from the vibrations in other notes – the tuners call that one ”the leading note”.

At this first stage, just coarse-tune each note to something near the right pitch, before you start to soften the next one. During the first part of the tuning the note can be left at a pitch that is a bit too low, because it usually raises when the other notes are being tuned.

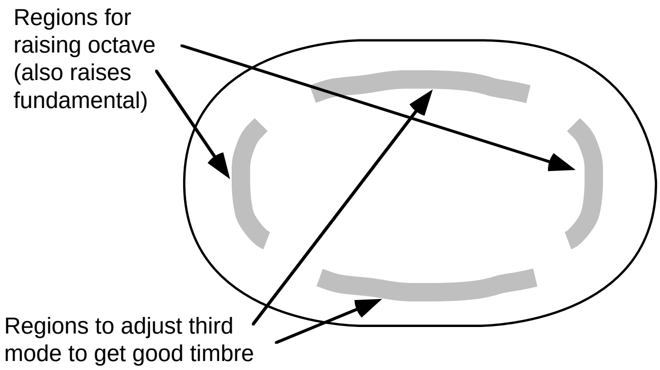


Fig. 9.8 Tuning the octave. Note seen from above.

Tuning of overtones (partials)

In this part of the tuning, the timbre of the steel pan tone is adjusted. This is done by tuning the overtones (or partials, as the acousticans call them) of the note, and it has to be done completely by ear. The partials are the parts of the sound that form the special steel pan timbre, the characteristic that makes it possible to recognize the sound as coming from a steel pan. When the octave and the higher overtones are brought into the tone, harmonics will be added to the tone and give it a longer, more pure sound. The partials are generated by vibrations along and across the note and are tuned near the ends of the notes. For a more general description of partials, see the theory section.

The partial tuning is actually done at the same time as the final adjustment of the fundamental. This is because it is hard to hear the pitch of a note if it not is sounding good, i.e., has a proper octave.

Before starting the tuning of partials you need to know that the note dents all are elliptical in physical shape. The ideal proportion between length and width of the note seems to be somewhere near 5 to 4 (but it works with other proportions too). The inner notes are nearly always oriented with the length axis of the ellipse pointing towards the centre. In the outer note circle, on the other hand, the notes are usually oriented with the length axis along the rim.

The octave partial of the note is generated by a vibration along the elliptical note. This vibration is adjusted by hitting the note from above in the end regions, see fig. 9.8. When this is done, the vibrating dent will get smaller and the fundamental will rise, together with the octave. The fundamental is then lowered by hitting in the middle and the procedure of adjusting the octave in the end is repeated. If the pitch of the fundamental starts to rise before the octave has reached its right pitch, hit the note down fully and then up and start over again. This may sound easy and straightforward, but it is in practice the most complicated part of steel pan tuning. You might say that this is the key to good tuning.

A crucial thing in octave tuning is to get the partials to act and sound well together. The tuners call this to "marry" the fundamental and the octave. This means that the fundamental and the octave have an harmonic relationship to each other. The octave should have a frequency that is exactly twice the fundamental.

The thing that is hardest to understand in tuning is how to move the octave without moving the fundamental and vice versa. A good tuner actually moves them at the same time, but in a way that will make them marry at the right pitch.

The upper partials are adjusted by changing the arch of the dent, rather than its size and height as in pitch tuning. To understand the tuning of partials you need to know how they sound and how their modes of vibration are distributed across the note. So, before you begin the tuning of the partials, take a look at the text and the pictures in the chapter on tone generation in the theory section.

The next higher partial, the third, is generated by a vibration across the note and is tuned along the side of the note. The relation of this partial to the fundamental forms part of the timbre, but it is not at all as important as the octave. In good pans, this partial is tuned to a harmonic interval in relation to the fundamental. Most ideally this interval would be a fifth above the octave, but often it is tuned to a third or fourth above it. This is because the fifth cannot always be reached with the fundamental at its right pitch. It is important that the interval to the fundamental not is disharmonic, such as a musical second or less, because this will make the note sound false and harsh.

A good trick to hear the octave and the third partial better is to generate a ”flageolet”. This is done by putting a finger in the middle of the note to damp the fundamental and then hitting the note near the end with the backside of the stick. See the chapter on tone generation in the theory section for an explanation of how this works.

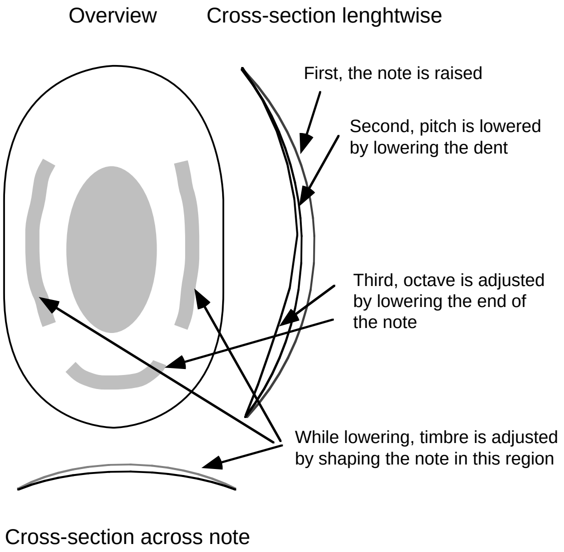


Fig. 9.9 Method for the tuning of inner notes.

TUNING OF INNER NOTES

The tuning usually begins with the inner notes in the middle region of the pan. These are the easiest to tune, and their sound will help with the tuning of the outer notes, which usually is much harder. Each note is treated according to the general steps described above; softening, pitch tuning and octave tuning. The steps are integrated with each other, so when you see a tuner working, it will all look like a single process. First the note is raised, then the pitch is lowered by hitting from above in the middle region, then the octave is adjusted by hitting from above in the end region of the note.

The tuner often reserves one end of the elliptical note for adjustments of the octave. This is usually the outermost end of the inner note, but if a note is hard to tune, the tuner may decide to shift the octave adjustments over to the inner end to see if this works better. An overview of the tuning regions for the inner notes can be seen in fig. 9.9, together with a cross-section of the note. Please note that the height of the dent in the

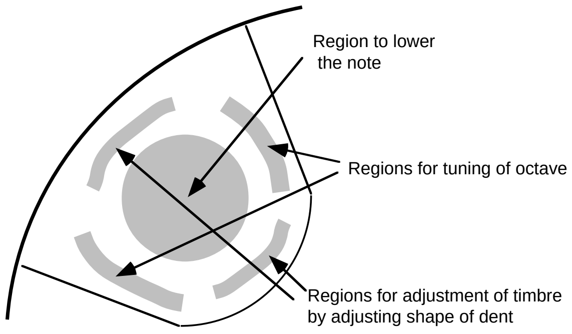


Fig. 9.10 Regions for tuning of lengthwise oriented outer notes. Valid for all pans except tenors.

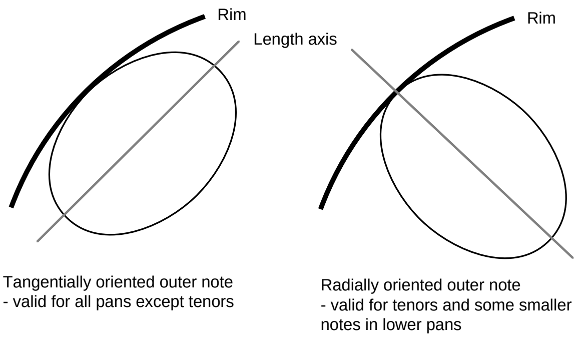


Fig. 9.11 Orientation of outer notes in different pan types.

figure is exaggerated. As seen from fig. 9.9, the final shape of the note dent is asymmetric within the note region, the dent being a little lower at one end.

If an inner note responds in a peculiar way, this might be because it has a badly shaped groove. This may be corrected by hitting around the note to bring it back in shape again. Especially important is the small region between the inner and the outer notes of an octave pair.

TUNING OF OUTER NOTES

When all the inner notes have got their right pitches and a crude timbre, it is time to tune the outer notes. The softening, pitch tuning and timbre adjustment of the outer notes is done in the same way as for the inner ones, but with some special tricks.

Begin by hitting around the note on the groove. While doing this, some strokes on the rim may be beneficial. This will stretch the metal in the note and make the dent come up easier. The next thing to do is to raise the note. While raising an outer note, especially on the tenors, the lack of space near the skirt that will make it difficult to hit with the hammer. Therefore a bent iron rod, shaped like a crowbar, or a wooden wedge is used to do this, see fig. 9.6.

The note is lowered by hitting it from above with the tuning hammer. On the larger notes it is important to distribute the strokes even over the middle part, and not hit in the same place several times. See fig. 9.10 for a definition of the middle working area. If a note bulges down and turns concave when you lower it, you are probably hitting it too much in the middle (or maybe the note has not

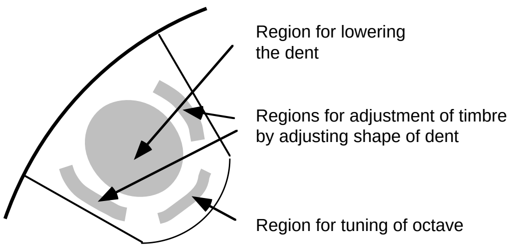


Fig. 9.12 Regions for the tuning of outer notes on tenors.

been backed enough). If so, raise it once again and try to hit it in a wider area around the centre. Raising a bulging note can sometimes be done by hitting at the rim to stretch the metal.

If a note is bulging so much that it seems impossible to tune, there is a trick to re-shape the dent. The tuners call this to ”tighten” the note. Hold the palm of your hand on it to keep it still while you re-shape it. This is done by hitting around your hand and it will result in a smaller, more sturdy dent.

When studying the tuning of the octave in an outer note, one has to keep in mind that the outer notes are oriented with their length axis in different ways in different pans, see fig. 9.11. In all pans except the tenors, the lengths of the outer notes are tangential, i.e., the length axis is oriented in parallel with the rim. On the tenors, the outer notes are rotated 90 degrees, i.e., with the length axis radial, pointing towards the middle of the pan.

As the most important partial, the octave, is acting lengthwise the procedures for its adjustment must be different for these different categories of pans. In most pans the end regions of the elliptical note will be reserved for octave tuning. See fig. 9.10 for an overview of the effects and regions for octave tuning in regular outer notes. For the tenors, the tuner usually reserves the inner end of the outer note for adjustments of the octave, see fig. 9.12.

Start the octave tuning of the outer notes with a note that has a tuned corresponding inner octave note. It will be easier to hear the sound of the octave of this one. On larger notes, check that the octave vibrations at both ends of the note have the same pitch. The best way to check the octaves is to hit the note with the hard backside of the stick.

When an outer note is beginning to sound good, the tuner lifts the pan from the tuning stand to check that the pitch stays the same and

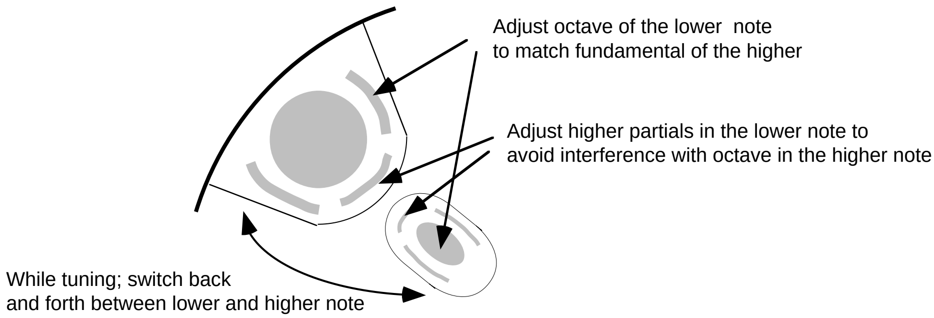


Fig. 9.13 Tuning of octave pairs.

the timbre is still good. This is done because the tuning stand damps the vibrations of the skirt and this often affects the tone of the outer notes.

If a big outer note not have an evenly shaped arch, a special problem may occur: The pitch of the octave may be different in the two ends of the note. The best way to check this is to damp the note with a finger in the middle and hit it with the hard end of the stick at each end of the note.

While tuning the outer notes, a new problem will arise. The formerly tuned inner notes will start to act together with the partials of the lower note. This is all well as long as the note is sounding together with its octave counterpart, but might be a problem if it acts together with some other note. This may be handled by damping the note as described above in the section for general steps in tuning.

OCTAVE PAIR TUNING

The process of octave pair tuning means that the tuner adjusts the notes in octave pairs to make them sound well together. This is often done to some extent while tuning the outer notes, by adjusting the corresponding inner one at the same time. But it can also be done as a separate step when all the notes of the pan have got their own sound.

During the later part of the tuning of the outer notes, it is very important that their inner octave counterparts have the correct pitch, otherwise it will be impossible to tune the octave of the outer note. This is because the fundamental of the inner note will interact with the octave of the outer note. A mistuned inner note may ”pull” the octave of the outer note off from the right pitch and confuse the tuning. You may also end up with two notes that have pitches very close to each other (within a few Hertz). This will result in unpleasant, fast ”beatings” and the sound of the note will be harsh.

The octave pair tuning starts by tuning the inner octave note. After

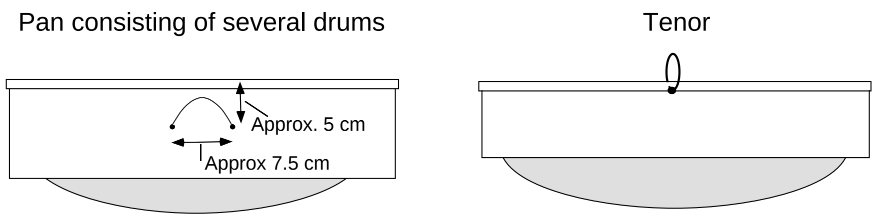


Fig. 10.1 Holes for strings.

that, the octave of the outer note is tuned and the fundamental is adjusted together with it. The tuner repeats this around the pan and ”goes by octaves”, adjusting each inner – outer note pair together.

At this stage it is also good to do a final check that the notes ”have their own tone”. This is done by damping the corresponding octave to see if the note still sounds good. Sometimes you may find that a note is ”living” totally on its octave counterpart. This means that it has a quite different sound and pitch without the octave note. Try to avoid this situation by giving the note a new start with softening and coarse tuning again. Softening and coarse tuning at this late stage will affect the surrounding notes in an unfavourable way, so the sooner these ”dead” notes are spotted the better.

A pan with many octave notes, such as a tenor or a double tenor, is harder to tune than a guitar or a bass, due to the interaction between the many notes. But it is easier to get a good timbre in a multi-octave pan if the notes in the upper octave support the lower ones with higher partials. This is the reason why the higher pans have a more brilliant sound than the lower ones.

The octave pair tuning is the last thing done while the pan is resting on the tuning stand, and it may be considered as the last step of the coarse tuning.

10. Holes for hanging

In the next step of the tuning, the fine tuning, the pan should be hanging to get the right sound. Therefore, the time has now come to make holes for the strings attaching the pan to the stand. The holes for the strings are made in the rim or the skirt. The position of the holes is

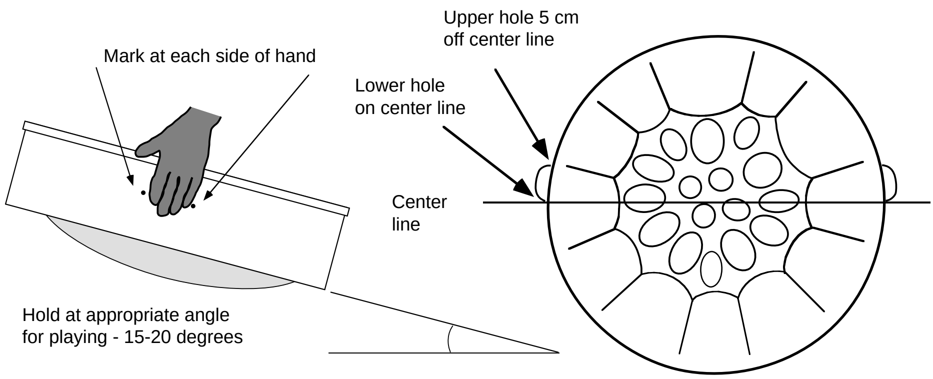


Fig. 10.2 Method to determine the position of the string holes.

quite important, because it establishes the position of the notes in relation to the player. It also determines at which angle the pan is going to hang.

On most pans, the supporting strings at each side go between two holes. For instruments consisting of several drums it is best to put the holes a bit down on the side (5 cm is common) so the upper ends of the stands get below the rim and not hinders the player by getting in the way of his arms. See fig 10.1 for a picture of how the string is attached to the holes in the side.

The holes have to be placed about 1–2 cm off centre to get the drum to hang at a suitable angle. The best method to find the position of the holes is the following: Hold the pan at the rim between you hands, using thumb and four fingers of each hand, see fig. 10.2. Place the hands so that the pan will hang at an appropriate angle. This means that your hands will be somewhat off the centre line, again see fig. 10.2. When the pan is hanging right, have someone mark the rim at each side of your hands, making two marks on each side of the drum, approximately 5 cm apart. Then mark the skirt 5 cm below these marks and make the holes there.

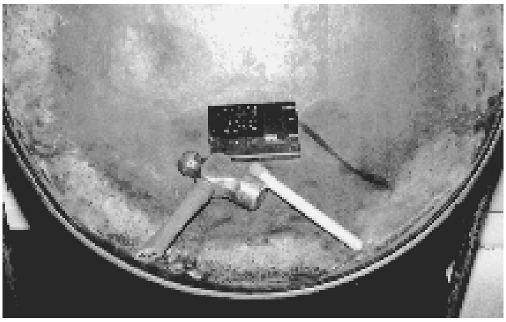


Fig. 11.1 Putting the pan on a stand for fine tuning. Picture showing tuning hammer, stick and electronic tuning device.

For tenors, that consist of only one drum, there is no need to keep the end of the supporting arms below the rim. Therefore, common practice is to make a single hole in the rim at each side of the tenor and tie the string in a loop trough it. The position of the holes on a tenor is decided by holding the pan in the rim between thumb and pointing-finger at each side and then marking it there. Again, the positions have to be a bit off the centre line to make the drum hang at the correct angle.

Typical positions of hanging holes for different pans are given in appendix A, together with the overview of the pan.

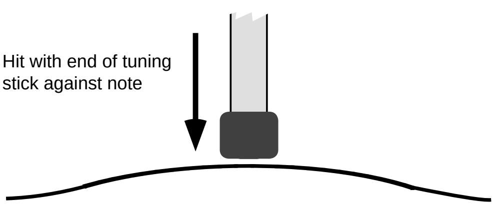


Fig. 11.2 Using the stick for a final adjustment of the pitch.

11. Fine tuning

The fine tuning is a continuation of the former coarse tuning, with the difference that the pan now is moved from the tuning stand to a hanging position. This is done to enable you to hear its final pitch and timbre properly.

In the fine tuning, the tuner concentrates on both the fundamental, the octave and the timbre. The same rules as earlier mentioned for coarse tuning also apply to the fine tuning. You keep on going around the pan, adjusting the partials and the fundamental of each note, this time only making small adjustments, see figures 9.7 through 9.13. If the first tuning is properly done, the fine tuning will only be a minor adjustment.

During the fine tuning you will need a strong stand to hang the pan on, see fig. 11.1. Furthermore, a well-tuned instrument or an electronic tuning device is needed to determine the correct pitch.

When a note reaches the right pitch, the tuner often makes some hard strokes with the stick to decide if the note is stable. If the pitch remains the same, the note is stable, otherwise it has to be re-shaped with a bit higher arch to make it more stable. Sometimes a hard stroke or a hard tap with the end of the stick can be used to fine-adjust the pitch of the note, see fig. 11.2.

If the pan is to be covered with chromium, the pitch and sound of the notes will change because of the extra metal put on. Even if this is the case, the tuner tries to tune the notes as well as possible at this stage. Hard tuning after the chroming will bend the metal enough to cause small cracks in the chromium layer. Later, air humidity may reach the steel through the cracks and make the pan rust.

12. Finishing

The crafting and burning usually removes most of the paint in the bottom of the drum. The bare steel will soon start to rust if it is exposed to the air moisture. During the first year, the only problem will be that the pan looks ugly. But later the sound will be affected by the rust and in the long run the rust will go through the metal and ruin the pan. Therefore, if you want the pan to last it needs to be preserved in some way.

Nowadays, the most common method to protect the pan is to electroplate it with a layer of a non-corrosive metal as zinc or chromium. This is an industrial process and basins with an electrolytic solution are needed. It is usually done only on small instruments such as tenors and seconds. Larger pans such as bases are usually painted on the side and the playing surface is covered with a thin layer of fat, such as car wax. The best is to combine both methods, first chroming, then a putting on a thin layer of wax to protect the surface from moisture and make it shiny.

REMOVING THE PAINT

To get the shielding layer of zinc or chromium to stick to the drum the remainder of the original paint has to be removed. This is preferably done with calcinated soda. If the paint is of a hardened lacquer type, the soda won't affect it – it has to be removed by grinding. The paint can also be removed by sand blasting, but this makes the surface dull, and is not recommended if you are going to chrome the drum later. If the pan is to be chromed, the factory will probably put it in a bath of acid to remove the last paint and fat, but usually the factories want most of the paint removed to avoid messing up their acid baths.

If the pan is going to be painted on the sides instead of chromed, it is sufficient to grind the original paint enough to roughen the surface to get the new paint to stick to it.

CHROMIUM OR ZINC COVERING

Chroming or zinc covering is usually done by factories, using electrolytic processes. On Trinidad, chroming factories are used to the panmakers needs and know how to handle pans. Therefore, the chroming is cheap and straightforward. In other countries, it may be hard to find a factory with an electrolytic basin that is big enough to handle a pan. The shape of the drum also causes trouble, since the electrical currents in the electrolytic bath will not reach into the inner parts of the drum. To insure an even coating of chrome or zinc, one or several "support anodes" (extra places to send current into the bath) have to be inserted into the drum, which makes the process even more complicated and costly.

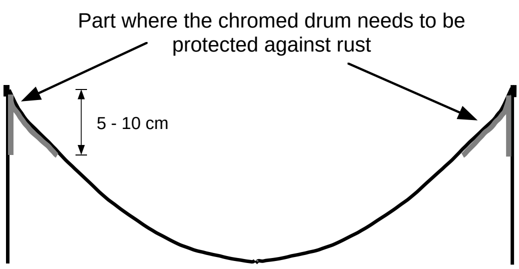


Fig. 12.1 Painting the pan to protect it from rusting after chroming. Cross-section of drum.

The coating has to have two

important properties: It has to be thin, and it has to be soft, i.e., it has to stick to the surface when the note is buckled during the tuning. If the layer is too thick it will affect the tone and damp it. The maximum thickness is still unknown to me, but a layer less than 0.1 mm in thickness should not affect the tone. If the layer is too hard, it will burst and start to fall off when the tuner is doing the final tuning. Some types of zinc or chrome layers are designed to give a hard, shiny surface. These are not suitable for pans.

RUST PROTECTION

The electrolytic process will put a thin layer of chromium or zinc all over the drum, except for the innermost angle between the outer notes and the skirt. The electrical field of the electrodes used in the electrolytic basin will not reach down to this narrow place. Therefore this part has to be shielded against rust in some other way. The best method is to cover it with a thin layer of paint as soon as it comes back from the chroming. If this not is done right after the finishing, you have to start by applying rust-eater to remove the rust.

When painting the playing surface, it is important not to use a paint that not is too thick, because this will damp the harmonics of the note and make the sound dull. Another undesirable effect of thick paint is that it makes the pans (especially the basses) rattle when it dries in the uppermost angle between the notes and the skirt. The best is to use spray-paint or to make the paint thinner before applying it. For chromed pans, it is often enough to paint it 5–10 cm up on the playing surface and the skirt, see fig. 12.1. If spray-paint is used, it may be applied to the whole playing surface of basses and other big pans that have not been protected by chroming.

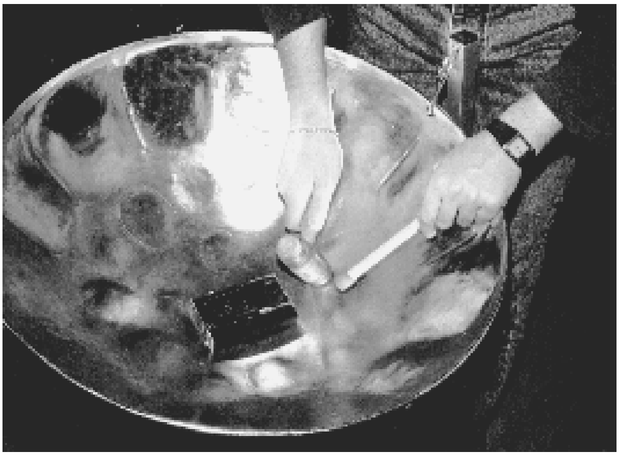


Fig. 13.1 Blending a chromed pan.

13. Blending

The blending is the final part of the tuning and it is done after the finishing. Blending means that the pitch, the timbre and the loudness of the various notes are adjusted. Sometimes this is done together with other pans of the same band, to get the pans to sound good together – to ”blend” well. The main part of the blending is the adjustment of timbre, but the tuner also tries to adjust the loudness of the different notes. This is done to make it easier to play balanced and not to out-power each other while playing in an ensemble.

The technique for blending is exactly the same as for the fine tuning. The pitch and the timbre of the notes are tuned in octave pairs, using the same regions for adjustments. The first step of the blending is usually a brief fine tuning. The chroming has covered the surface with a thin layer of chromium that makes the metal thicker and heavier. The increased weight of the notes affects the pitch. The fine tuning of the pitch is often included in the adjustment of the octaves

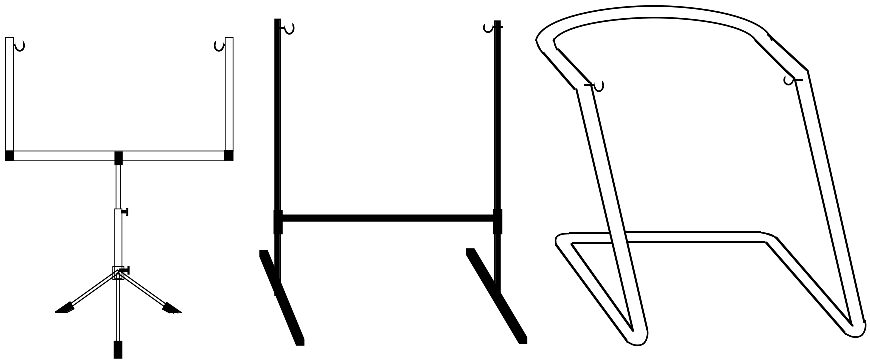


Fig. 14.1 Examples of playing stands.

described below.

The next step of the blending is to fine-tune the octaves of the notes to make them match the fundamental. This was first done during the fine tuning, but the altered weight of the notes after the chroming has also affected the partials of the note, so now they need to be adjusted again.

Start the octave blending with the highest note of an octave pair. Make sure that the fundamental and the octave of this note are in perfect pitch. This may be a little difficult to do if the lower note is out of tune, because its octave will interfere with the higher note. When a higher note is properly tuned it will help the tuning of the lower one, as the octave mode of the lower note acts together with the fundamental of the higher one.

The blending, like everything else in pan tuning, has to be done in a circular step-wise process as blending of one note may affect the surrounding ones.

Fig. 14.2 Tilted drums of a two-drum set-up.

14. Stands

The early steel pans were played hanging in strings from the player's neck. Pans are still played in this manner sometimes, but this is a special, traditional style for small street bands called "pan around the neck". Nowadays pans are usually mounted in racks on wheels for carnival or on stands for stationary concert performances.

The common denominator for all hanging mechanisms for steel pans is two supporting limbs separated by a distance slightly more than the diameter of the drum. The drums are hung in strings from hooks on the limbs. The limbs must be at least as long as the skirt of the pan, taking into account the extra length of the tilted drum. Below the skirt, the limbs are joined to form a standing mechanism. One convenient way to make a collapsable stand is to use the lower part of a regular cymbal stand and attach a U-formed fork on top of it, see fig. 14.1. Fig. 14.1 also shows the most common type of stand (in the middle) and the regular Trinidad concert stand, made of bent chromium-coated steel tubing (to the right).

The stands are usually positioned so that the lowest side of the tilted drum is facing the player. This works for all tilted pans, from tenors down to cellos. But if an instrument consists of two drums, another set-up technique may be used. An individual stand for each drum makes it possible to put the stands in a way that makes the drums tilt towards each other, see fig 14.2.

This set-up will put the lowest side of the drums in the middle, making it easier to move the hands from one drum to the other while playing fast figures. This technique has been developed by solo artists but has not yet been adopted by the regular Trinidad steelband. This seems to be due to the fact that there is a technical problem to integrate these twisted stands in the racks of a mobile steelband set-up.

15. Sticks

The first steel pans were beaten with wooden sticks. When the instrument evolved further it was found that damping of the stick could reduce the amount of overtones in the notes and make the sound more mellow.

Nowadays, sticks for steel pans are usually made by wrapping one end of a wooden stick with a strip of rubber from bicycle inner tubing. The sticks are usually made of drumsticks that are cut off to a suitable length. The length and thickness of the stick and the amount of rubber vary for different pans. Sticks for high tuned instruments are short and light while they are longer and thicker with more rubber for lower tuned instruments. Common measures for the different stick types are given in appendix C.

LENGTH

You may choose the length of the stick to your personal preference, but you should be aware how the length will influence your playing. First, power – the longer the stick, the louder you can play. Second, reach – you reach further with longer sticks, which can be a good thing, especially for the lower pans with notes distributed over several drums. Third, skill – it is usually trickier to play with longer sticks.

DIAMETER

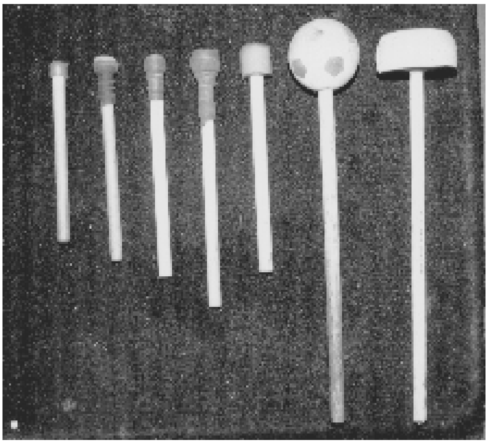


Fig. 15.1 Overview of sticks for various pan types. From left to right: Tenor, double tenor, double second, guitar, cello and bass.

The diameter of the stick decides its weight, and thus the amount of force you put into the note when you hit it. The sticks are usually thinner for higher tuned pans and a bit thicker for the low ones. The diameter varies from 10 to 15 mm.

RUBBER

The amount of rubber is crucial for the quality of the sound. The contact between the stick and the pan has to be soft, not to excite the higher vibrational modes of the note. These higher modes do usually not have a harmonic relationship to the fundamental, and therefore they are not desirable in the sound of the note. The higher modes are damped if the contact time between the rubber and the note is long enough. The thicker the rubber, the longer the time of contact.

If too much rubber is applied to the stick the fundamental will also be damped, thus making it hard to hear the pitch of the note. The right amount of rubber is applied when the sound of the struck note is mellow rather than sharp, with the overtones coming in somewhat after the fundamental. You may read more about the function of damping in the theory section.

Larger notes need softer sticks to sound pleasant. The larger and lower the note, the longer the time of contact needs to be to damp undesirable vibrations in the note. For instruments with a large tonal range this leads to a problem as you are forced to use the same pair of sticks on notes of very different sizes. Then you have to compromise between the quality of the sound of the highest and the lowest note. Too much rubber; weak sound in the higher notes, too little rubber; harsh sound in the lower notes.

The rubber for the sticks is usually bicycle inner tubing cut into strips, about 1–1.5 cm broad, and wrapped around the stick several rounds. There is a special technique to keep the rubber strip wrapped around the stick: Begin at the top and wind the rubber round the stick, going further down for each turn. When you come to the end of the strip, roll back the previous winding and put the last piece of the rubber under it while stretching it. This will lock the end of the strip.

Nowadays, it is possible to buy rubber sheets or latex tubing in hardware stores. The sheets can be cut to strips and used the same way as the bicycle inner tubing. The thickness of the wall in the latex tubes varies from 3 to 8 mm, and they are easiest to come by in dimensions suitable for tenors and double tenors. For tenor sticks, rubber tubing for spear-guns is often used. Sticks for basses are usually made by putting sponge rubber balls at the end of the drumsticks. Sometimes, part of the ball is cut off to reduce the weight, see the last bass stick at the right in fig. 15.1.

II. FUTURE

Developments, Innovations and Experiments

The steel pan is very much an instrument in development – new layouts, new crafting methods and refinements are tried by panmakers all the time. Several of the new methods have been mentioned in the practical section, but some of these experiments need extra attention. This section lists inventions and experiments that I have come across or heard about and it may be seen as a hint to where the pan is going in the future.

PAN INNOVATION AWARD

To encourage the creativity of tuners and pan players, a competition for innovations on the pan has been founded – the Rudolph Charles Pan Innovation Award Competition. The competition is a part of the Trinidad & Tobago National Steelband Music Festival, held in November each year. The awarded innovations may involve any aspect of the steelband, from the pan to its accessories. The competition has resulted in several inventions; among the more interesting is the bore pan, which is described below.

16. Innovations regarding the instrument

THE BORE PAN

In the crafting section it has been mentioned that the groove around the note can be supplemented by a line of holes. The holes make the border "joint" of the note looser than the ordinary grooving. The acoustic effect is to preserve the vibrations more efficiently in the note area. This lowers the pitch and makes the tone clearer and longer, but somewhat weaker in volume.

The bore pan was invented by the panmaker Denzil Fernandez in the mid 80's, but it has not won a broader acceptance among the steelbands of Trinidad yet. So far, I have only seen the bore method used on tenor pans.

The most significant effect of the row of bore-holes is that the improved acoustic separation from the surrounding surface lowers the pitch of the note. This makes it possible to make the notes of a bore pan smaller than on an ordinary pan. The bore pan is also said to be easier to tune, as the interference from the surrounding notes is minimized.

The spacing of the holes is crucial; it affects both the pitch and the strength of the sound from the note. The pitch can be lowered by increasing the number of holes and putting them closer to each other. But if the holes are drilled too close, the border of the note will be too soft, making the tone too long and weak. The best result seems to be accomplished with holes of approximately 0.5 cm diameter, spaced with 1 cm between them, see fig. 16.1. See the theoretical section for a discussion of how the groove works and how an increased acoustic separation of the notes affects the tone.

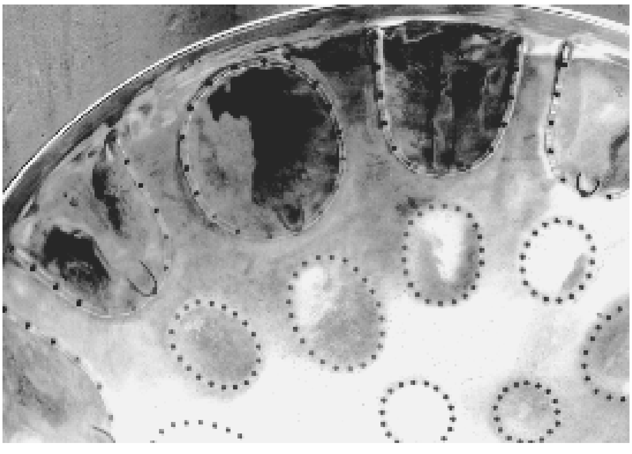


Fig. 16.1 A section of a Bore Pan. The outer notes have reeds, see the chapter about the bore-reed method below.

The decreased area of the notes in the bore pan makes it possible to put more notes in each drum. This advantage will make the bore pan a good candidate for further development of the pan. If the tuners want to develop new pans with an increased tonal range, this should be the best way to go.

But the bore method has two major disadvantages. The first is of a practical nature; the many sharp edges of the holes will presumably make it harder to protect the pan from rusting. The second disadvantage is aesthetic; an instrument with many holes doesn't look good to most people.

If the row of bore holes can be used fully *instead* of a groove (which seems plausible), this may have interesting implications for future attempts to industrialize the panmaking. It is presumably much easier to design a machine to make a row of holes than a groove.

THE BORE-REED PAN

The tuner Denzil Fernandez has continued his work on the bore pan. He has invented a new method to lower the note resonance frequency further. This is done by introducing a "reed" at the end of the note, see figures 16.1 and 16.2.

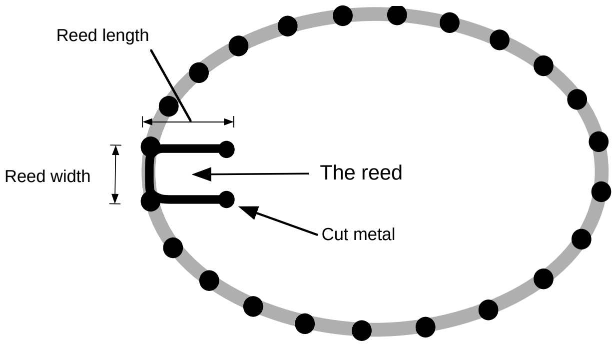


Fig. 16.2 A note from the Bore-reed Pan.

The reed is done by making a 1 to 1.5 cm long cut along the groove. Then a 1 to 2 cm long cut is made into the note at each side of the former cut, making a rectangular "tongue" in the note. The reed has a resonance frequency of its own, which can be adjusted by varying the length of the tongue. The fine adjustment of the resonance frequency is done by filing off metal from the tip of the reed. The pitch of the reed is adjusted to match the octave of the note.

Denzil Fernandez claims that he can make notes of the same size more than an octave lower with the reed method. The reed method can also be applied to a note without bore-holes with a similar result.

Acoustically, the reed method seems to be somewhat questionable. The adding of a new resonance part to the note dent introduces further complicating factors into the tone generation mechanism. The sound of the reed pan can be perceived as "double" in its nature, because of the different resonance frequencies of the note and the reed. The tuner has to control them both while he is tuning. If the reed and the note are not in tune, the tone will sound harsh and false.

One benefit of the reed method though is that the reed can be tuned to the right pitch independently of the dent. This will presumably make it easier to tune the note afterwards. I believe, however, that the bore-reed pan is an offspring that will have hard to catch on. The benefits of the lowered pitch and the saved space don't compensate the increased complications in tuning and the more complex tone.

STAINLESS STEEL

The material used for steel pans since the beginning of the steel pan history has been mild steel. This is of course because mild steel is the most common material in steel drums. One problem with the mild steel is that it rusts and therefore must be protected against moisture. This protection is expensive and involves an extra step in the crafting process. So, if a non-corrosive material could be used from the start, it would be a benefit. Therefore, tuner Lawrence Mayers and I decided to do an experiment on a drum made out of stainless steel. The following is a brief description of our work and the result.

Stainless steel is much harder than mild steel. This means that all processes that involve shaping of the steel will demand much more energy input from the panmaker. The sinking down to tenor depth, for instance, took about three to four times as long as an ordinary drum. The backing was also tough, but the hardness of the steel made the surface stay more firm and reduced the need for re-shaping.

The grooving couldn't be done with the ordinary grooving hammer – the tuning hammer had to be used to get enough force. Afterwards, I realised that a nail-punch with a smaller head would have made more impact on

Fig. 16.3 Experiments with stainless steel. Tuner Lawrence Mayers and the author during a discussion about the sinking. *Photograph by Linus Torell.*

the surface. Reducing the diameter from 5 mm to 3 mm may make it possible to use the ordinary grooving hammer. The appropriate time for tempering is still unknown. We burned the drum over a tyre for 2 min 15 sek, but this was later found to be insufficient. Three to four minutes seems to be more appropriate.

During the tuning, the inner notes needed softening about four to five times to get a good tone. The softening also needed much more force than on an ordinary drum. Some notes were hard to tune, but the notes that came in tune were very stable due the hardness of the stainless steel. The sound was also good and had a prevalent brilliance. The tone could be considered to be a bit ”harder” than on an ordinary pan, but on the other hand it could take much harder hitting without ”breaking” in sound.

This experiment revealed that the stainless steel seems to be acceptable to make a good pan. When tuned it can perhaps make ”a lifetime pan”, because of the hardness and its ability to stay in tune. To sum up, the arguments speaking for stainless steel as raw-material for panmaking are that no chroming is needed and the result is a more durable pan with a louder and more stable tone. The drawbacks are that the raw-material is expensive and rare and that much more crafting work is needed.

COLLAPSABLE DRUMS

During transportation, the full-length drums of the basses take up a lot of space. Much work is being done to find a way to reduce the transport volume of the basses. One way to do this is to make the sides of the drums removable or collapsable. As the bass pans are hanging on strings when they are being played, the main function of the sides is to give resonance to the sound. This can be done with a weaker side. One possibility is to design the sides as ”telescopic” sections, to be pushed into each other when the drums are transported. A disadvantage of removing or collapsing the bass sides is that the parts will tend to rattle during performance if they are not securely fastened to each other and the playing surface.

AMPLIFICATION

One way to increase the output volume from a steel pan would be to put a microphone in front of the pan and connect the microphone to an amplifier. This is frequently done when pans are used together with other (electrical) instruments. In a steelband this doesn't seem to work well, because the very special sound of a steelband is formed by the "blending" of the sound from several pans. If microphones are put close to each pan, the assembled sound "picture" of the band is broken up into pieces and you will get a hard, noisy sound. To get the right, mellow sound, the microphones have to be placed at a far distance, and much of the purpose of the amplification is lost.

NEW PAN MODELS

The steel pan has not yet been established as a fixed instrument. New pan models are emerging all the time. Many of the models vanish after a few years. Some of the models are restricted to use in one or a few steelbands. Here are some examples of new models that have caught wider acceptance and two experimental pans:

Quadrophonic pan, Four pan

The "Quad" pan and the Four pan are two recently invented pan models. They have quickly found their place in the steelbands and are now used by almost every band. The Quadrophonic pan can be seen as a double second, whose tonal range is extended, mainly downwards. The Four pan may be seen as a guitar pan that is extended upwards. The models are now so common that I have chosen to include them in appendix A, together with the rest of the standard pan models.

Ten bass, Twelve bass

These bass models are commonly used extensions of the ordinary nine bass. The advantage of the extended tonal range doesn't seem to be enough to get them to catch on, though. The 27-note range of the nine bass is usually considered to be sufficient, and it doesn't seem possible to reach much lower in musical pitch by using more drums.

Over-sized tenor

Steel drums are made with several different diameters. The most common exception from the standard drum is a small drum, used for kiddies' pans and tourist pans. Some drums have a diameter that is bigger than the ordinary drum. The Phase II Steelband has several tenor pans made from "over-sized" drums. These tenors cover a range that is almost equal to a double tenor and have a pleasant tone.

Due to the difficulty in finding these big drums the idea of making pans from over-sized drums will presumably have hard to catch on. But to the experimenting panmaker, the differently styled pans show that it is possible to make pans with other sizes than the standard one. If the pan-making process is mechanised in the future it is probable that the standard steel drum is abandoned as raw-material. It may well happen that the drums will be shaped and sized in a way that is more directly adapted to the acoustical needs of the pan, maybe bigger and in another shape rather than round.

"Rocket pan"

The Rocket pan is a fancy, experimental pan, used by the Desperadoes Steelband. The lower ends of the drum skirts are attached to funnel-shaped tunnels – they look like the back end of a rocket. The purpose of these tunnels is to act as acoustic horns to increase the sound level of the pan. I have not seen the rocket pan used in any other band than the Desperadoes. It will probably not catch on.

IMPROVED STICKS

A problem with the tenors is that the small, innermost notes need a hard stick to get a good tone, while the outer notes sound better with a soft stick. A way to accomplish a compromise is to make the tip of the stick rounded. This can be done by removing rubber on the inside of the tubing in the end that is going to be at the top of the stick, see fig. 16.4. This makes the rubber rounded off towards the top, which makes the stick harder in the part you are using when you are hitting the small,

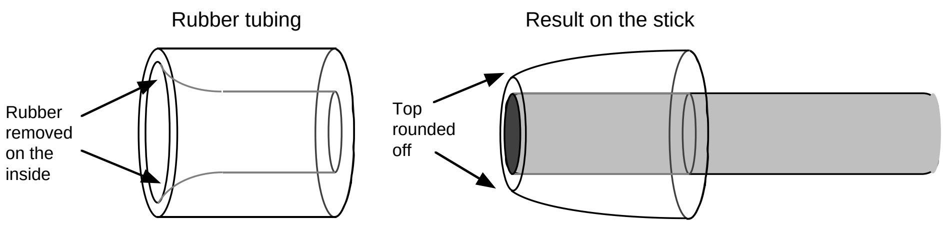


Fig. 16.4 Tenor stick with rounded top.

higher notes.

17. New tools and crafting methods

NEW TOOLS

Wooden wedges for the raising of outer notes

The tuner Denzil Fernandez has introduced special wooden wedges to be used for the raising of outer notes during softening and tuning. The paddle-like wedges are specially shaped for the various pans.

Usually, two different wedges are used for each pan – one broader and one narrower. The narrower one is used to raise the part of the outer note that is closest to the rim. The broader one is designed to raise the note in the middle, see fig. 17.1.

The benefit of using wedges instead of a bent iron or just hitting it with a hammer is that the shape of the wedges establishes the curvature of the dent. Properly shaped wedges will thus make the tuning easier. These wooden wedges are being used in the pre-tuning work at MIC (Metal Industries Corp. – see next chapter).

The wedges are used in the following way: Put the wedge at the bottom of the side angle, leaning against the skirt. Then hit it at the top with a hammer while moving it along the note to raise the note to the desired shape.

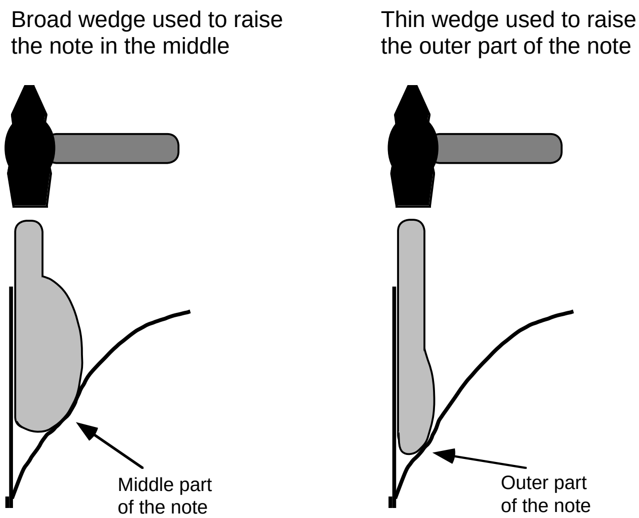


Fig. 17.1 Using wedges to raise outer notes.

Templates for outer notes

Denzil Fernandez uses quasi-circular templates when he marks the outer notes. The benefit of using templates for the outer notes is that the radial length of the notes and their inner curves are fixed by the template. This means that no arbitrary bending of a ruler is needed to shape the inner border of the notes.

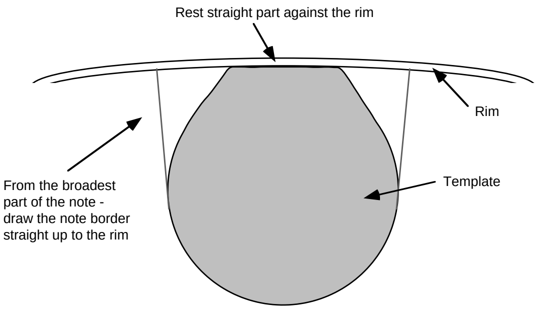


Fig. 17.2 Shape of a suggested template for an outer note.

The shape of a template for an outer note is suggested in fig. 17.2. The straight part is meant to lean against the rim. For the tenor maker, a set of templates for tenor outer notes can be found in appendix A.

Moulds to shape the note surface

A tool that I have never seen used, but that I believe would be of benefit for the tuning is the abutments, used to re-shape dented cars. While hammering from above, the abutment is held tightly against the opposite side and makes the surface shape after it, see fig. 17.3.

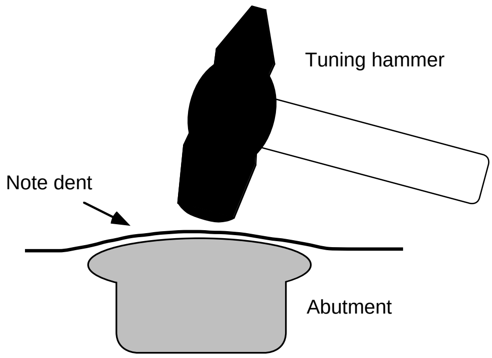


Fig. 17.3 Using an abutment to shape a note.

The use of an abutment would presumably reduce the amount of small unevenesses in the note surface and make it easier to tune the overtones of the note. At least, the note would react more consistently to the tuning manoeuvres when it is more evenly shaped.

A future test has to reveal if working with abutments is an improvement. For a beginner it might be beneficial, but if the backing and the levelling are well done, the shape may be smooth enough without any mould-shaping. The best stage to use an abutment would presumably be in the latter part of the softening, just before the actual tuning starts.

INDUSTRIAL DEVELOPMENTS – A PAN FACTORY

In Trinidad & Tobago, an awareness of the cultural and economic potential of the unique steel pan instrument started to awake during the 1970's. In the late 70's, a research committee was founded; the 1979-85 research committee on pan. An outcome of the work of the committee was the decision to start a steel pan factory on Trinidad. One of the objectives for industrialisation was the increased need for cheap, standardised instruments for the education on steel pan playing is schools. Another prospect was to start exporting instruments on a larger scale.

The benefits of an industrialised production were considered to be: Reduced price, increased production and improved quality. Mechanised sinking and tempering would give a product with a higher and more uniform quality for the tuners to work on.

A first attempt to start a pan-factory has been made by CARIRI – The Caribbean Industrial Research Institute, in cooperation with MIC – Metal Industries Corporation Ltd. The mechanisation of the pan-making only involves the sinking and the tempering so far, see below.

Spin form sinking

By using a lathe with a mould mounted on it, the bottom of a drum can be shaped by pressing it into the mould while the lathe is rotating. This is done in the following way: A raw plate that is to be the bottom of a drum is mounted on the mould at the lathe. While the bottom is rotating, a support is pushed against its surface and moved sideways along the bottom, see fig. 17.4.

When the bottom has been shaped to that of the mould, it is removed and mounted to the side of the drum. The sunk plates are mounted to the side in pairs so that the drum will have two bottoms, i.e., both ends are sunk. Spin form sinking can be utilised for pans ranging from tenor down to cello. (The lower pans are not

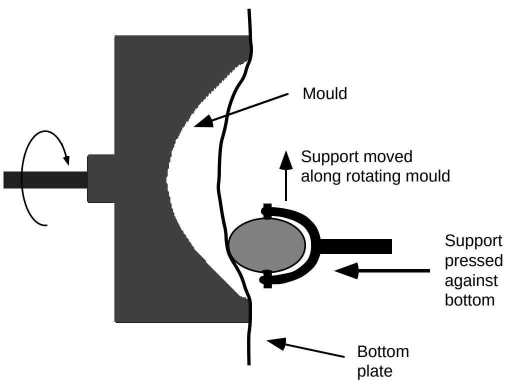


Fig. 17.4 Spin form sinking.

sunk before the shaping of the notes.)

MIC are selling these machine-sunk drums to tuners and claims that the even, machine-sunk surface will make it easier to control the harmonics of the notes. Some tuners claim that the machine-sunk bottoms do not have the right shape and that they are too thick in the middle. The spin forming also makes small circular scratches in the metal, which some tuners consider to be fatal for the later grooving and backing.

Electrical oven for tempering

In the industrial pan-making at MIC, an electrical oven is used for the tempering. This gives better control of the amount of heat transferred to the drum than the ordinary heating method. Unfortunately, I haven't been able to get any specifications on temperature and heating time yet.

Press form sinking

At the University of the West Indies some research has been done on the steel pan. Researchers at the Department for Industrial Engineering have experimented with the possibility of forming the surface of the pan by pressing it into a mould. The difference from spin-form sinking is that here, the bottom is pressed to its final shape in one, single process.

The research on press-forming has not led to any explicit results yet. Experiments with moulds for single note shaping in the same way have also been done. In 1990, all university research on the pan had stopped, due to the present lack of funding.

18. Standardization

NOMENCLATURE

As a proposal for a Trinidad and Tobago standard, a glossary of terms relating to the steel pan was outlined in 1989. The purpose of the glossary is said to be ”to standardize and co-ordinate the meaning of terms used in connection with the steel pan.” ”The need for such a glossary arose from the very prevalent use of synonyms in the steel pan industry, most of which are purely local in origin and application.” (Ad Hoc Specification Committee on Steel Pan, 1989.)

A more thorough discussion of the use of terms can be found in appendix E. Appendix E also shows how my use of various terms relates to the proposed standard of Trinidad and Tobago.

LAYOUTS

The need for a standardisation of pan layouts has increased since steel pan playing was introduced as a regular subject in the schools of Trinidad and Tobago. The standardisation organisation of Trinidad and Tobago conducted a ”pan survey” together with Pan Trinbago during 1990. The intention of the survey was to gather data and layouts on the various existing models of pan. As far as I know the data from the survey have not yet been compiled.

The works by Pan Trinbago and the Trinidad and Tobago Bureau of Standards are intended to point out the direction for a standardised set of steel pans. But, as the pan still is evolving, special odd models and experimental pans will be seen for a long time in the future. The pan models listed in appendix A may be seen as a sample of the models that have come farthest towards standardisation.

III. THEORY

Acoustic Function of the Steel Pan

This section presents measurements and theoretical models from my research on the steel pan. The presentation is complemented by some speculations on the relation of the measured data and the models to the practical tuning work and the design of the steel pan. Since my research only has been going on for a short time, this section is still a bit thin, raising many questions that have to be left without answers.

It is not necessary to read this section to use the handbook for steel pan making and tuning. But if you are curious and want to know why you have to perform the various steps during the making of a pan, this part may provide some explanations. For the experimenting panmaker, this section is intended to provide some theoretical insights to guide the further development of the tuning techniques and the instrument.

To be able to discuss the theoretical aspects of the steel pan later, the section begins with a chapter on music acoustics.

19. Music acoustics

SOUND

Physically, sound is defined as small, periodical variations – vibrations – in the air pressure. The pressure variations are produced by small differences in the density of the air. The vibrations are transferred to the air when a vibrating body (such as a musical instrument) pushes the molecules of the air.

A musical sound can be described in terms of three fundamental characteristics: *loudness*, *pitch* and *timbre*.

The loudness represents the perceived strength of a sound and it is denoted by the sound pressure level, which is measured in decibels (dB).

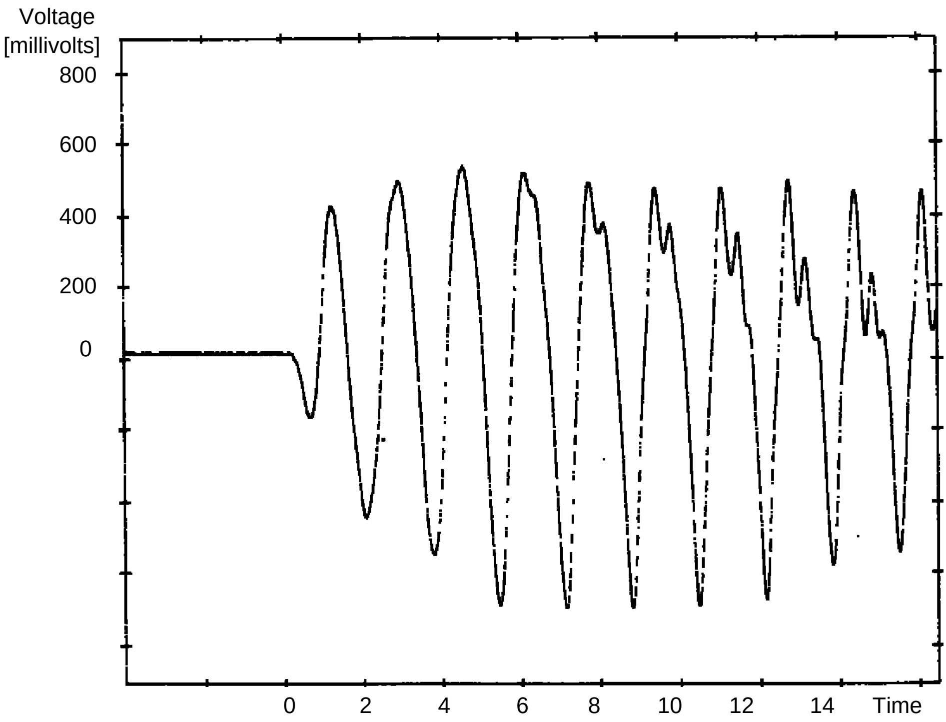


Fig. 19.1 Wave-form of a steel pan tone. (Time measured in milliseconds.)

The pitch is related to the physical measure frequency. The frequency of a sound describes how many times the air molecules are pushed back and forth each second. Frequency is measured in Hertz (Hz).

If the frequency of a single tone is related to its perceived place on a musical scale, the result is called the pitch of the tone. The pitch of a tone is denoted as C, C#, D, D#, etc. If more accuracy is needed, the octave position of the pitch is also included as a number; C1, F#3, G6, etc. The usable range of musical pitches extends from C0 (16 Hz) to C9 (8372 Hz).

The timbre of a sound is a much more complicated characteristic than the loudness and the pitch. It describes the tone ”colour” – the character of the sound, and there is no single physical entity that can describe it fully. The timbre can roughly be described by the wave-form, as seen when analyzing the sound with an oscilloscope, see fig. 19.1. The more rugged the wave-form, the more brilliance and treble in the sound.

Musical instruments usually produce simultaneous vibrations of several different frequencies, which are added together to form what is called a *complex* tone. The parts of a complex tone are called *partials.*

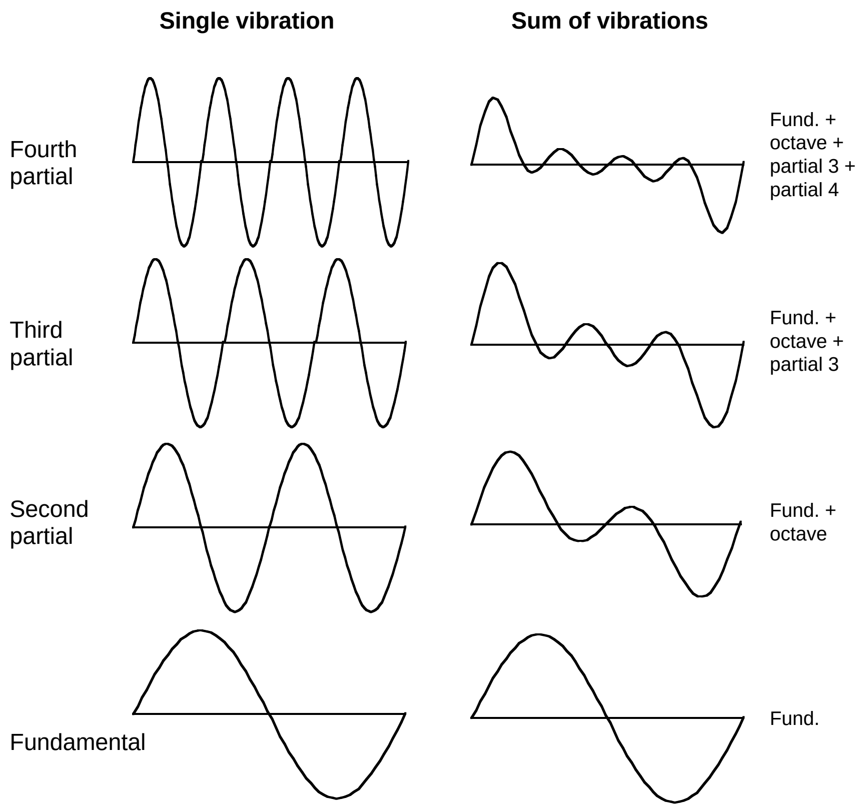


Fig. 19.2 Adding of partials in a complex tone.

Each partial is emanating from a vibrational mode of the instrument (see below). The partials are numbered one, two, three, etc., from bottom to top. Fig. 19.2. shows the resulting wave-form when several partials are added together to form a complex tone.

The process of dividing a complex tone into its individual partials is called a *spectral analysis*. Nowadays, computers can do a spectral analysis in a matter of seconds. The result of a spectral analysis is a diagram, showing the frequency and the relative intensity of the partials. This is called a frequency spectrum, or a *spectrogram*. The spectrogram can reveal a lot about the timbre of the sound. Fig. 19.3 shows a spectrogram of a typical steel pan note.

A complex sound that is perceived as a tone is usually built up of a number of partials that are equally spaced on a frequency scale. This means that the frequencies of the higher partials are multiples of the lowest one. This is called a harmonic series, and the tone is therefore called a *harmonic* tone. Most musical instruments generate harmonic tones. As an example, a harmonic steel pan tone with the lowest partial

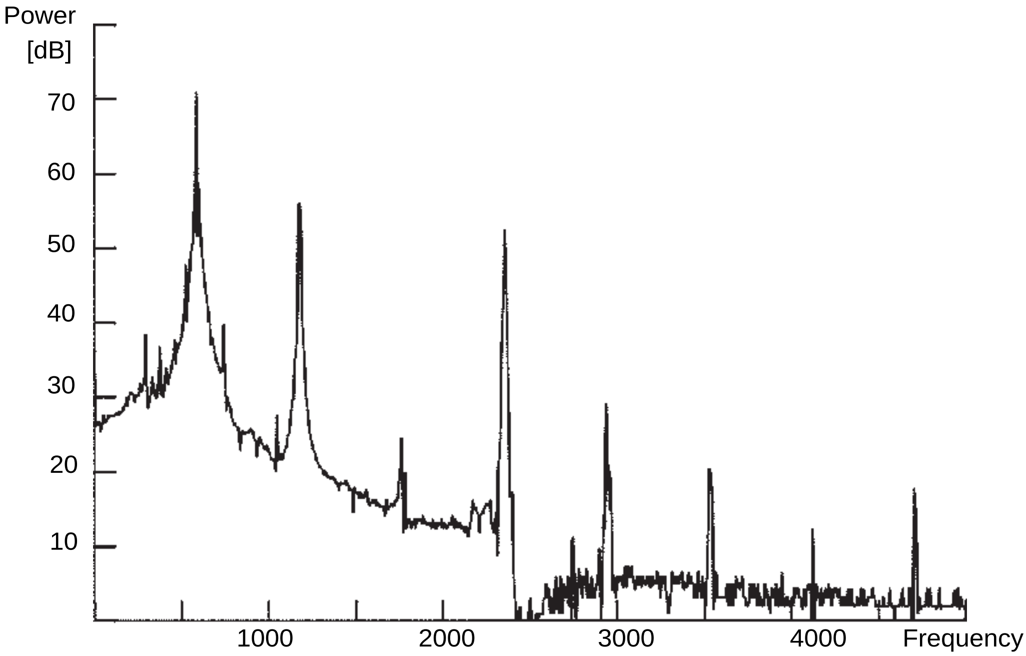


Fig. 19.3 Frequency spectrum of a steel pan tone. (Frequency in Hertz.)

at 200 Hz has upper partials at 400, 600, 800, 1000, 1200 Hz, and so forth.

When we listen to a complex tone, we unconsciously analyse the sound and split it into its partials. The lowest partial of a harmonic sound is what we perceive as the pitch of the tone, i.e., the note's position on the musical scale. Therefore, the lowest partial is called the *fundamental*. The higher partials are often called *overtones* to the fundamental.

It is important that the overtones have a harmonic relationship to the fundamental, because we use them to perceptually define the pitch of a complex tone. A sound with many non-harmonic partials will be perceived as dissonant and vague in pitch. Partials that do not fall within the harmonic series are called disharmonic, and do not contribute to the sense of pitch in the tone. Disharmonic partials instead add more character to the timbre of the sound.

VIBRATIONS IN BODIES

The vibrations in a body are generated by two fundamental properties: the *mass* of the material and a *tension* that tends to restore the material to its rest position if it is disturbed. When an instrument is *exited* (hit), the interaction between the mass and the tension will generate sound waves passing through the body.

When the sound waves reach a point of difference in the density of the medium they are travelling in, they are reflected. When the reflected sound wave is travelling back and forth in the body, the sound energy will add at some points and cancel at some other points. This phenomenon is called a *standing wave*. In the points where the wave energy cancels, the surface of the body remains at rest. These points are called *nodes*. At the points where the energy adds, the body is vibrating fiercely. These parts are called *anti-nodes*.

The *resonance* of a body makes it respond with certain standing-wave vibrations when hit. These vibrations are called the *normal modes* (or eigenmodes) of the body. Each normal mode has its corresponding resonance frequency, producing a specific partial in the frequency spectrum of the note emitted from the vibrating body.

PARTIALS

As seen from above, the normal modes of a vibrating body generate partials. The distribution of these partials determines whether the sound can be considered to be harmonic or not; if the partials are evenly spaced, the tone sounds harmonic. To be able to discuss the importance of harmonic partials later, we need to take a first look at their musical significance.

Fig. 19.4 shows an example of the partial distribution in a harmonic tone with a fundamental at 200 Hz.

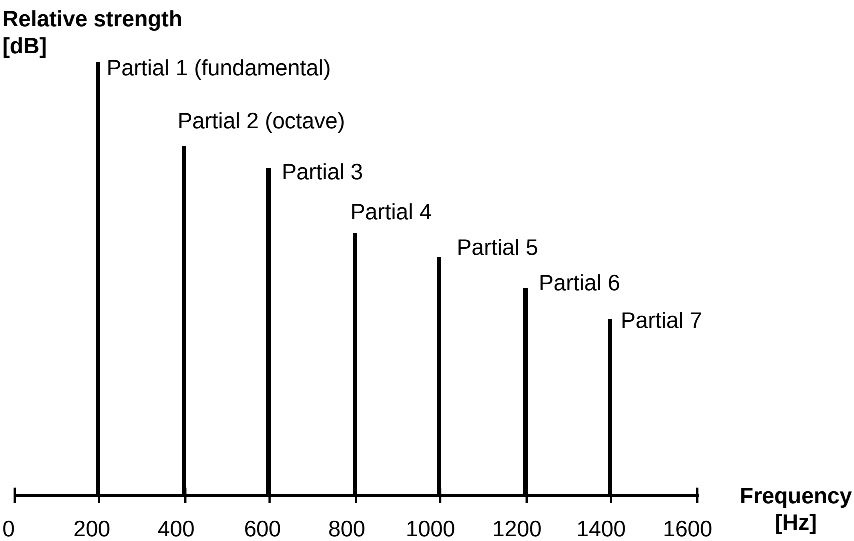


Fig. 19.4 Harmonic partials of a complex tone.

The table below shows how the same partials can be looked upon in a musical situation. The first row shows the partial number, the second its frequency, the third shows the step between two successive partials, and the fourth shows their musical interval related to the fundamen-

Partial	Frequency	Step interval	Interval relation to fundamental
1	200 Hz		Fundamental
2	400 Hz	Octave	One octave above the fundamental
3	600 Hz	Fifth	One octave and a fifth above fundamental
4	800 Hz	Fourth	Two octaves above the fundamental
5	1000 Hz	Third	Two octaves and a third above fundamental
6	1200 Hz	Minor third	Two octaves and a fifth above fundamental

tal. The table shows that the harmonic partials all have a relationship to the fundamental that can be derived from the musical scale. For instance, each doubling in frequency represents an octave step.

Musically, the intervals that sound most harmonic are, in falling order, the octave, the fifth and the third. If another note that has a pitch that is an octave or a fifth above the fundamental sounds together with the hit note, it will fall into its harmonic spectrum and support it. This has implications for the design of steel pans, which will be seen later in the chapter about layout.

MUSICAL INSTRUMENTS

All musical instruments have in common that they convert kinetic energy from the player into acoustic energy, i.e., to vibrations it the air. The player can transfer the energy to the instrument by blowing, bowing, plucking or hitting. In the search for a model of the tone generation in the steel pan, only instruments that are hit – percussion instruments – are of further interest.

Percussion instruments may employ strings, bars, membranes, plates or shells as sources of sound. The listing of instrument types below has been made according to the shape of the vibrating part of the instrument. It represents a scale of increasing complexity in tone generation, leading from the simple string of a guitar to the complex shell of a steel pan note.

String and bar instruments

The string is the simplest example of a vibrating body. The restoring force of the vibrations is supplied by the tension of the string. The

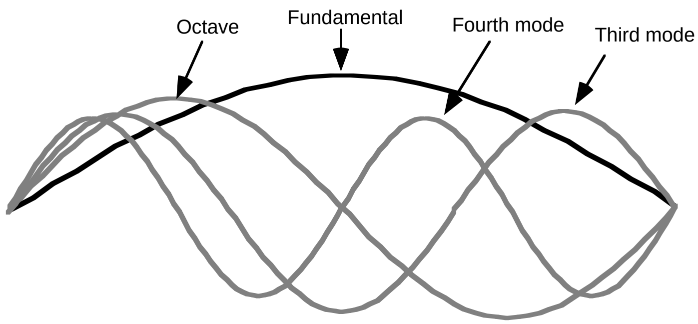


Fig. 19.5 Vibrational modes in a string.

frequency of the string vibrations is determined by three factors: The length of the string – a longer string yields a lower tone. The tension – higher tension yields a higher tone. The mass – a heavier string gives a lower tone. Strings generate harmonic overtones automatically. Fig. 19.5 shows the standing wave patterns of the lowest normal modes in a string.

For musical purposes, a bar may be seen as a string with one new property; its stiffness. The stiffer the material of the bar, the higher the frequency will be. In principle, the bar is acting like a string, but the restoring force in the vibration is supplied by the stiffness of the bar instead of the tension. The partials of bar instruments are not harmonic, but the lower partials can be tuned by thinning the bar at appropriate places. Examples of bar instruments are xylophones, vibraphones or triangles.

Membrane and plate instruments

A membrane may be thought of as a two-dimensional string. The vibration of a membrane is basically the same as the string, but here the vibrations can extend in several directions. In principle, a rectangular membrane acts as two independent strings; one along the length of the membrane and one across it. This means that there will be independent vibrational modes in both the directions, see fig. 20.2.

The partials of a vibrating membrane are seldom harmonic – they depend on the tension and the relative length of the sides of the membrane. Drums are the best examples of membrane instruments.

The next step in complexity is to make the membrane stiff. This yields a stiff plate. Vibrating plates bear the same relationship to membranes that vibrating bars do to strings. The restoring force is produced by the stiffness of the material, instead of the tension. The normal modes for a rectangular plate are approximately the same as for the rectangular membrane. The partials of a plate are not harmonic.

Shell instruments

Finally, if we make the plate slightly curved, we arrive at a physical shape that resembles a steel pan note. Theoretically, the note dent in a steel pan may be seen as a shallow *shell*. "Shallow" here means that the height of the arch is small compared to the size of the dent. The new acoustic factors introduced by the curving of the shell are the rise and the shape of the dent. Further, the fastening of the note in the pan surface makes it possible to introduce a tension in the dent.

The factors affecting the frequencies of the vibrations in a steel pan note represent the sum of all the factors of the less complicated resonators mentioned above, plus the two extra introduced by the arching:

- The size of the note
- The weight of the material
- The stiffness of the material
- The tension
- The rise of the arch
- The shape of the arch

The tension in a steel pan note is presumably not produced by stretching, as in the string. It is rather of a suppressive type, forced into the note when it is lowered during the tuning. According to acoustic theory, a suppressive tension applied on a vibrating body lowers the frequency of the tone. The existence of a tension in the steel pan note is is still to be proved.

The steel pan is classified as belonging to the instrument class of *idiophones*, which means that the pitch is determined by the shape and the internal state of the resonator. There are not any ready-made formulas for the calculation of the vibrational modes in such a complex shape as the steel pan note. A formula would have to include all the variables (factors) mentioned above and would be very complicated.

To entangle the situation further, the tone generation in a steel pan note seems to be very *non-linear* in its nature. This means that the variables involved in the tone generation affect each other in a way that makes it impossible to express the mechanism in a simple formula. For more about the non-linear tone generation, see below.

But some relief is to be found; my studies show that, as a first approximation, the steel pan note may be considered as an almost rectangular plate, disregarding the arching and the tension in the note. This means that the vibrational patterns of a rectangular plate (or a membrane) are to be found in a steel pan note, and that the study of the vibrational modes can be simplified accordingly.

20. Tone generation in steel pans

The shallow dent of a steel pan note is indeed a complicated resonator. No one has so far been able to explain how the steel pan works and why it generates such harmonic tones. As a physicist and a steel pan-player, I got curious and decided to try to find an explanation to the tone generation in the steel pan. Therefore, I started to do some part-time research at the Royal Institute of Technology in Stockholm.

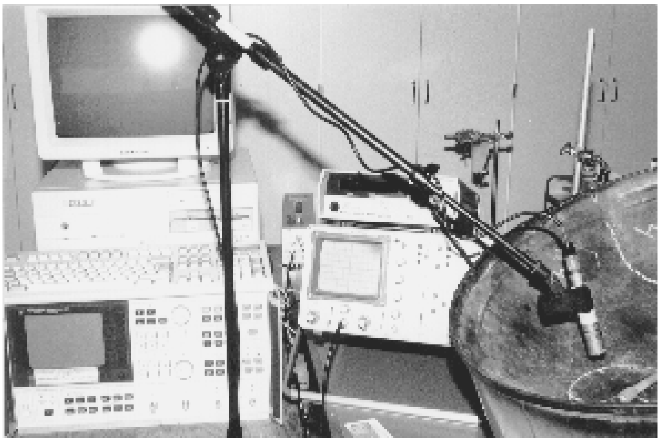


Fig. 20.1 Research on the steel pan. Experimental setup with (left to right) frequency analyser, computer, oscilloscope, frequency counter and microphone.

During the three years the research has been going on, I have made some measurements and I also have some preliminary results. In this chapter I want to present the findings from my work and what ideas and thoughts that will govern my future research on the steel pan.

My research started off with two simple questions:

(A) *How is the unique tone of the steel pan generated?*

(B) *How does the choice of material, design and crafting methods affect the tone?*

To make progress with these two main questions, I needed to know more about both the tone and the instrument. Therefore, I decided to focus my study to three fields:

(1) To register and understand the *acoustic properties* of the steel pan tone.

(2) To register and understand the *construction* of the instrument.

(3) To reveal the *relationship* between the acoustic properties of the tone (1) and the physical properties of the instrument (2).

The discussions with the tuners and the practical section of this book can be seen as main actors in the part of understanding the instrument. The laboratory work that is to be presented in this chapter represents the understanding of the tone. The rest of this theoretical section is a first attempt to explain the relationship between the construction and the tone.

MODES OF VIBRATION

A good steel pan tone has many harmonic partials; at least five or six that are strong relative to the fundamental, see fig. 19.3. The question is, how are these partials generated? If we disregard arching and thickness of the note and look at the note as a membrane, we get some clues to the normal modes generating the partials.

Fig. 20.2 shows a graphic view of standing wave patterns of the lowest three normal modes of a rectangular membrane. The lowest three modes of typical steel pan notes have been measured to be the

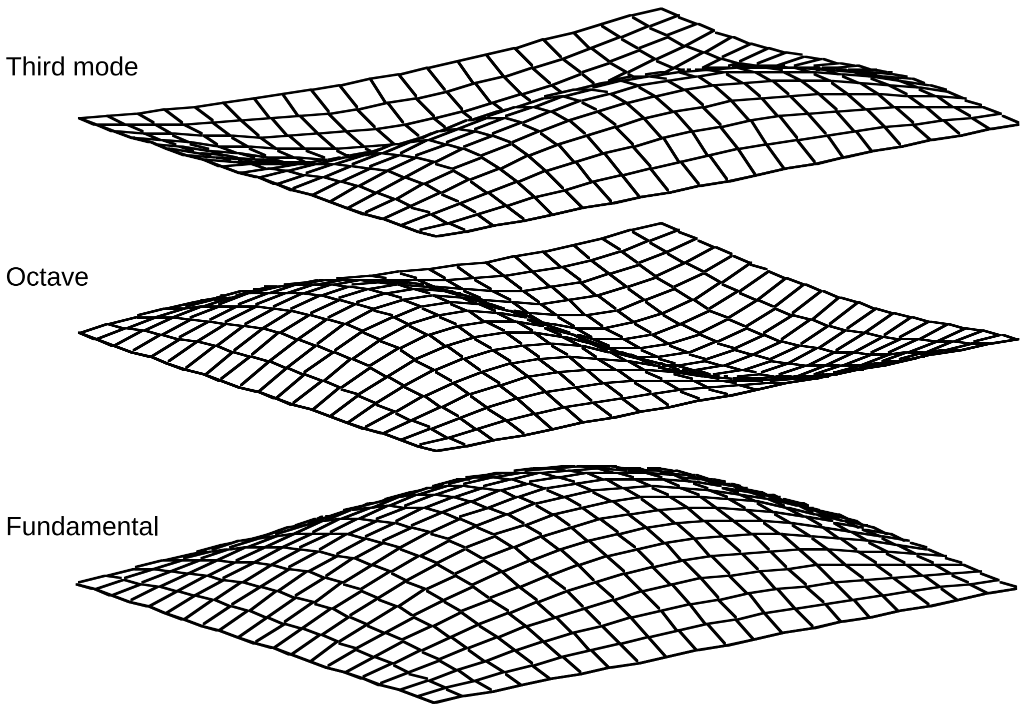


Fig. 20.2 The lowest three normal modes of a rectangular membrane, which are equal to the standing wave patterns of normal modes in a typical steel pan note.

same as these. Fig. 20.3 shows the lowest three modes of a steel pan note, together with cross-sections of the motions along and across the note.

The lowest mode, the fundamental, is easy to understand – the whole note is vibrating up and down like the head of a drum. This is equivalent to the situation in which two hypothetical strings stretched along and across the note would be moving up and down in their whole length, see fig. 20.3.

For the second mode, the octave, the note is vibrating up and down

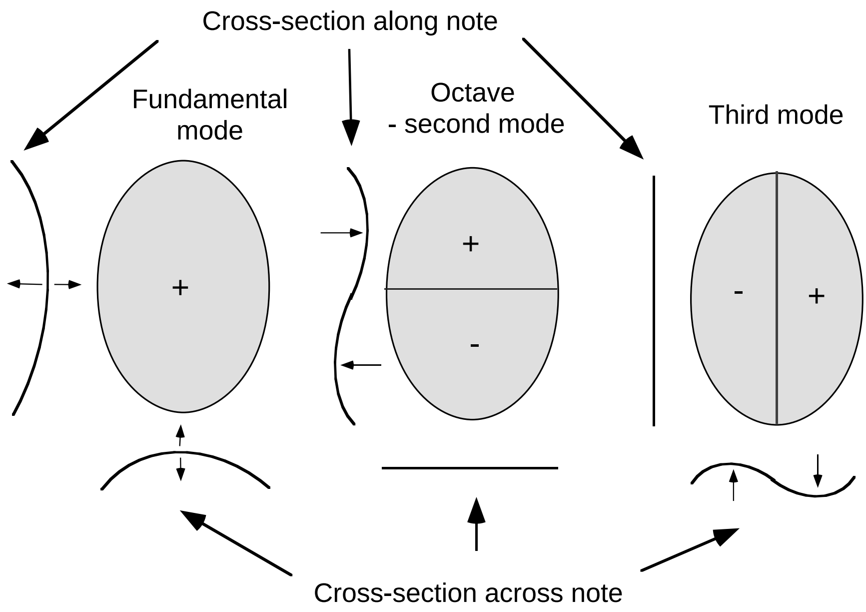


Fig. 20.3 The three lowest modes of vibration in a steel pan note.

twofold along its length. A node line – a part where the surface is standing still – can be found in the middle, see the dotted line in the second note in fig. 20.3. The existence of the octave mode is easy to prove by putting a finger in the middle of the note and striking it at one end. This damps the fundamental and generates a flageolet – the octave sounding alone.

The third partial is generated in the same way as the octave, but here the note is vibrating up and down twofold across. A nodal line can be found lengthwise in the note. This can be proved in the same way as with the octave, but is a bit harder to hear. Put two fingers along the dotted line of note three in fig. 20.3 and hit the note near the side, preferably with the hard end of the stick.

I have measured the frequency of the lowest three modes of several steel pan notes and examined their relation to the lowest three partials in the steel pan spectrum. This is easily done by driving the note at the measured partial frequencies with a tone from a loudspeaker and looking at its mode response. The result can be seen in fig. 20.4.

HIGHER PARTIALS

From the discussion above, we see that the lowest two harmonic partials in the steel pan tone can be explained as generated by the two lowest vibrational modes of the note. But what about the higher partials?

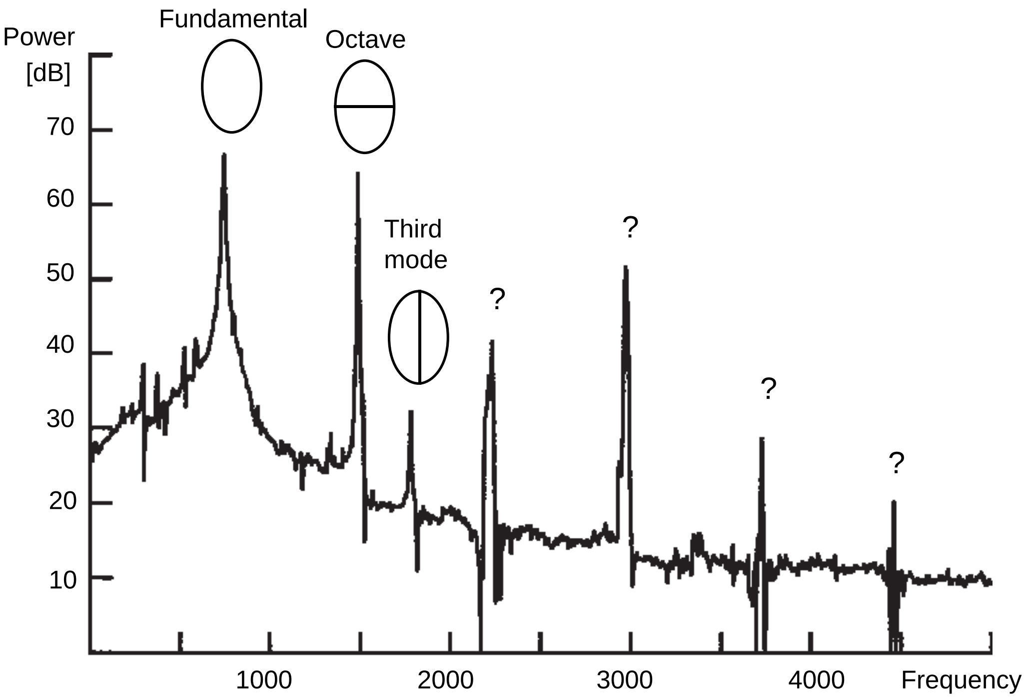


Fig. 20.4 Relation between normal modes and partials in a steel pan note. Nodal lines of the modes indicated above corresponding partial peaks in the diagram. (Frequency measured in Hertz.)

According to the measurements they are present in the tone, but the modal theory does not seem to be able to explain their existence. In fact, the third mode of a steel pan note often generates a partial that not is harmonic, see fig. 20.4. It often sounds with a tone that is one octave plus a third or a fourth above the fundamental.

The theoretical value for the third partial in a harmonic series should be one octave and a fifth above the fundamental. As seen from fig. 20.4, the tone of a steel pan has a partial that matches this harmonic interval perfectly, but it does not come from the third mode of vibration. A suggested explanation of the generation of higher partials can be found in the chapter about non-linearity.

When looking at the onset (the beginning) of a steel pan tone, one notices that the higher partials tend to arrive a bit after the beginning of the tone. My measurements show that they arrive about 20-30 milliseconds later then the onset of the fundamental, see fig. 20.5. In ordinary percussion instruments, the higher partials usually arrive at the onset, together with the fundamental.

The notion that the higher partials tend to arrive later in the steel pan tone suggests that they are not initiated by the stroke. It rather seems that they are generated by some other mechanism that needs a few milliseconds to start working.

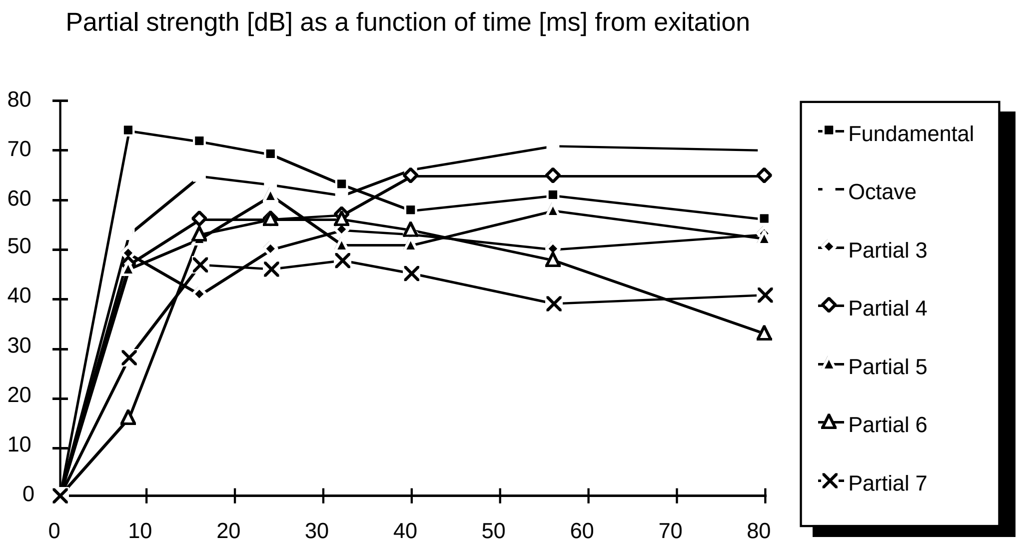


Fig. 20.5 Relative strength of the partials during the first 80 milliseconds of a steel pan tone.

NON-LINEARITY

The contradiction that the frequencies of the normal modes of the steel pan note do not have a harmonic relationship but the frequency spectrum still shows a large number of harmonically spaced partials, reveals that the higher partials must emanate from some other source than the vibrational modes. My hypothesis at this stage is that the harmonic partials are generated by a non-linear "distortion" process of the vibrations in the note, but this still has to be fully explained and proved.

The non-linearities may be introduced in the tone generation by the shape of the note and its tension. These properties will make the note move asymmetrically when it is vibrating, probably moving a bit easier and farther upwards than downwards. If the note moves asymmetrical, the vibration of the fundamental will also start to generate overtones.

This would explain why the higher partials arrive later: Only the lower normal modes are exited by the stroke and the higher partials are then generated later by the shifting of energy from the fundamental mode to higher frequencies.

This non-linear "distortion" process may be compared to the situation where a pure sine wave is the input to an amplifier that tries to output it beyond its range of power. The output tone will then exhibit harmonic overtones. You might say that the fundamental mode of the note acts like a sine wave, but it is forced to generate overtones by the asymmetric shape and tension of the note.

To speculate further, it seems as if the harmonic spectrum of the steel pan tone is generated by some intricate interaction between the non-linearities of the fundamental and the octave mode. The octave mode of the note also generates a series of harmonic overtones when it is vibrating. These overtones will be equally spaced over the frequency axis, but with an interval that is equal to the frequency of the octave. If the fundamental has a frequency of 200 Hz, the octave will be at 400 Hz. Then the partials generated by the octave mode will be found at 800 Hz, 1200 Hz, 1600 Hz, etc. This means that they will coincide with every second overtone of the fundamental. The cooperation between the harmonic spectra of the fundamental and the octave would explain why the partials with even numbers (2, 4, 6, etc.) are stronger than the odd numbered partials, see figures 19.3 and 20.4.

If a proper harmonic spectrum is to be generated, the octave has to be tuned to a perfect two-to-one relationship to the fundamental. If the octave is only a few *cents* (100 cents equals a half-tone interval) away from its exact value, the sound of the note will be dissonant. This can also be seen in the spectrogram, which will show a tone with double partial peaks, see fig. 20.6

My thoughts about the generation of higher partials have eventually led me to form a working-hypothesis. The following is a conclusion of the hypothesis that will govern my future research on the steel pan, together with some measurements that support it:

Hypothesis regarding the mechanism for generation of harmonic partials in steel pans

"The harmonic partials above the octave in a steel pan tone are not *generated by vibrations of the higher normal modes of the note, but by a non-linear process involved in the motion of the fundamental and the octave modes."*

The measurements supporting the hypothesis are:

1. The frequencies for measured normal modes of order three and four do not fall into the harmonic spectrum of the tone. Mode three is sometimes too high, sometimes too low, seldom in the harmonic spectrum. Mode four seems to be most often too high. Measured harmonic partials, on the contrary, are all spaced with exactly equidistant intervals.
2. After striking the note, the fundamental reaches its maximum

within a few milliseconds (ms) and the octave within 15 ms. The higher partials reach their peaks after 20-30 ms. This indicates that the higher partials are not generated by the stroke.

3. A note driven by a pure sine wave at the frequency of the fundamental responds by emitting a tone containing a large number of harmonically spaced partials.
4. If the frequency of the driving sine wave is varied, the higher partials are more sensitive to these variations than the fundamental and the octave. A variation of ±2 Hz gives as an average a 30 dB difference in the higher partial level, whereas the corresponding difference for the fundamental and the octave is about 10 dB.

More focused measurements in the future and the development of a refined model will have to reveal if this hypothesis can be considered to be valid for the tone generation in steel pans.

Non-linear effects are present in all instruments but so far the acousticans have paid little attention to them because the tone generation of regular string and wind instruments can be explained fairly well by linear models. But to the steel pan, the non-linearities seem to be the foundation of the tone generation. Therefore, my belief is that a future

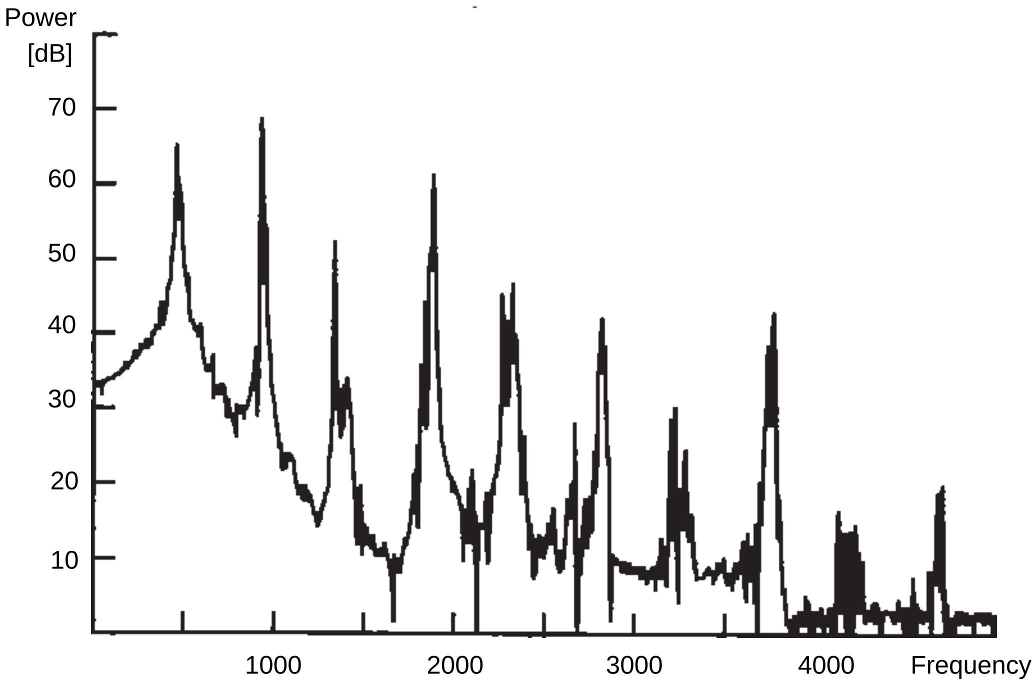


Fig. 20.6 Spectrogram of a dissonant steel pan tone. (Frequency measured in Hertz.)

theoretical model of the tone generation in steel pans has to be non-linear.

The final notion will be that – whatever the mechanism – the tone generation in the steel pan does not work like any other tonal instrument. The only instruments that seem to have a similar tone generation are cymbals and gongs.

21. Material

Just as it is important to choose the right wood for string instruments, the metal is important to the steel pan. The choice of metal is even more crucial for the pan, as the steel is the primary source of the sound in the pan, not only acting as an amplifying resonator as the wood of string instruments.

QUALITY

First, the quality of the metal is vital to steel pan fabrication. The steel that is used for the drums is a compound that, besides the iron, contains small amounts of carbon (0.1-0.2%) and manganese (0.4-1.4%). The concentration of these added substances determines the mechanic and acoustic properties of the steel.

One major problem for the community of panmakers seems to be their lack of control over the raw material. The reason is that, during the evolution of the pan, the tuning has come to put more extensive requirements on the steel quality than the drum's original purpose as a container does.

A first step towards a solution to this problem would be to analyse the metal of a well-sounding instrument. A documentation of the exact content of carbon and other substances in the steel would be of good help in the choice of raw-material. I have taken some samples, but I have not had the opportunity to analyse them yet.

The next step would be to get a steel mill to deliver raw material according to this specification and have a steel drum factory to produce high quality drums especially for steel pan making.

Further measurements, stating within which ranges the content of the various substances could vary and still make a good instrument, could also give clues to which factors in the properties of the metal that are important to the tone generation.

THICKNESS

The thickness of the steel affects the resonance frequency of the note. Thicker metal is stiffer and therefore it produces a higher pitch in a note with constant measures. But thicker metal is also heavier. This lowers the frequency, which will counteract the effect of the stiffness. The acoustic effect of changes in thickness has to be measured to reveal what the net result will be. Suitable experiments would be to add chromium or grind off material successively and do measurements of the frequency spectrum.

Another important acoustic effect of the thickness is that an increased mass can conserve a larger amount of energy. Notes with thicker metal can take harder hitting without ”breaking” in sound. This means that they are capable of receiving and radiating more sound energy – the instrument will be more powerful.

But thicker metal also means that it will be more difficult to get the notes to vibrate – to excite them, which can result in a problem for the small notes in tenors and double tenors. Measurements show that the sinking of a tenor makes the metal about 30% thinner in the middle. The thinning in the middle is of benefit for the higher note that will be located there, because the reduced stiffness will make it easier to get them to vibrate. This might be one of the reasons for sinking the higher pans deeper and putting the higher notes in the middle.

CRAFTING

The acoustic effects of the crafting work are shaping the metal, making it softer and forcing tensions into it. The softening of the metal occurs because the initial crystal structure of the metal is destroyed when it is re-shaped. A new crystal structure is later established by the tempering, and this restores some of its former hardness.

One reason for doing the backing, besides the shaping of the note dents, could be to force a tension into the notes by compressing the metal in them. This possible tension could later be conserved by the groove in the metal and by the tempering. If there is a conserved tension introduced by the backing, it would presumably result in an expansion force, acting to push the sides of the note outwards. According to acoustic theory such a tension lowers the pitch, see the chapter about tone generation above.

If the effects of the manual crafting work could be neglected, it would be possible to use machines and do the sinking and the backing with mechanised methods. The sinking has already been mechanised at MIC – Metal Industries Corporation, and some claim that it works, while other say the opposite.

It is practically impossible to do any laboratory experiments on the acoustic effects of the crafting. Future field experiments will have to determine if it is possible to press-form the whole pan.

TEMPERING

Another source of problems for the tuners seems to be the rather uncontrolled method for tempering and the lack of theoretical knowledge of what happens to the metal during the heating. The most important effects of the tempering are presumably an anneal (removal of tensions) and a hardening.

The crafting introduces many tensions and local differences in hardness in the metal due to an effect that is called a *cold-hardening*. When the metal is hit with a hammer it gets hot in the spot where it is hit. But the heat is quickly led to the surrounding metal, which results in a fast cooling of the heated spot, which has a hardening effect.

The most significant effect of the tempering is presumably the anneal, which removes this cold-hardening and the uneven tensions put into the metal during the grooving and the backing. If they were left, they would disturb the delicate physical conditions in the note and make proper tuning impossible. The anneal should result in notes with an even tension over their whole surface. This anneal is presumably the main reason why quality steel pans can't be made without heating.

Beside the anneal, the steel also seems to be affected by two other processes during the heating: First, it is hardened by the reorganization and fixation of the new crystal structure in the metal by the heating and the cooling. Second, there seems to be an oxidation of some of the carbon content of the steel, making it more stretchable. Carbon is initially put into the steel to make it hard.

The most critical part of the tempering is to balance the two processes against each other. If the pan is heated too little, it will not be tempered enough, making it soft and unstable during the tuning. This problem can be solved by heating the pan again, this time a little longer.

If the pan, on the other hand, is heated too long, too much of the carbon will oxidise, making the metal too stretchable and thus impossible to tune. Unfortunately, there is no way to redo the tempering if the pan is burned too long. The existence and the acoustical significance of these two processes have to be investigated further by analysing the metal before and after the heating.

The next vague point of the tempering is the cooling of the pan. Some tuners use water, some use oil, but nowadays most tuners don't seem use anything at all. They just let the pan cool by itself in the air.

People that are knowledgeable about metals tell me that it is impossible to temper without using any cooling liquid. This would only result in an anneal. But the tuner doing the practical work knows that the pan feels harder after the heating. This is a contradiction that needs to be investigated further in cooperation with metallurgists.

Future solutions to the present problems would be: First, an investigation of what happens in the metal during the tempering. Second, measurements of a properly done tempering. Third, development of a controlled tempering method, such as the use of an oven.

22. The "sink"

There are at least three acoustic reasons for sinking the bottom of the drum: First, to remove the low tone in the bottom. Second, to make the metal thinner in the middle where the highest notes are to be put. And third, to make an overall curvature that is suitable for the notes of the different pan types.

The most obvious acoustic reason for sinking the bottom of the drum to a round basin is that the spherical shape has a very high resonance frequency related to its size. This means that any tones generated by vibrations in the sunk bottom will be well above the pitch of the notes.

The deeper the pan is sunk, the thinner the metal will be in the middle. Thinner metal is presumably beneficial for the tone generation of the higher notes, see the chapter about material. This may be one of the reasons why small notes in the outer ring often sound poorly and higher notes usually are put in the middle.

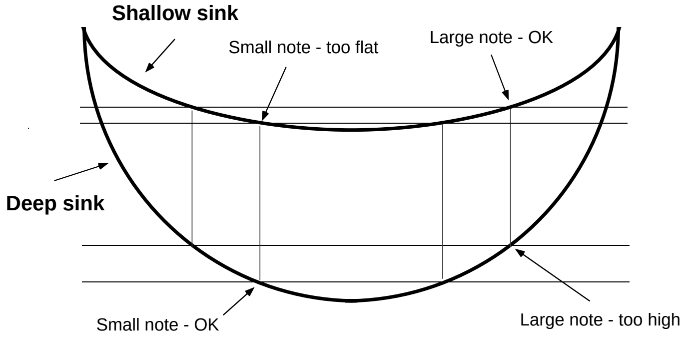


Fig. 22.1 Relation between sink shape and note height.

There also seems to be a certain relationship between the size of the notes and the needed overall curvature of the pan – small notes need a rounder arch of the sink while large notes need shallower sinking to get the right height. If a large note was made in a pan that is deeply sunk, its arch would presumably be too high to generate a good steel pan tone, see fig. 22.1.

The intricate relation between the shape of the sink and the note size is presumably due to the very special, cylindrical shape of the note dents. When elliptical notes are shaped in the sunk concave surface, the resulting note arch will be cylindrical with its largest curvature across the note. The length axis of the note is almost flat, a result that well coincides with the fact that most of the partials are generated from vibrations along the length axis of the note, see fig. 24.3 and the discussion of note arch further down.

23. The groove

When a steel pan note is vibrating, some of its vibrational energy is transmitted into the air and to the rest of the pan, but the main part is reflected back and conserved in the note. The acoustic purpose of the groove seems to be to provide this conserving mechanism. Tuner Denzil Fernandez says: ”The purpose of the grooving is to create boundaries where-by a transverse wave can be generated and trapped within the region of each boundary.” This notion seems to be in accordance with acoustic theory.

The groove presumably introduces a local difference in what is called the acoustic *impedance* of the metal. The acoustic impedance is a property of the metal that describes how difficult it is for sound waves to travel through it. The harder the material, the faster and easier the sound waves travel, and the less the impedance. The grooving ”breaks” the crystal structure of the metal and makes it soft, forming a ”joint” that acts as an acoustic impedance barrier. When the vibrational impulses in the note reach the barrier they are reflected back into the note.

GROOVE HARDNESS

Harder grooving will presumably result in an increased difference in the acoustic impedance. This will result in a more effective reflection, which means that less acoustic energy will leave the vibrating note. The less the amount of energy that is lost to the surroundings, the longer and weaker the tone will be.

The bore pan, presented in the section about developments, presents a way to study the effect of the groove joint: If the holes are made closer to each other the border will be softer. Denzil Fernandez' experiments show that this makes the tone longer and weaker, which proves that the energy is conserved better in the note.

It is fully clear that no one can make a steel pan without grooving it, but the needed amount of grooving impact is still to be revealed. My studies show that it seems to be enough to make a light groove, whose mark is barely visible in the metal of the finished pan. Presumably, this disturbs the crystal structure enough to create a sufficient acoustic impedance barrier. Future experiments with controlled mechanical grooving may reveal the effect of the groove hardness.

GROOVE WIDTH

The width of the groove presumably doesn't have any acoustical significance. But it should not be wide enough to generate any internal resonances by reflection of sound waves, i.e., the width should be less than 10-15 mm.

24. The note

The note properties that most affect the tone are the size, the shape, the tension and the arching of the note.

NOTE SIZE

The size of the note is the property that most obviously affects the tone. The size of the vibrating dent is crucial for the pitch – the larger the dent, the lower the tone. This is analogous to the situation in a guitar string or a horn, where a longer string or a longer horn results in a lower tone. But it is not as simple as in a string, because in a steel pan, notes of equal size can have different pitches, due to varying height and shape of the dent.

Another complicating ingredient in the pan is the fact that the size of the vibrating dent is not the same as the size of the note. The acoustic "size" of the note is not set by the boundaries defined by the groove, but rather by the ending of the dent arch. The size of the sounding dent is always less than the area restricted by the groove, see fig. 24.1. This is proved by the tuning, where a hit from above near the side of the note decreases the note-size and thus raises the pitch.

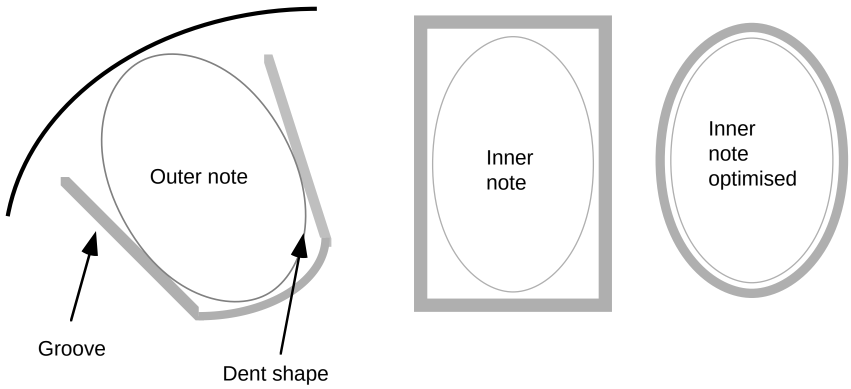


Fig. 24.1 Note dent shape in relation to groove border.

The optimal note design seems to be when the dent has the same size as the area inside the groove. In this way no space is lost. But this is a critical situation; if the note area is made too small it will be impossible get the pitch low enough. If the note is a little too big, you can always make the dent a bit smaller inside the groove. This safety-measure is the reason why the notes usually are a bit larger than they need to be. There seems to be a trend towards making the notes smaller and smaller. This is primarily done to be able to put more notes in each drum, but it may also have acoustical implications, such as minimizing the loss of acoustic energy.

I have measured the note sizes of various pans as a part of my research. It would be plausible to think that notes with the same pitch

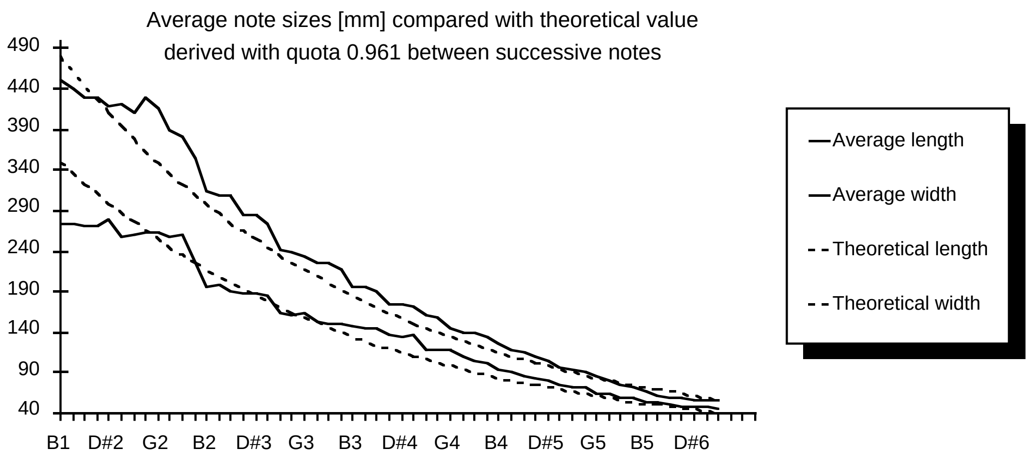


Fig. 24.2 Average note sizes.

on different pan models could have the same size. Therefore, I have compiled the data in a graph on the average length and width for each note on the musical scale, see fig. 24.2. By looking at this graph, a tuner can get a hint as to which notes of his design that can be made smaller. Please note that the lengths and widths in fig. 24.2 are measured from the groove, not on the actual note dent.

According to tuner Denzil Fernandez it is the *area* of a note that determines its pitch. He has calculated the ratio between the areas of successive notes to approximately 0.94. This means that the area of a note always is 94% of the next larger one. Converted to a ratio between lengths this will be 0.97. As a comparison, lines following this theoretical ratio have been drawn in fig. 24.2.

It would seem like an easy and straightforward project to study the relation between the note size and the pitch. But the diffuse ending of the note dent arch and the other variables affecting the pitch have made it difficult to establish a simple relationship between size and pitch. A way to progress with these studies could be to make a number of dents that exactly fill some notes with pre-defined sizes, and then try to tune them as low as possible. Such an experiment would give a practical measure of the minimum note sizes.

NOTE SHAPE

The first thing to say about the note shape is that the shape of the area delimited by the groove has little to do with the shape of the actual vibrating dent. The groove area can be of any shape, as long as the groove surrounds the dent, again see fig. 24.1. It is the shape of the dent that is important for the acoustic properties. Theoretically, the relation between the length and the width of the note should determine the frequency relationship between the fundamental, the octave and the third mode of vibration. It is still to be revealed if this is the case in practical tuning.

In old steel pans, the inner notes were often round, but nowadays they are elliptical. The upper line in fig. 24.2 represents the length of the notes and the lower line represents the width. The relationship between the width and the length is about 2 to 3 (0.65) for notes in the outer ring and about 6 to 7 (0.85) for the notes in the inner ring. This means that the smaller notes are more round in their shape, while the outer are more elliptical. Tuner Denzil Fernandez says that he is working with an average ratio that is 5 to 6 (0.83). The optimal ratio between length and width is still to be revealed.

ARCHING

The arch shape of the note dent is the most difficult property to measure, describe and relate to the tone. To a tuner, its effect on the tone is obvious, because the note needs a very special arch to generate a good steel pan tone. But how do you measure and describe an arch technically?

I started with the intention to measure the heights of various notes to see how they were related to their sizes and pitches. My first measurements revealed that the notes had one height when they were measured lengthwise and another when they were measured across. The reason for this was the lack of a well-defined plane to relate the heights to. I had related my measurements to the groove, which followed the spherical shape of the basin.

Then I started to use a shape-mould and realised that the note dents are fairly flat in their length direction, and more curved across, see fig. 24.3. I found that the quota between height and length is most often less than 1%, whereas the quota between height and width is about 2.5%, which means that a note that is 10 cm across is 2.5 mm high. The length axis seems always to be flat, regardless if the length axis of the note is oriented radially or tangentially in the pan.

The cylindrical arch is likely to be due to the cross-section between the spherical concave shape of the pan and the elliptical shape of the note. To get a better view of the arch shape, I did an experiment: I made a spherical ball of clay and then I pressed objects of various shapes against it to make indentions in it. To get a shape like an elliptical steel pan note, I had to use a cylindrical rod, see fig. 24.4.

The cylindrical arch of the dents seems to agree with the acoustical behaviour of the note. Presumably, the non-linear tone generation mechanism works best when the note is almost flat in the lengthwise direction. According to my hypothesis, the note behaves like a non-linear string in its length direction, and these vibrations generate all the high partials. If you listen to the vibrational modes across the note, you will find an acoustical behaviour that is

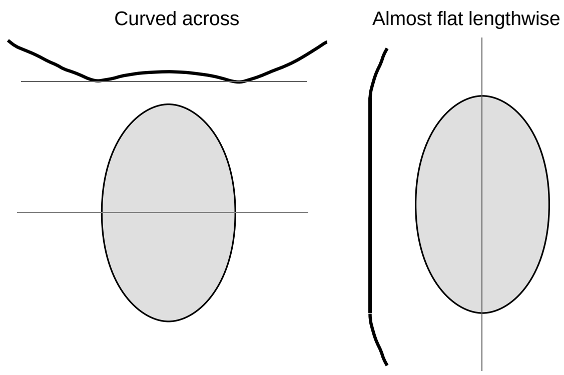


Fig. 24.3 The arch shape of a note.

much more like a shell (or a bell) with a hard and metal-like sound.

Thus, the optimal arching of a steel pan note seems to be very close to the cylindrical, raising less than one percent lengthwise. The more flat the note is lengthwise, the more partials it will generate. But a flat note will also be less stable and it will be very sensitive to strokes that tend to change its shape. Therefore, the tuning result will have to be a compromise between an ample overtone generation and considerations to keep the tone stable.

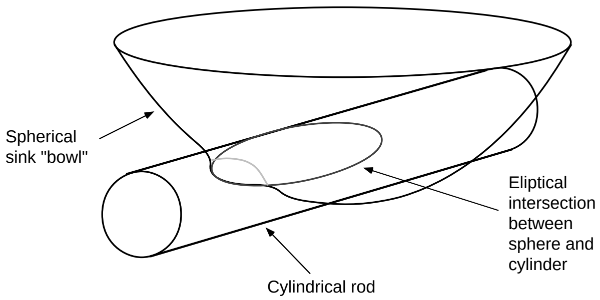


Fig. 24.4 Reproducing the cylindrical arch of a note by pressing a rod against a sphere.

There are two different tuning philosophies related to the shape and the corresponding generation of partials in the note. The first, that can be called the ”steelband” philosophy, is to shape the note with a rather high arch. Notes of this type will demand a relatively strong stroke to produce harmonic partials – to get right timbre. On the other hand, the note will be able to produce a strong sound without ”breaking”, i.e., producing a harsh, distorted sound. Due to the relative stiffness it will also stay in tune longer.

The other school of tuners, which can be called the ”jazz” or the ”soloist”, makes the notes more flat, which will make them produce a brilliant sound with many partials at relatively modest playing levels. This is good for solo or electrically amplified playing, but the flat note will produce a weaker tone and is easier played out of tune.

The best way to go further with the discussion about the shape of the arch would be to refine the measurements by using holographic methods to study the shape and the wave-patterns in the vibrating dents.

TENSION

As mentioned earlier, two notes with the same area can have quite different pitches. This is due to the arching of the note – a higher dent yields a higher pitch. This pitch change can be caused by changes in the geometric relations of the dent but also by variations of the tension in the metal.

When a note is tuned, it is first stretched. This may result in a plastic deformation by the hammering from underneath. This stretching of the metal raises the pitch.

It is likely that the lowering during the tuning removes the stretching tension and it is substituted by a compressive tension that lowers the pitch further. This occurs because the plastic de-formation can't be compensated by a plastic "re-formation". This means that the stretched metal is not moulded together, but forced into the arch. The suppressive tension will give the note a lower pitch with the same arch height as before.

One thing that indicates the existence of suppressive tensions in steel pan notes is the notion that they tend to raise when they are played out of tune. If the only effect of playing would be that the dent was lowered by the hitting, the result would be the opposite – lowered pitches. My hypothesis here is that the playing successively releases the suppressive tension from the note, which will result in raised pitches.

It has not yet been possible to do any measurements to verify that there are any tensions in the notes of the steel pan.

TUNING

The measurements showing that the notes are cylindrical in shape and the hypothesis for non-linear partial generation give us some new clues to the secrets of steel pan tuning. There are three properties of the note that the tuner can modify while he is tuning: the size, the arch and the tension.

Variations in the area have most effect on the fundamental mode of vibration. Changes in the length affect the octave mode, whereas changing the width affects the third mode that is responsible for the timbre.

The shape of the arch is responsible for the generation of higher overtones and has to be adjusted to be sufficiently flat. The tension, last, seems to affect mainly the pitch of the fundamental.

The non-linear mechanism for tone generation shows the importance of tuning the fundamental and the octave to a perfect 1:2 frequency relationship. The secret of good tuning is to change the frequency of the fundamental and the octave separately so that they will meet at the right pitch. If the above mentioned hypothesis holds true

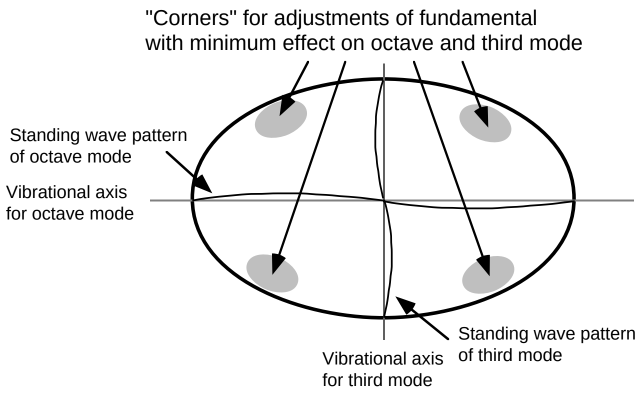


Fig. 24.5 Places to tune the fundamental with minimum effect on other modes.

and the area and the tension are mainly responsible for the frequency of the fundamental, this gives us a simplified model for the tuning: The fundamental can be changed without affecting the octave by hitting the note along the sides. This will affect the third mode, but the pitch of the third mode is not as critical as the octave.

The best place to use for changes of the fundamental, with a minimum of impact on the octave and the third mode, would be the "corners" of the elliptical note, see fig 24.5. Lowering the note here will affect the area with a minimum of change in length and width.

The best way to adjust the octave is to re-shape the dent lengthwise – by hitting it at the ends, along the vibrational axis in fig. 24.5. These adjustments will also affect the fundamental, but to a lesser extent than the octave.

The tuning will have to be a balancing act, adjusting the area, the length, the width, the arch and the tension at the same time. The area and the tension should be adjusted so that the fundamental is right, while the length is right for the octave. At the same time, the arch shape has to be the very special one that generates harmonical overtones. The last consideration is that the width of the dent should place the third mode at a frequency that has a harmonic relationship to the fundamental.

25. Layout

The layout of the notes in the pan is, of course, important for the ergonomy of the player. But there are also important acoustical considerations in the positioning of the notes in a good pan. As the whole pan vibrates every time a note is struck, it is important that the notes that are vibrating the most sounds well together.

To understand the theoretical foundations for a good note layout it is useful to know the musical relations of the partials of a harmonic tone, see the chapter about partials above. The intervals that have the most harmonic relationship are the octave, the fifth, the fourth and the third. If notes at these intervals ring together with the struck note, they will support its harmonic spectrum. Therefore, a favourable design is to put these notes close to each other.

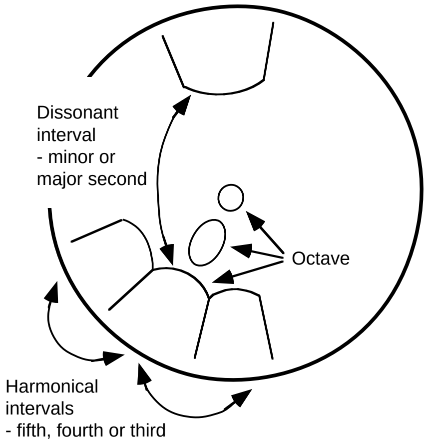


Fig. 25.1 Principle for a harmonical distribution of notes.

The general idea for a good note layout in steel pans is to position notes with a harmonic relationship as close to each other as possible, while placing notes with a non-harmonic relationship as far apart as possible. A design notion that is valid for all steel pans is that the octave counterparts always are placed close together. Fifths, fourths or thirds are also consequently placed close to each other in some pans, as in the fourths-and-fifths tenor and the quadrophonic pan with their ingenious designs.

Notes with a non-harmonic relationship – as the minor or the major second – are usually placed as far apart as possible, preferably in separate drums. If the notes with semitone intervals are spread consistently over different drums, pans with different numbers of drums will have correlated minimum intervals that have to be placed in the same drum: Two drums – a major second, three drums – a minor third, four drums – a major third.

If notes with a dissonant harmonic interval – one or two semitones apart – have to be placed in the same drum, they are usually placed on opposite sides of the drum, see the layouts of the tenor and the double second in appendix A. On the other hand, if the smallest interval between the notes that have to be placed in the same drum is harmonic, the notes are put close to each other to support each other's harmonic spectra, see the quadrophonic pan and the triple cello in appendix A.

The acoustical implications of a good layout are that it will make the pan sound better and make it easier to tune. A pan with more octave notes will be harder to tune due to the interaction of the notes. But it will also be easier to get a good tone in the end, because the notes in the upper octave will support the lower ones with higher partials. This is very easy to demonstrate; just put a finger on a high note while playing on its lower octave counterpart – this will usually make the brilliance of the lower tone disappear.

”ROADS” BETWEEN NOTES

The acoustic function of the ”roads” – the space between the notes – is to damp the acoustic waves coming from the vibrating note before they reach the surrounding notes. This means that an increased distance (or a double groove) reduces the interaction between two adjacent notes.

The more dissonant the relation between two notes, the more they need to be separated. On the contrary, the better the acoustic separation between the notes, the less the need will be to keep the dissonant tones apart.

Sometimes, ergonomic or construction considerations are judged to be more important than the acoustical ones. The double tenor is an example of this. A double groove has been introduced to make it possible to put dissonant notes close together and still have a well-sounding instrument with many notes in it, see appendix A.

Pans that are designed with harmonically sounding notes close to each other, as the fifths-and-fourths tenor, may have adjacent notes put close together, with just a single groove between them. Octave counterparts should always be put as close together as possible, to enable positive feedback.

26. The skirt

The skirt of the pan has two major acoustic functions: First, its length determines the volume of the resonant cavity of the pan. Second, it keeps ringing after a note is struck, giving the pan a natural reverberant sound. A third possible function may be that it acts as some sort of counter-vibrator for the notes in the outer ring. Some of the notes in the outer ring lose their energy when the side is rested against a firm surface. This implies that there is an exchange of energy between the note and the side and that the side may be important for the sound radiation from the pan. The interaction between the side and the notes is still to be further examined and explained.

The length of the skirt determines how the sound produced by the notes will be coloured on its way out into the air. The sound waves emitted from the pan tend to ”creep” around to the backside of the

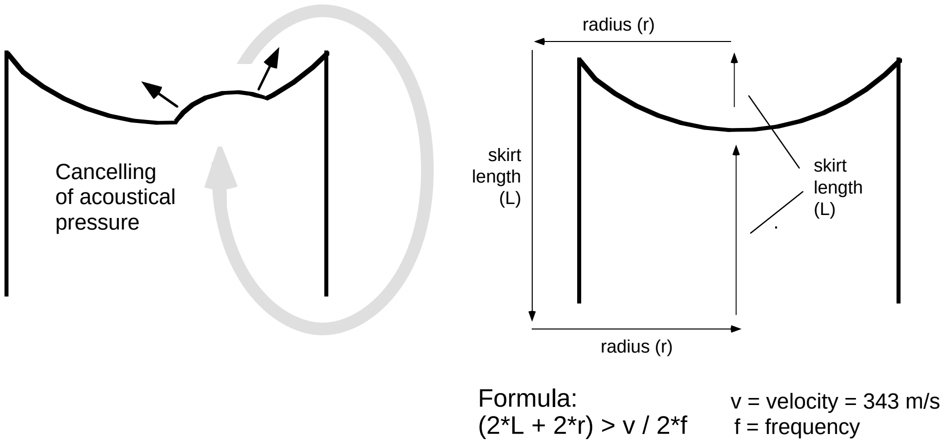


Fig. 26.1 Acoustical effect of the skirt.

playing surface and cancel the produced air pressure, see fig 26.1. If the surface of a note still is moving upwards when the sound wave reaches around, this will cancel the produced sound pressure.

This cancelling effect will be most predominant for the lower notes, as a note is vibrating slower when it is producing a low tone. If the side of the pan is made longer, it will take a longer time for the waves to reach around to the backside. This will move the cancelling effect down to lower frequencies. A physical formula for this tells us that the total length the sound has to travel should be more than the half wavelength of the sound, if no cancelling effect is to occur.

If the side of a tenor is 15 cm, the average length between the front and the backside will be about 80 cm, see fig. 26.1. This means that all notes below 277 Hz (A3) will tend to cancel and therefore be weak in sound. Fortunately, this is below the range of the tenor (lowest note D4).

But what if we were to design a cello pan that goes down to B2 (123 Hz)? The formula tells us that the side would have to be at least 40 cm. The side of a regular cello is about 45 cm, so this is in accordance with the theory. What about a six bass with lowest note B1 (62 Hz)? This gives a side of minimum 100 cm, which is about 10 cm more than the length of the standard steel drum. This indicates that basses may be improved by lengthening the side.

As the resonant effect of the skirt doesn't affect the pitches of the notes, it is possible to make pans of the same model with very different side lengths. The length is chosen according to the desired sound "colour" of the pan, see appendix A. The lower the pitch, the longer the side.

The reverberation effect of the side will be more prevalent the longer the side is. The reverberation will also tend to have a pitch of its own. A long side will have a low pitch and a shorter side will have a higher pitch. But the pitch of the skirt is so low that it will not interact with the notes, just ”colour” the sound with a constant low tone, resulting in the typical steel pan timbre.

27. Sticks

Last in this discussion of the theoretical implications of the various parts of the pan, we have to take a look at the sticks. While the sticks are not a physical part of the instrument, they still play a very important role in the tone generation.

To get a sound out of a musical instrument you have to get it to vibrate in some way – to put energy into it. This is called the *exitation* of the note, and the properties of the exiting body are of vital importance for the tone. The properties of the stick that may have importance for the tone are: weight, length and hardness.

WEIGHT AND LENGTH

The importance of the weight of the stick is easy to understand. The heavier the stick, the more energy can be transferred to a note when it is hit. This means that a heavier stick gives the pan a stronger tone, but on the other hand you risk getting a sound that ”breaks”. It is also easier to hit the notes out of tune. The same thing goes for the length – a longer stick makes louder playing possible. The acoustical implications of the weight and the length as such can almost be disregarded, as they can be seen as a part of the stroke, the force of which the player can vary within a wide range.

HARDNESS

To get a good sound out of a pan it is important to have sticks with the right hardness. If the sticks are too hard, the sound will be harsh with a weak fundamental and many non-harmonic overtones. If they are too soft the tone will be weak and muffled. Small notes need a hard stick and big notes need a soft stick to sound good. This means that ideally you should use sticks with varying hardness for the different sized notes in one pan. This is not possible, of course, so you have to compromise.

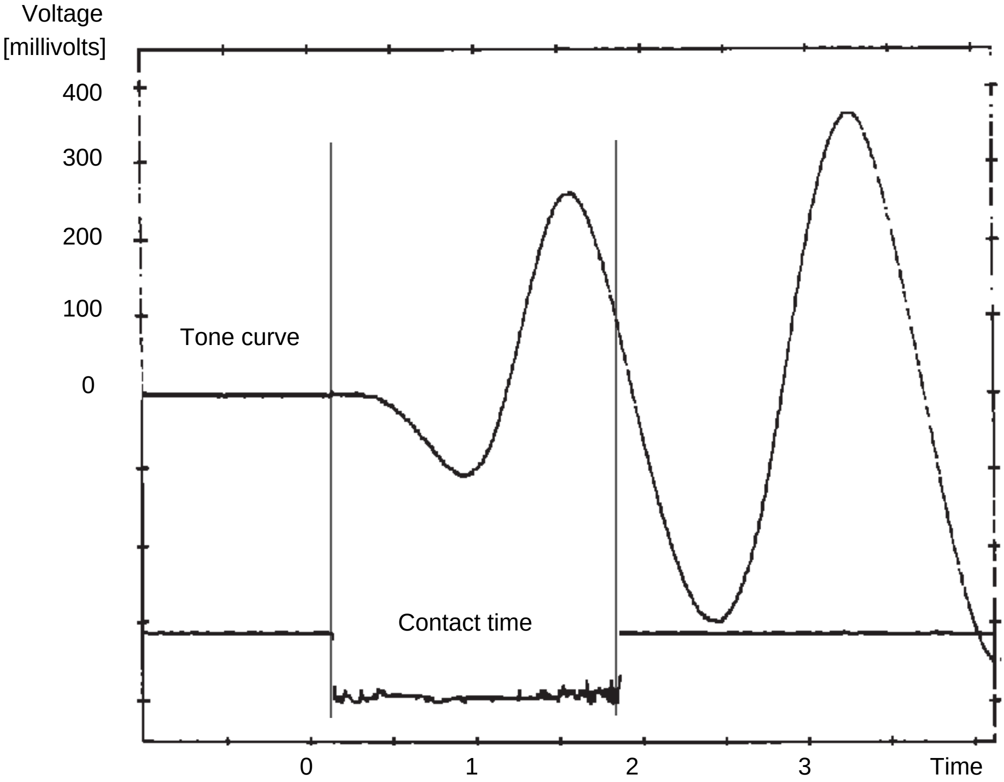


Fig. 27.1 Contact time of the stick in relation to the first milliseconds of a steel pan tone.

of the striking indicate that the optimal hardness of the stick seems to be when the contact time equals the period time of the fundamental, see fig. 27.1. This results in the fundamental being the only vibrant mode of the note that is exited by the stroke. The higher modes, that vibrate faster than the fundamental, will tend to move up and down several times during the time of contact, which causes them to be damped by the soft stick.

The smoothness of the beginning of the curve in fig. 27.1 also shows that it is only the fundamental that vibrates in the beginning of the tone. The ruggedness occurring later shows that the higher partials are beginning to occur, see fig. 19.1.

The findings on the exitation of the note are well in line with my hypothesis concerning the sound generation. According to this, the exitation that would lead to the most harmonic tone would be a stroke that only excites the fundamental mode of vibration, and lets the non-linear mechanism do the work of converting the energy to the higher, harmonic partials.

IV. APPENDICES

Layouts, Measures and Tools

A. Measures for common steel pan models

This appendix describes some commonly used steel pan models, together with data on note sizes, sinking depths, side lengths, etc. The measures have been gathered from instruments built in Sweden by the tuners Rudy Smith and Lawrence Mayers and during a research trip to Trinidad in March 1990. Some measures for the lower pans are still missing. As different tuners use different measures, the measures given here are to be seen as guideline examples.

DEFINITION OF MEASURES

This section contains a description of how to apply the measures in appendix A. Please note that the length of the outer notes, denoted ”along the rim”, is measured using a flexed ruler held against the rim. It is easier and more precise to follow the rim than to use a straight ruler when checking the length of the outer notes. The sum of the note measures along the rim should equal the circumference. The inner diameter of a regular drum is 567 mm, which means that the circumference is 567 * π = 1780 mm (π=3.14). A good way to make sure that the measures are correct is to take a measuring-tape, mark the lengths of the outer notes clockwise, and then paste it to the inside of the rim before marking the notes.

The lengths of the radial grooves (the ones going from the rim towards the centre) are measured all the way up to the rim, even if the groove stops about 40-50 mm from the rim. This is because the whole length is a more exact measure.

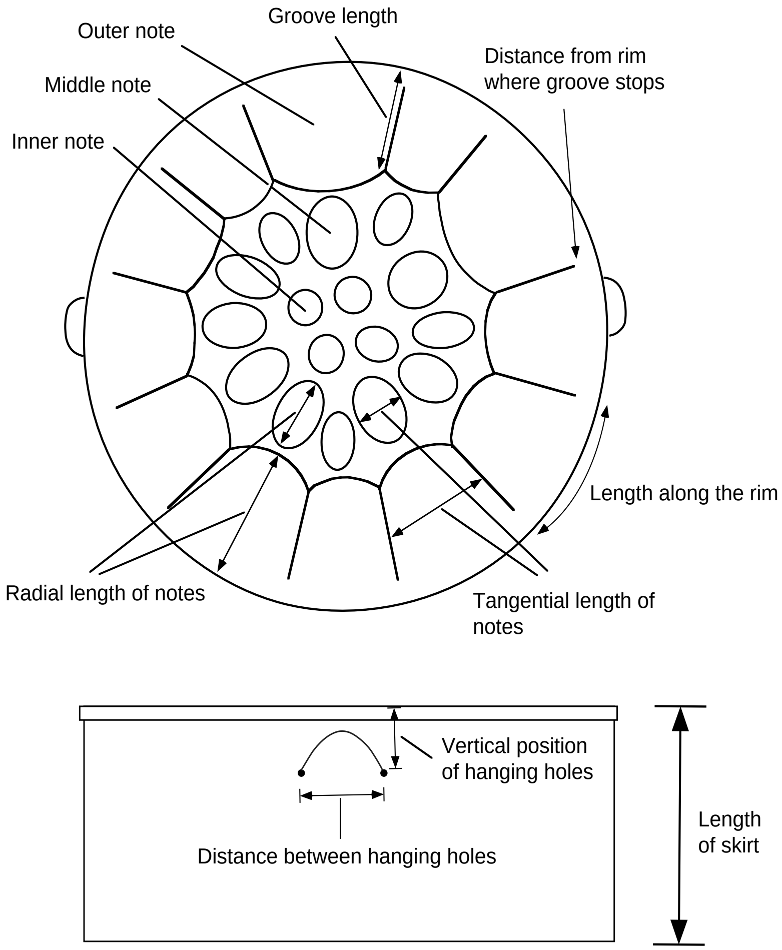


Fig. A.1 Definition of measures.

The outer notes that have a rounded inner border will extend a bit beyond the length of the groove. The length from the rim to the inner groove is given by the radial length of the outer note, see fig. A.1.

The tangential lengths of the outer notes are given for comparison purposes and possible future theoretical calculations of note sizes only. These are not suitable to be used for pan making.

Conversion table – mm to inches

All measures in this handbook are given in millimetres (mm). I have chosen this unit because it is metric and well accepted in technical and scientific literature. As the tradition of steel pan making is based on inches, a conversion table and a conversion diagram is provided here. An inch equals 25.4 mm.

Inches	Millimetres	Centimetres	Meters
0.04	1	0.1	0.001
0.4	10	1	0.01
1	25.4	2.54	0.0254
39	1000	100	1

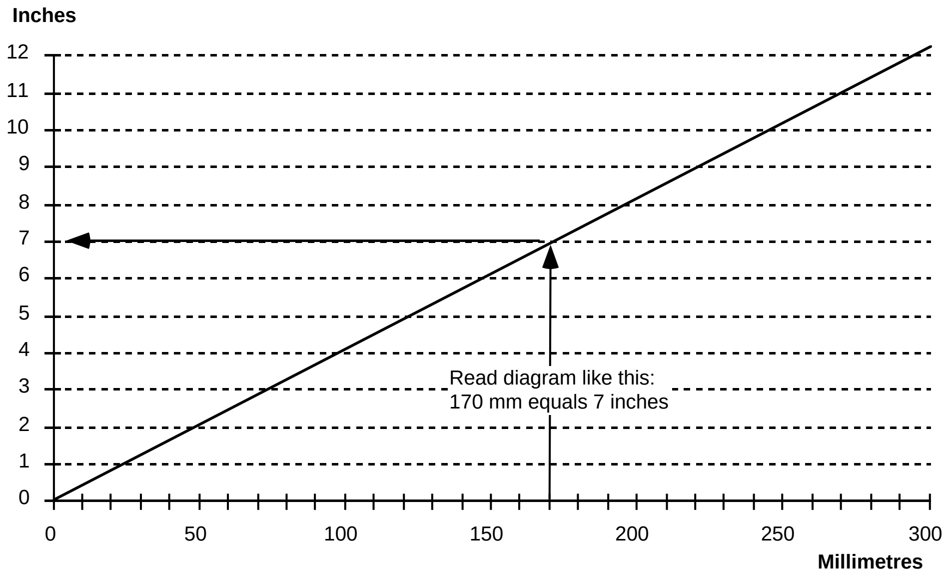


Fig. A.2 Conversion diagram between millimetres and inches.

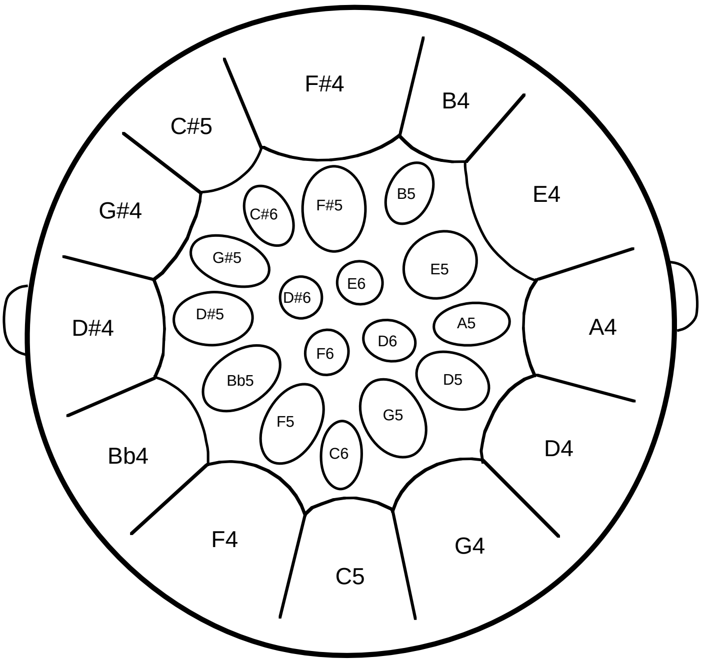
TENOR (SOPRANO)

The reason for naming the highest pan of the steelband ”tenor” is historical: In the early days, the lead melody was played on a pan with less than ten notes. These notes were bigger than on todays tenors and the pitch was in the tenor range – therefore it was suitable to call the pan a tenor.

As the instrument developed, more notes were put into the tenor to increase its range. The new notes had to be made smaller, thus putting the pan in a higher tonal range. But the name ”tenor” prevailed. Today it would be more proper to call it a soprano, which is also the usual case outside Trinidad.

The early tenors (ping-pongs) still had some of their lower notes, such as F# in the middle section, but eventually all the lower notes were moved to the outer ring with the corresponding octaves just inside them. The first ”fifths-and-fourths” tenor pans, created by pioneer tuner Anthony Williams, were ”spider web” pans with the notes close together and the intersections shaped as a spider-web-like pattern. In 1963 Herman Johnson changed the design by moving the inner notes apart to reduce the acoustic coupling of adjacent notes.

Overview of the Tenor pan



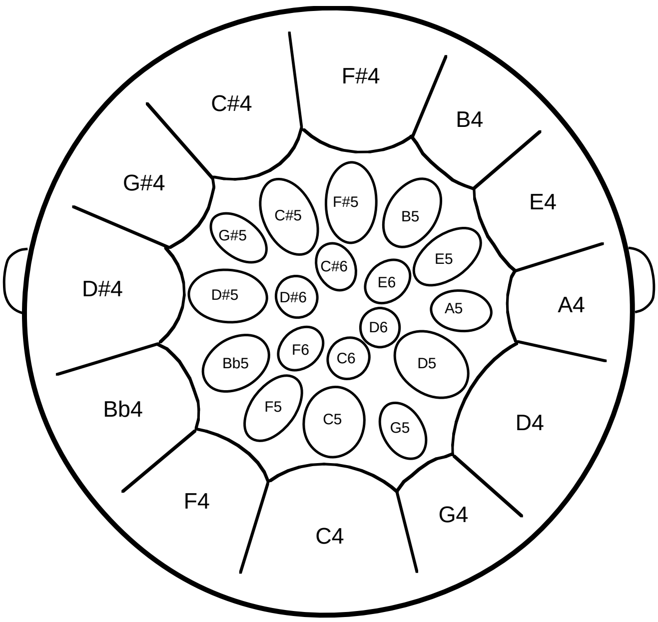
Due to the new ingenious layout according to the circle of fifths, the tenor is the pan that has come the longest way towards a standardization. As seen from the layout figure, all the lower notes are arranged according to the circle of fifths around the rim, with the corresponding octave notes in a similar circle inside. In this way the harmonics of the octave, the fifth and the fourth, will surround each note and help up the harmonic spectrum of the tone.

The size of the lower notes limits the tonal range of the tenor down to D4. During the later development, the tuners have tried to increase the range downwards by making the outer tenor notes smaller. This has resulted in a new tenor model that incorporates a low C4 and a C#4, instead of the C5 and C#5 usually found in the outer ring.

The layout of the low tenor is the same as the ordinary tenor. The C and the C# in the outer ring are made bigger and the rest of the notes a bit smaller. This is accomplished by shifting the pan so that the previous lowest D4 and D#4 become the new C4 and C#4, respectively.

It seems as this tenor has exactly the same measures as the higher one, but you tune each note two semitones lower and then shift it around so that the bottom C4 (former D4) faces the player. This means that every note will be a bit smaller and that two notes has to be added at the top if the range upwards is to be retained. As the pan develops further this model will presumably get more common.

Overview of the Low Tenor pan



Special crafting techniques

For the 8" (200 mm) sinking of tenors it is sufficient to use the sinking hammer down to 7 1/2" (190 mm) = 95% of final depth. The rest of the sinking is done during the smoothing and the backing.

The holes for the supporting strings can be put either as a single hole in the rim or as a pair 50 mm down the side, spaced about 50 mm. The pan will probably ring a little more if the strings are attached to the rim (because there is no damping of the side).

Measures for the Tenor pan

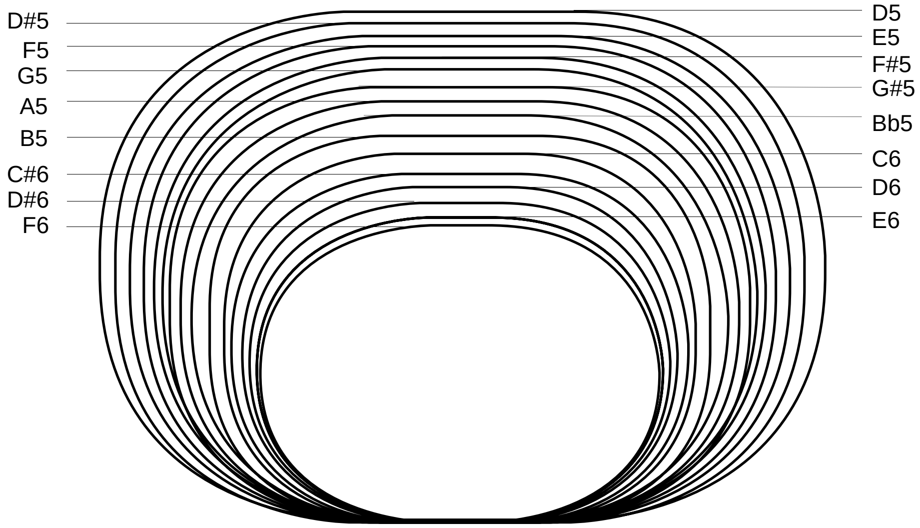
The measured tenor pans were made by Lawrence Mayers in 1990.

Notes		Drum			Groove		
Number of notes	Tonal Range	Depth of playing surface [mm]	Length of side [mm]	Hole pos. from rim [mm]	Width [mm]	Radial length [mm]	End from rim [mm]
28	D4-F6	200	140	In rim	4.5-5	130	40

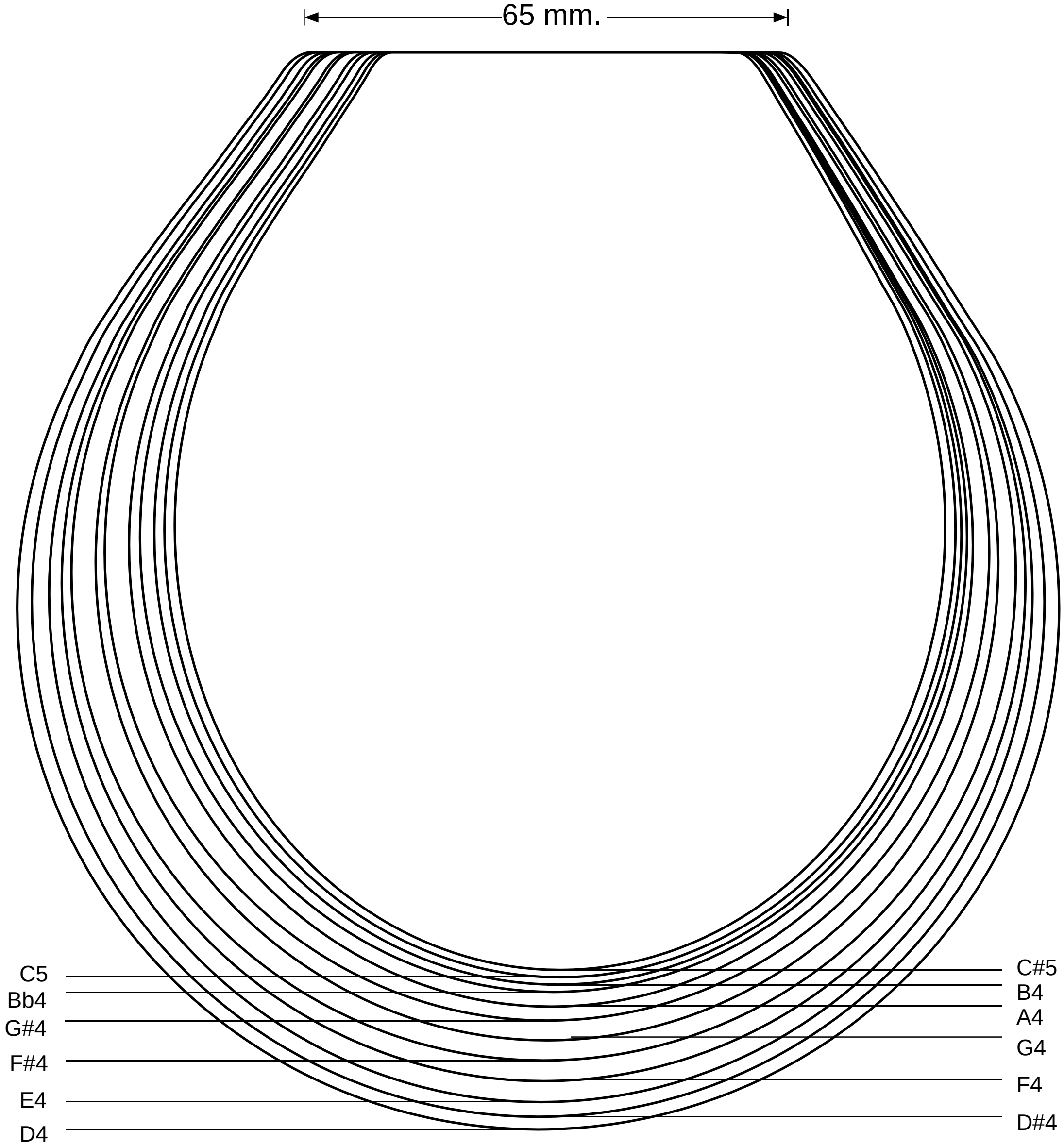
Measures for Tenor pan notes

Note	Position	Radial length	Tangential length	Length along rim
D4	Outer	150	155	180
D#4	Outer	150	153	175
E4	Outer	145	144	165
F4	Outer	145	135	160
F#4	Outer	142	133	155
G4	Outer	143	128	150
G#4	Outer	138	128	150
A4	Outer	140	120	140
Bb4	Outer	138	115	135
B4	Outer	140	106	125
C5	Outer	135	101	120
C#5	Outer	135	98	120
D5	Middle	100	70	
D#5	Middle	100	70	
E5	Middle	91	67	
F5	Middle	85	65	
F#5	Middle	86	65	
G5	Middle	82	63	
G#5	Middle	76	58	
A5	Middle	77	57	
Bb5	Middle	69	52	
B5	Middle	65	50	
C6	Middle	60	47	
C#6	Inner	59	48	
D6	Inner	60	45	
D#6	Inner	58	48	
E6	Inner	55	41	
F6	Inner	55	41	

Templates for Tenor inner notes



Templates for Tenor outer notes



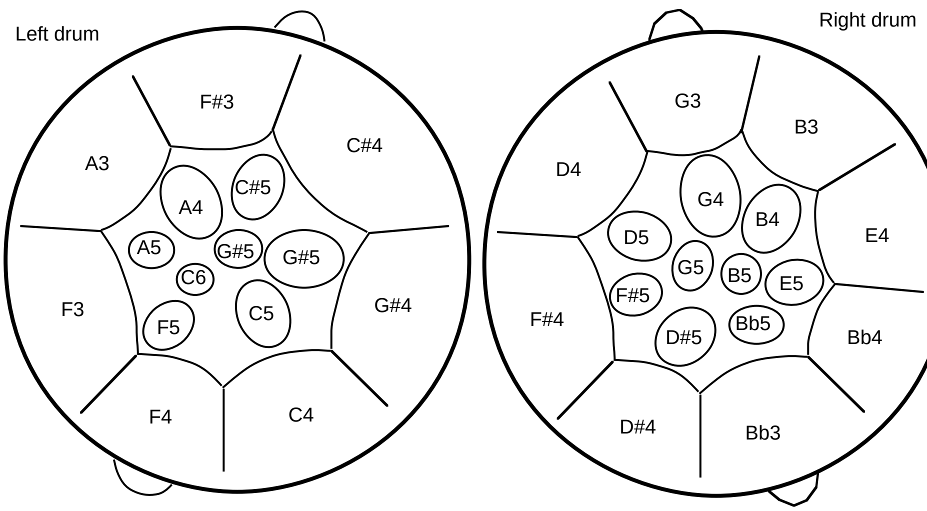
DOUBLE TENOR (ALTO)

The double tenor pan has a tonal range of two and a half octaves, distributed over two drums with 15-17 notes in each. The layout of the double tenor pan seems to consider playing convenience and tonal range more than acoustical matters. Since the notes are separated by a double groove there might be less need for a harmonic arrangement of the notes than in other steel pan models.

The regular Trinidadian way to hang the double tenor is to use two stands with their supporting arms in line with each other. This has the advantage that double tenors and tenors can be used in the same stands in the steelband set-ups. But it will also mean that both drums will hang at a slight angle, tilted with the back end lower. If you want to play fast this will be a disadvantage, because you have to lift your hands rather high when you move them from one drum to another.

To speed up the playing Rudy Smith and other solo players have turned their stands with the supporting arms almost in parallel with each other. In this way the drums will be tilted towards the point between the drums where the player is standing. Thus the lowest part will be facing the place where you want to move the sticks between the drums while playing. This will presumably be a more common styling in the future. Therefore, the pan shown in the layout figure is a regular (as far as I know) Trinidad double tenor, but it is rotated according to Rudy Smith styling for ease in playing.

Overview of the Double Tenor pan



Special crafting techniques

The notes on a regular Trinidad double tenor are separated by two grooves at a distance of 10 mm. According to some tuners there is no need for this nowadays; they are just there for good ”looks”. Presumably, there was an acoustic need for them earlier, and then people got used to the look. If this extra distance was to be removed, even more notes could be packed into the double tenor pan. This is presumably what will happen in the future.

The straight inner border of the outer notes on a double tenor in Trinidad style also seems to be just for ”looks”. The acoustically active dent is shaped in the same way as for the rest of the pans. Making this inner border rounded would presumably make the pan easier to tune and reduce the acoustic interference between the notes.

Measures for the Double Tenor pan

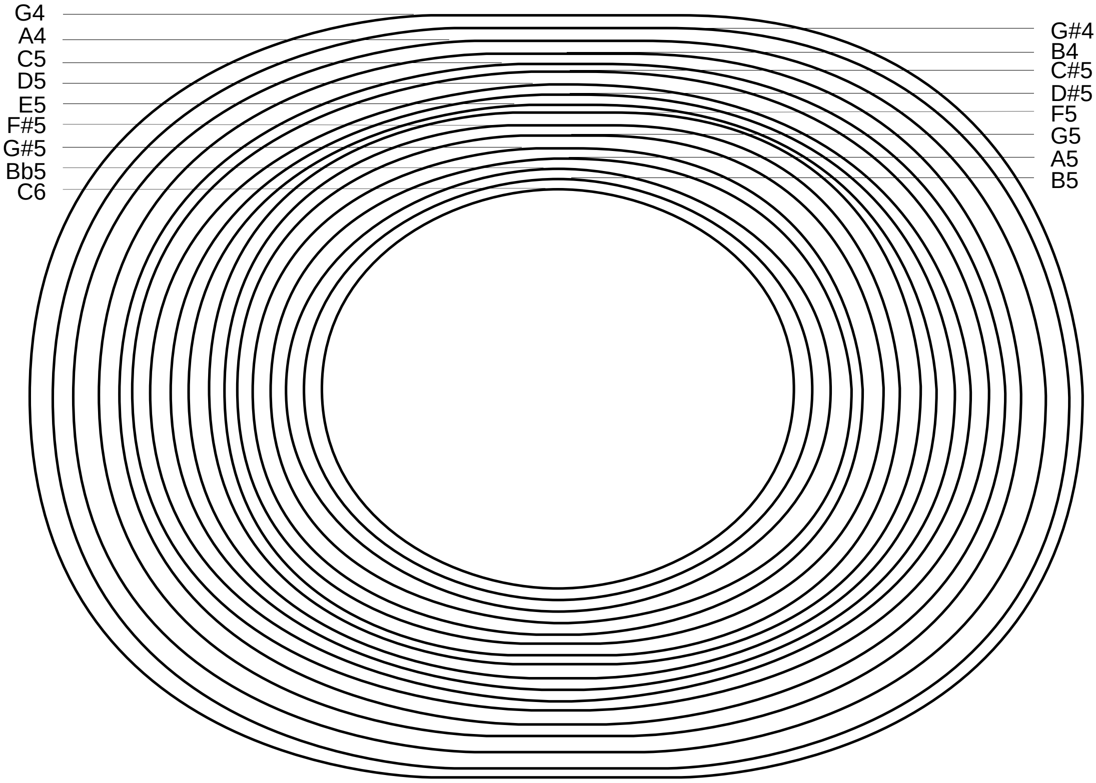
The measured double tenor pan was made by Rudy Smith in 1988. (Smiths left hand set-up was converted to Trinidad right hand style according to tuner Lawrence Mayers.) The measured pan had the inner borders of the outer notes rounded off in the same way as double seconds, etc. The normal distance between the grooves of adjacent notes in the outer ring is 10 mm.

Notes		**Drum**			**Groove**		
Number of notes	Tonal Range	Depth of playing surface [mm]	Length of side [mm]	Hole pos. from rim [mm]	Width [mm]	Radial length [mm]	End from rim [mm]
32	F3-C6	180-195	240	50	2 * 6	130	50

Measures for Double Tenor notes

Note	Position	Radial length	Tangential length	Length along rim
F3	Outer left	155	230	270
F#3	Outer left	155	230	265
G3	Outer right	150	225	270
G#3	Outer left	150	225	255
A3	Outer left	150	220	255
Bb3	Outer right	147	210	235
B3	Outer right	145	200	230
C4	Outer left	150	200	225
C#4	Outer left	150	195	215
D4	Outer right	147	187	210
D#4	Outer right	140	175	205
E4	Outer right	147	175	200
F4	Outer left	145	170	185
F#4	Outer right	140	165	185
G4	Middle right	145	103	
G#4	Middle left	140	103	
A4	Middle left	139	97	
Bb4	Outer right	140	120	150
B4	Middle right	125	90	
C5	Middle left	115	90	
C#5	Middle left	111	85	
D5	Middle right	110	84	
D#5	Middle right	105	80	
E5	Middle right	97	77	
F5	Middle left	96	74	
F#5	Middle right	95	72	
G5	Inner right	85	65	
G#5	Middle left	82	63	
A5	Middle left	75	58	
Bb5	Middle right	73	60	
B5	Inner right	71	55	
C6	Inner left	65	55	

Templates for Double Tenor inner notes



DOUBLE SECOND (TENOR)

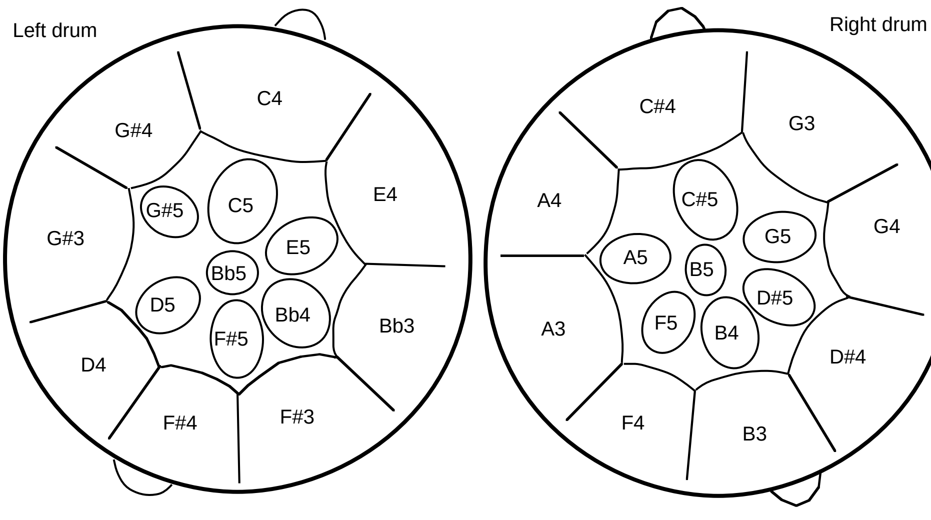
The double second pan consists of two drums with 15 notes in each. The tonal range is almost two and a half octaves in the same range as the double tenor pan. The sound of the double second is, though, a little deeper than the double tenor due to its longer side.

The note layout of the double second seems to be more consistent than for the double tenor. On a chromatic scale, the notes are positioned in drums left-right-left-etc., which means that the most dissonant intervals – the small seconds – are distributed over two drums. The smallest intervals residing in the same drum – the large seconds – are spaced as far apart as possible. For instance, C and D are almost at opposite sides of the left drum.

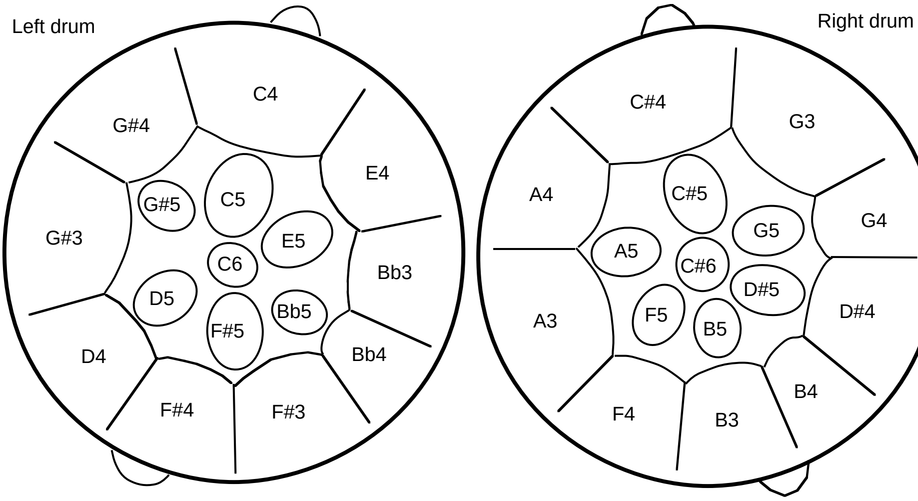
For the positioning of the drums while playing, the same reasoning as for the double tenor is valid. It is easier to play fast if the stands are turned so that the lowest ends of the tilted drums are facing the player. Therefore, the layout is shown in this fashion.

According to some sources there is a special ”Ellie Manette styling” of the double second, ranging from the ordinary low F#3 up to C#6, that is; two semitones higher than the usual. This is accomplished by making each note a little smaller and moving Bb4 in the left drum and B4 in the right drum from a middle position to the outer ring, making space for the extra two top notes. The outer ring of notes will then contain nine notes in each drum, again a result of the efforts to make the notes successively smaller.

Overview of the Double Second pan



Overview of Double Second pan, Ellie Mannette styling



Double second pan according to Ellie Manette's styling. Note the Bb4 and B4 moved to the outer ring and the extra C6 and C#6.

Measures for the Double Second pan

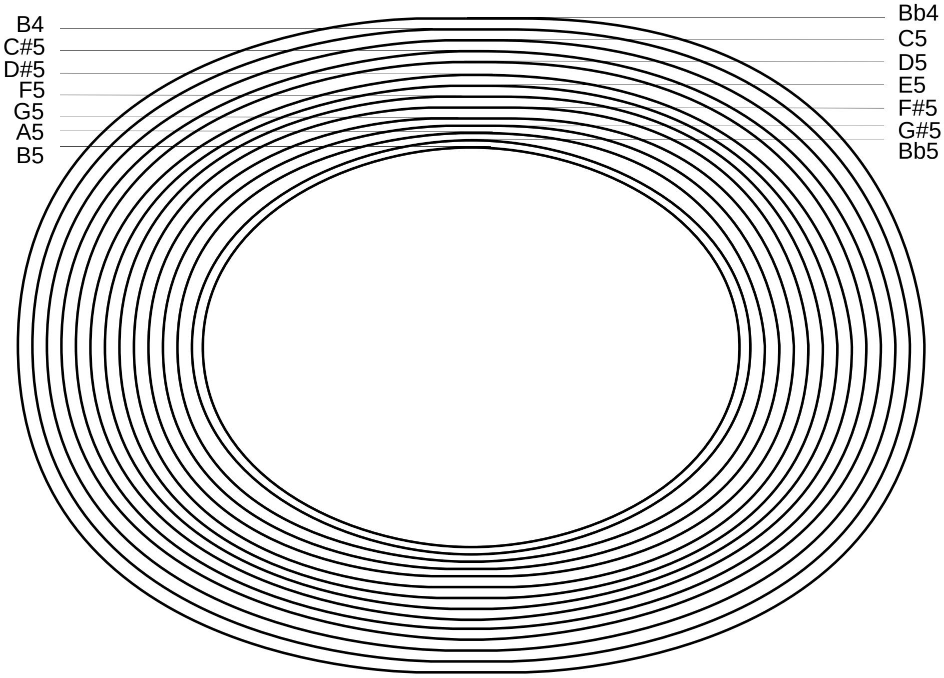
The left drum of the measured pan was made by Lawrence Mayers during a research project of summer 1989. Measures for right drum were extrapolated by the author, together with some data from a double second built by Rudy Smith 1988.

Notes		Drum			Groove		
Number of notes	Tonal Range	Depth of playing surface [mm]	Length of side [mm]	Hole pos. from rim [mm]	Width [mm]	Radial length [mm]	End from rim [mm]
30	F#3-B5	160-165	215	50	5	125	47

Measures for Double Second notes

Note	Position	Radial length	Tangential length	Length along rim
F#3	Outer left	162	235	290
G3	Outer right	160	210	290
G#3	Outer left	160	202	250
A3	Outer right	158	210	250
Bb3	Outer left	158	210	250
B3	Outer right	155	200	245
C4	Outer left	153	200	245
C#4	Outer right	152	180	210
D4	Outer left	150	162	205
D#4	Outer right	148	155	190
E4	Outer left	145	150	185
F4	Outer right	145	147	185
F#4	Outer left	145	143	185
G4	Outer right	140	135	175
G#4	Outer left	140	130	165
A4	Outer right	135	115	165
Bb4	Middle left	125	90	
B4	Middle right	118	85	
C5	Middle left	112	80	
C#5	Middle right	112	77	
D5	Middle left	113	72	
D#5	Middle right	100	70	
E5	Middle left	92	67	
F5	Middle right	85	64	
F#5	Middle left	80	60	
G5	Middle right	78	60	
G#5	Middle left	76	61	
A5	Middle right	75	58	
Bb5	Inner left	74	55	
B5	Inner right	74	55	

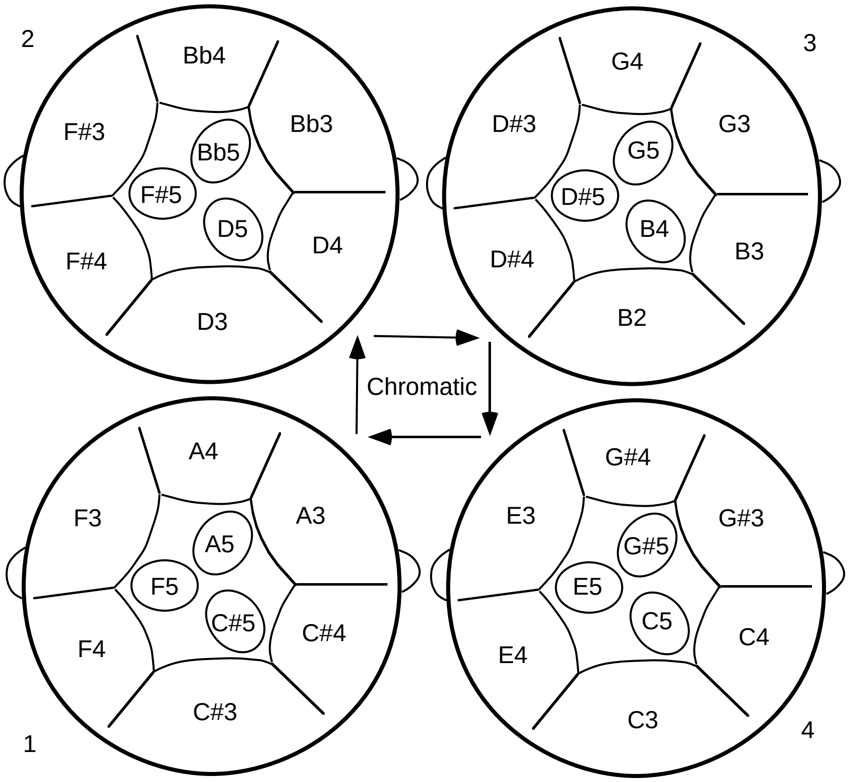
Templates for Double Second inner notes



QUADROPHONIC PAN

The recently invented quadrophonic pan covers the largest tonal range of all regular steel pans. The four drums accommodate altogether 36 notes, ranging from B2 to Bb5. The notes are distributed over the drums in a chromatic sequence from left to right, drums numbered 1 to 4 (see figure), beginning with B2 in drum 3. In this way, the smallest tonal interval residing in the same drum will be a major third. The notes in this interval are placed beside each other, resulting in one major chord for each drum: C# maj, D maj, D# maj, and E maj, left to right.

Overview of the Quadrophonic pan



Measures for the Quadrophonic pan

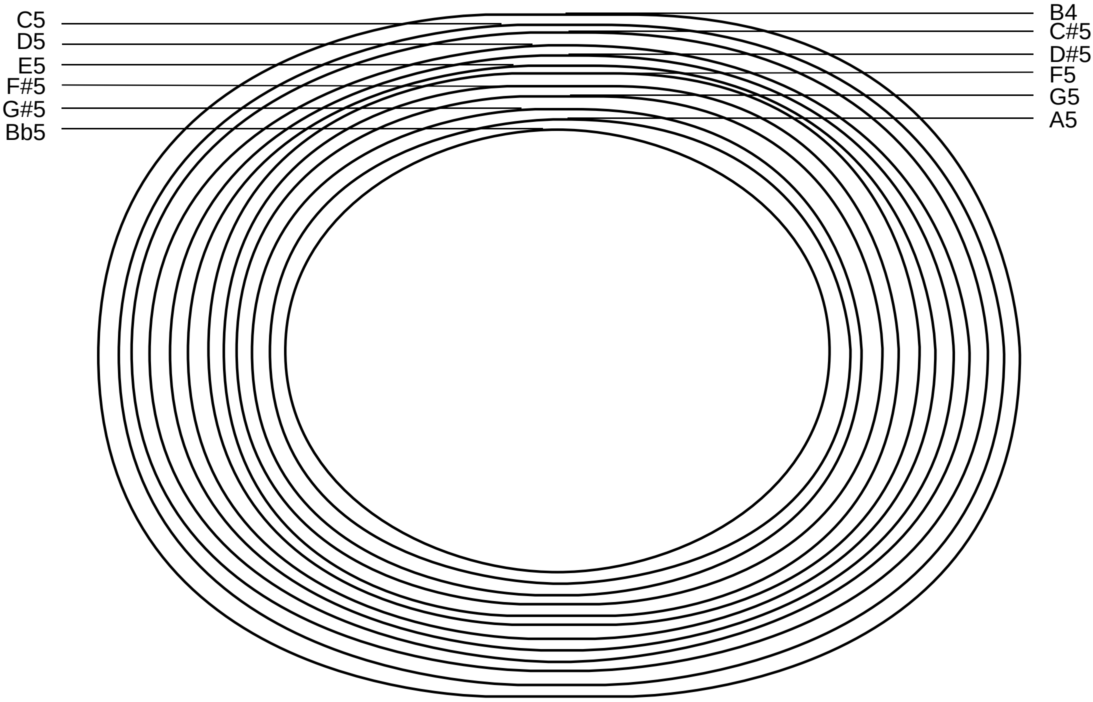
Data for the quadrophonic pan was gathered during a research trip to Trinidad in March 1990. Some measurements are still missing, especially the note sizes. The measurements given here are extrapolated from the same notes in guitar pans and double seconds. There is no existing pan with these note sizes, but the real measures should not deviate too far from what is given here. Tangential measures for outer notes are not given, because these are not relevant for panmaking.

Notes		**Drum**			**Groove**		
Number of notes	Tonal Range	Depth of playing surface [mm]	Length of side [mm]	Hole pos. from rim [mm]	Width [mm]	Radial length [mm]	End from rim [mm]
36	B2-Bb5	150	280	60	2 * 5	130	50

Measures for Quadrophonic pan notes

Note	Position	Radial length	Tangential length	Length along rim
B2	Outer 3	175		380
C3	Outer 4	175		380
C#3	Outer 1	175		380
D3	Outer 2	175		380
D#3	Outer 3	170		340
E3	Outer 4	170		340
F3	Outer 1	170		340
F#3	Outer 2	170		340
G3	Outer 3	165		300
G#3	Outer 4	165		300
A3	Outer 1	165		300
Bb3	Outer 2	165		300
B3	Outer 3	160		270
C4	Outer 4	160		270
C#4	Outer 1	160		270
D4	Outer 2	160		270
D#4	Outer 3	155		230
E4	Outer 4	155		230
F4	Outer 1	155		230
F#4	Outer 2	155		230
G4	Outer 3	150		200
G#4	Outer 4	150		200
A4	Outer 1	150		200
Bb4	Outer 2	150		200
B4	Inner 3	128	94	
C5	Inner 4	123	90	
C#5	Inner 1	118	86	
D5	Inner 2	112	82	
D#5	Inner 3	108	78	
E5	Inner 4	102	74	
F5	Inner 1	97	70	
F#5	Inner 2	92	66	
G5	Inner 3	88	64	
G#5	Inner 4	83	62	
A5	Inner 1	78	60	
Bb5	Inner 2	75	60	

Templates for Quadrophonic pan inner notes

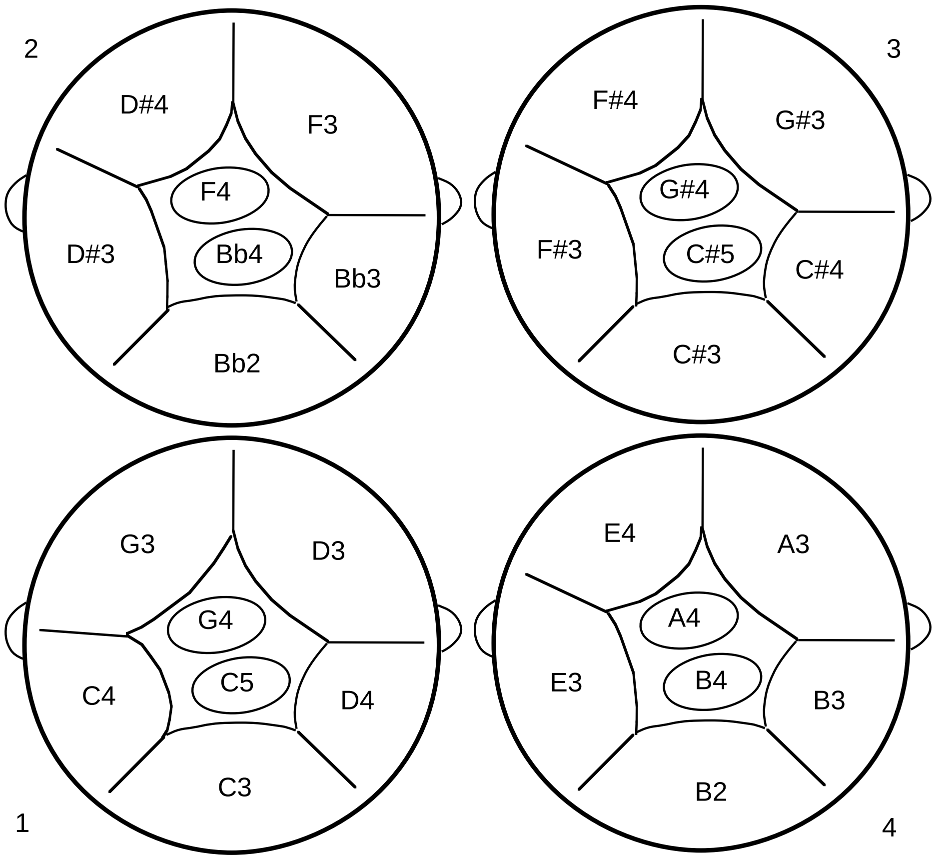


FOUR PAN

The four pan consists of four drums, cut at half their lengths, with seven notes in each. The musical range is just above two octaves, from Bb2 up to C#5. The four pan has the same musical function as the old double guitar, i.e., mainly to play chords in the rhythm section, but its larger tonal range makes it more suited to fill in melodic lines. As the pan instrument develops, I belive we will see the four pan successively replace the ordinary guitar pan.

Unfortunately, the layout of the notes in the four pan is not as well structured as for the quadrophonic pan. A chromatic scale from the lowest note Bb2 and one octave upwards will follow the drum sequence 2-4-1-3-1-2-4-2-3-1-3-4-2 (see figure). There seems to be no reason why the layout of the four pan not could be chromatically sequenced in drums 1-2-3-4 as the quadrophonic pan, resulting in a major chord in each drum. Maybe we will see this happen in the future.

Overview of the Four pan



Measures for the Four pan

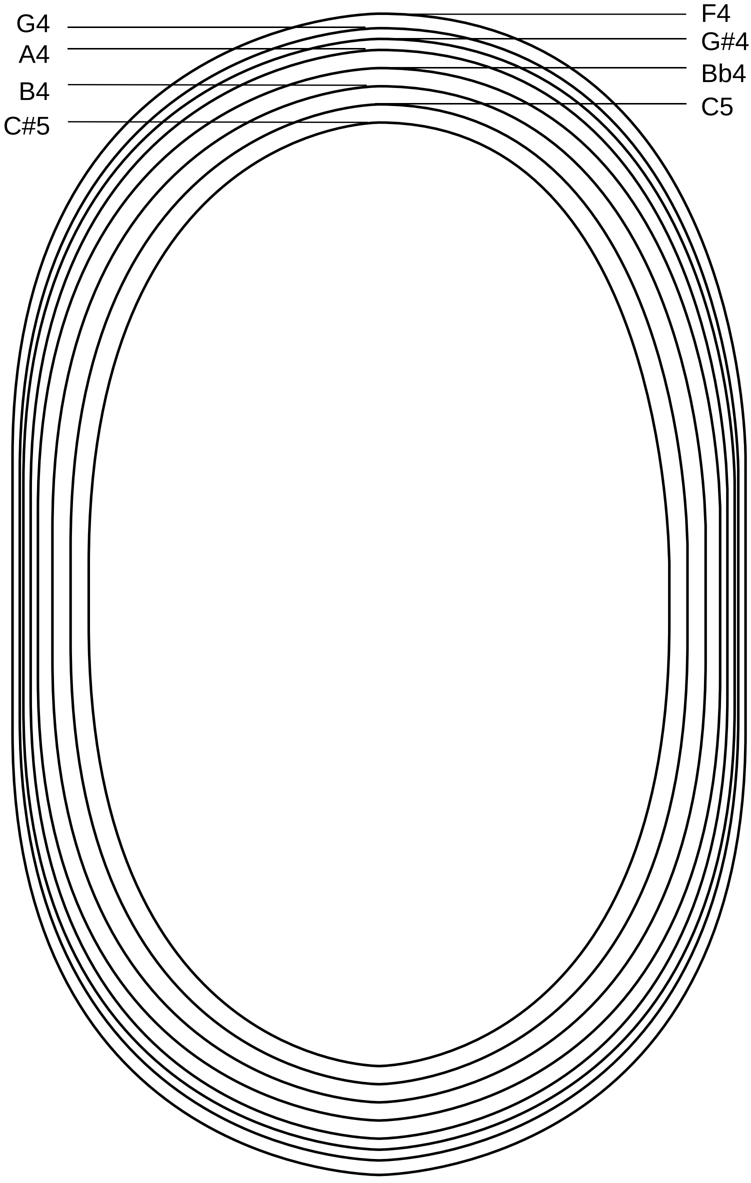
Data for the four pan was gathered during a research trip to Trinidad in March 1990. Some data is still missing, especially measures for the note sizes. The note sizes given here have not been measured, but are extrapolated from the same notes in guitar pans and double seconds. There is no existing pan with these notes, but their real sizes should not deviate too far from what is given here. Tangential measures for outer notes have not been calculated, because these are not relevant for panmaking.

Notes		**Drum**			**Groove**		
Number of notes	Tonal Range	Depth of playing surface [mm]	Length of side [mm]	Hole pos. from rim [mm]	Width [mm]	Radial length [mm]	End from rim [mm]
28	Bb2-C#5	145	550	80	6	130	50

Measures for Four pan notes

Note	Position	Radial length	Tangential length	Length along rim
Bb2	Outer 2	200		400
B2	Outer 4	200		420
C3	Outer 1	200		420
C#3	Outer 3	200		420
D3	Outer 1	190		390
D#3	Outer 2	190		380
E3	Outer 4	190		390
F3	Outer 2	190		390
F#3	Outer 3	180		380
G3	Outer 1	180		360
G#3	Outer 3	180		370
A3	Outer 4	180		360
Bb3	Outer 2	170		320
B3	Outer 4	170		320
C4	Outer 1	170		320
C#4	Outer 3	170		320
D4	Outer 1	160		290
D#4	Outer 2	160		290
E4	Outer 4	160		290
F4	Inner 2	102	160	
F#4	Outer 3	160		290
G4	Inner 1	100	156	
G#4	Inner 3	99	152	
A4	Inner 4	98	148	
Bb4	Inner 1	95	144	
B4	Inner 4	90	140	
C5	Inner 1	86	135	
C#5	Inner 3	80	130	

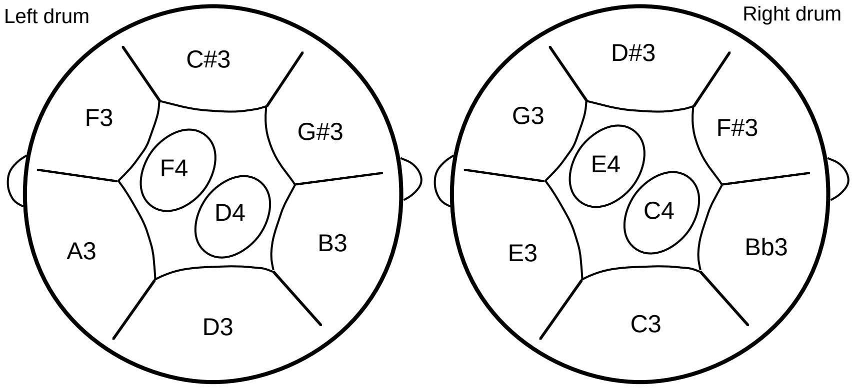
Templates for Four pan inner notes



DOUBLE GUITAR PAN

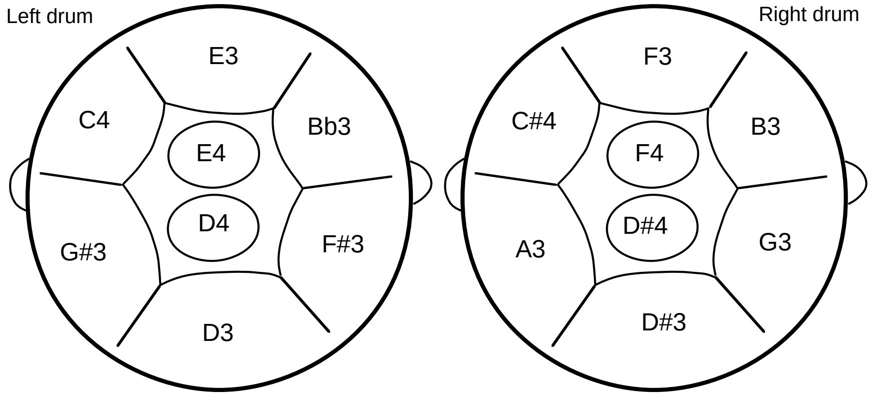
The double guitar pan consists of two drums, cut to half their lengths, with eight notes in each. The tonal range just above one octave, from D3 to F4. The guitar pan is mostly used as a rhythm instrument, playing chords, in the same way as an ordinary guitar in an orchestra. The common Trinidad layout, called "Invader style", is somewhat peculiar, as it goes from C3 up to F4, but lacks the C#4 and the D#4 in the upper octave. This makes it difficult to do musical arrangements for this instrument.

Overview of Double Guitar pan, Invader style



I have chosen to present an alternative guitar pan designed by tuner Rudy Smith, as this covers a full tonal range from D3 to F4. The layout of the Smith Guitar Pan is designed with notes consequently in drums left-right-left on a chromatic scale in the same way as the double

Overview of Double Guitar pan, Rudy Smith style



second pan. There are just four octave intervals and the higher notes reside right inside their lower octave counterpart.

Special crafting techniques

While sinking the guitar pan; do not work closer to the rim than 70 mm. This is done to leave material for the outer notes and get the right shape of the sunk basin.

Measures for the Double Guitar pan

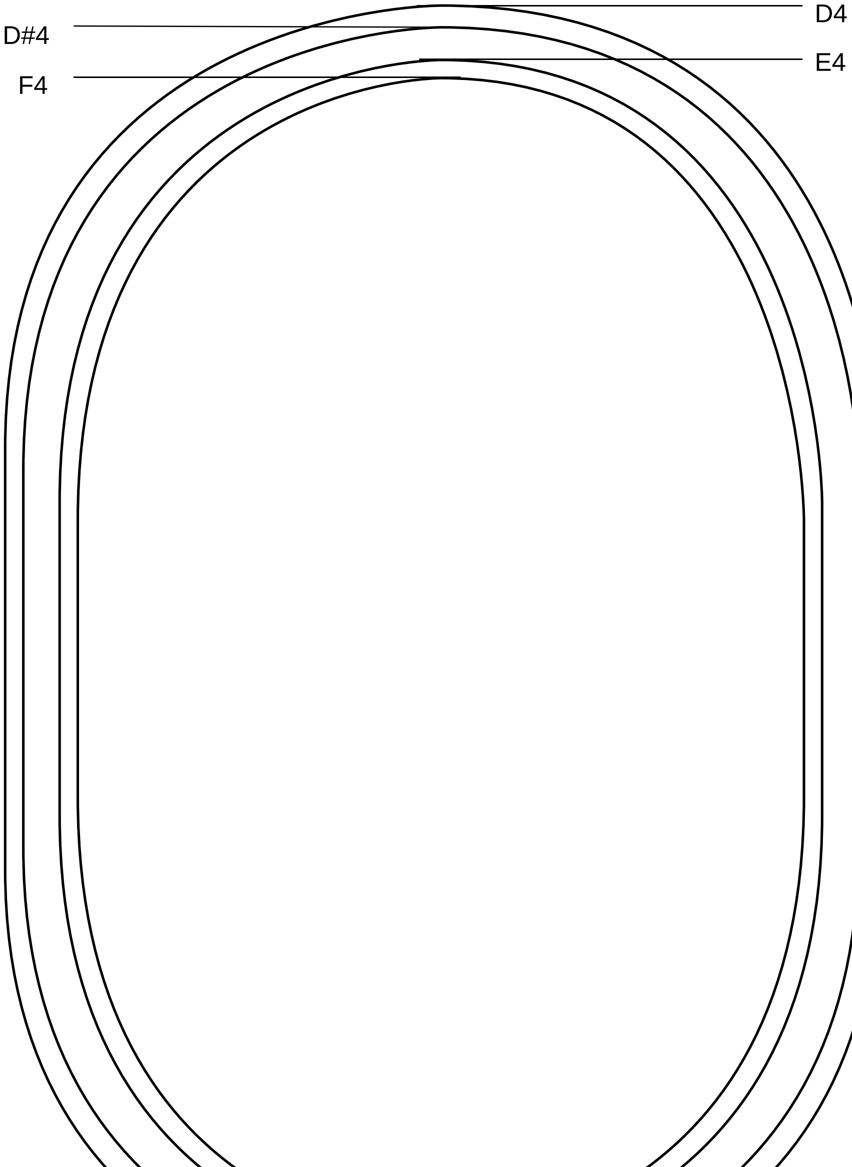
The measured guitar pan was made in Sweden by Rudy Smith 1988.

Notes		**Drum**			**Groove**		
Number of notes	Tonal Range	Depth of playing surface [mm]	Length of side [mm]	Hole pos. from rim [mm]	Width [mm]	Radial length [mm]	End from rim [mm]
16	D3-F4	140	460	80	6	135	50

Measures for Double Guitar pan notes

Note	Position	Radial length	Tangential length	Length along rim
D3	Outer left	180	260	345
D#3	Outer right	175	260	335
E3	Outer left	170	250	330
F3	Outer right	175	250	330
F#3	Outer left	170	240	310
G3	Outer right	170	240	300
G#3	Outer left	165	230	285
A3	Outer right	170	225	285
Bb3	Outer left	160	210	250
B3	Outer right	160	205	250
C4	Outer left	160	195	240
C#4	Outer right	160	190	245
D4	Middle left	120	180	
D#4	Middle right	125	180	
E4	Middle left	105	165	
F4	Middle right	100	165	

Templates for Double Guitar pan inner notes

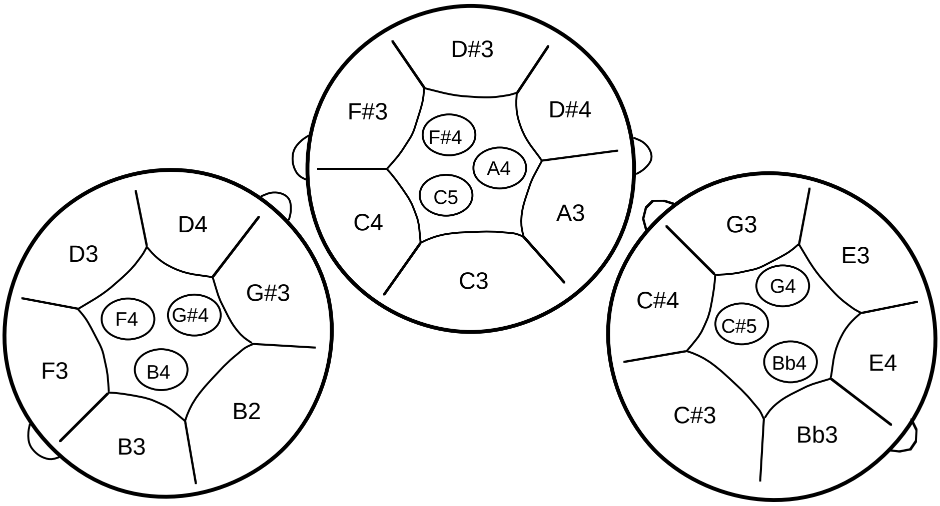


TRIPLE CELLO (BARITONE)

The triple cello pan is made out of three drums cut at approximately half their length. Each drum has eight or nine notes, with two or three of them in a middle position. The cello is mostly used for lower chords and bass riffs, filling in the bass line.

The notes are chromatically distributed, left to right from drum 1 to 2 to 3. Since the set-up consists of three drums, this layout procedure means that every third semitone will be put in the same drum. This makes the harmonic intervals of the notes in each drum form a diminished chord: B dim, C dim, and C# dim, left to right.

Overview of the Triple Cello pan



Measures for the Triple Cello pan

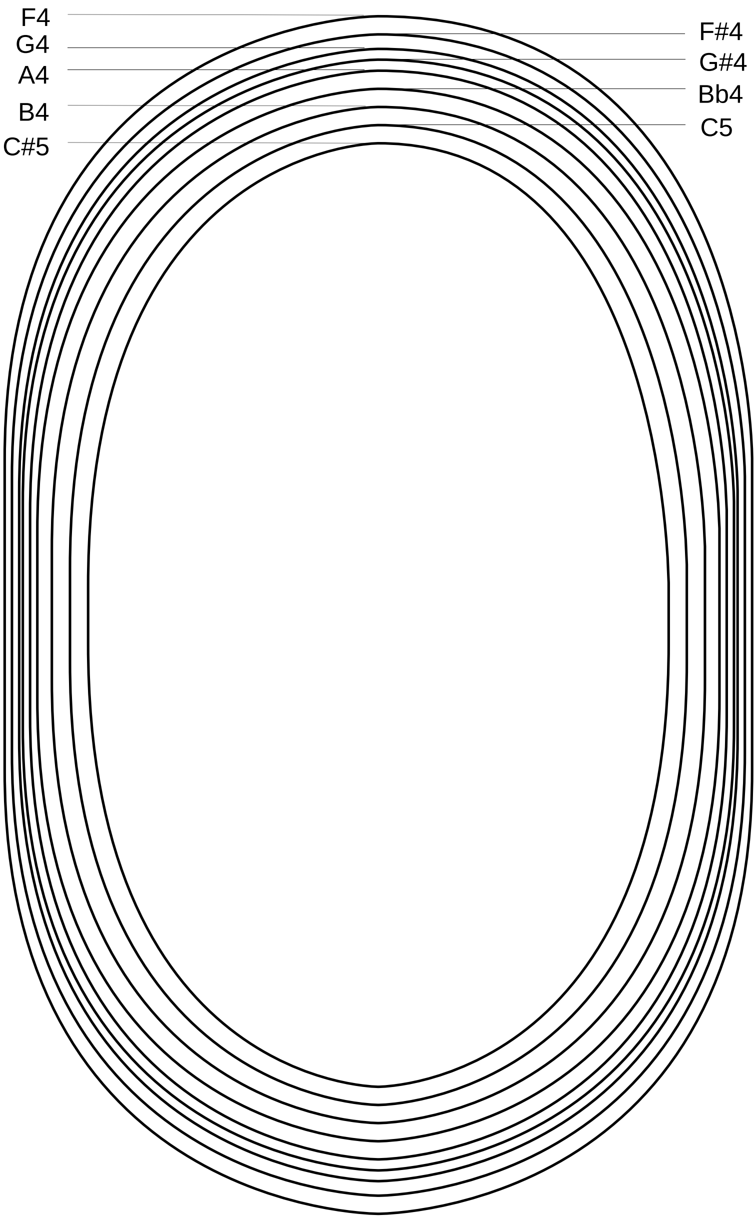
The measured cello pan was made in Sweden by Rudy Smith 1988. The layout of the pan has been extended with three extra upper notes according to a sketch from a folder in the CD-album "Steel Bands of Trinidad and Tobago", 1987.

Notes		Drum			Groove		
Number of notes	Tonal Range	Depth of playing surface [mm]	Length of side [mm]	Hole pos. from rim [mm]	Width [mm]	Radial length [mm]	End from rim [mm]
27	B2-C#5	130-160	450	50	5	135	50

Measures for Triple cello pan notes

Note	Position	Radial length	Tangential length	Length along rim
B2	Outer 1	177	290	360
C3	Outer 2	175	290	360
C#3	Outer 3	175	300	360
D3	Outer 1	175	265	335
D#3	Outer 2	175	265	335
E3	Outer 3	175	265	330
F3	Outer 1	170	245	305
F#3	Outer 2	170	245	300
G3	Outer 3	170	240	300
G#3	Outer 1	170	230	285
A3	Outer 2	165	235	285
Bb3	Outer 3	170	230	285
B3	Outer 1	170	195	240
C4	Outer 2	185	195	235
C#4	Outer 3	165	195	235
D4	Outer 1	160	180	215
D#4	Outer 2	160	182	215
E4	Outer 3	160	186	215
F4	Inner 1	103	163	
F#4	Inner 2	103	165	
G4	Inner 3	130	156	
G#4	Inner 1	98	152	
A4	Inner 2	98	152	
Bb4	Inner 3	94	145	
B4	Inner 1	90	140	
C5	Inner 2	85	135	
C#5	Inner 3	80	130	

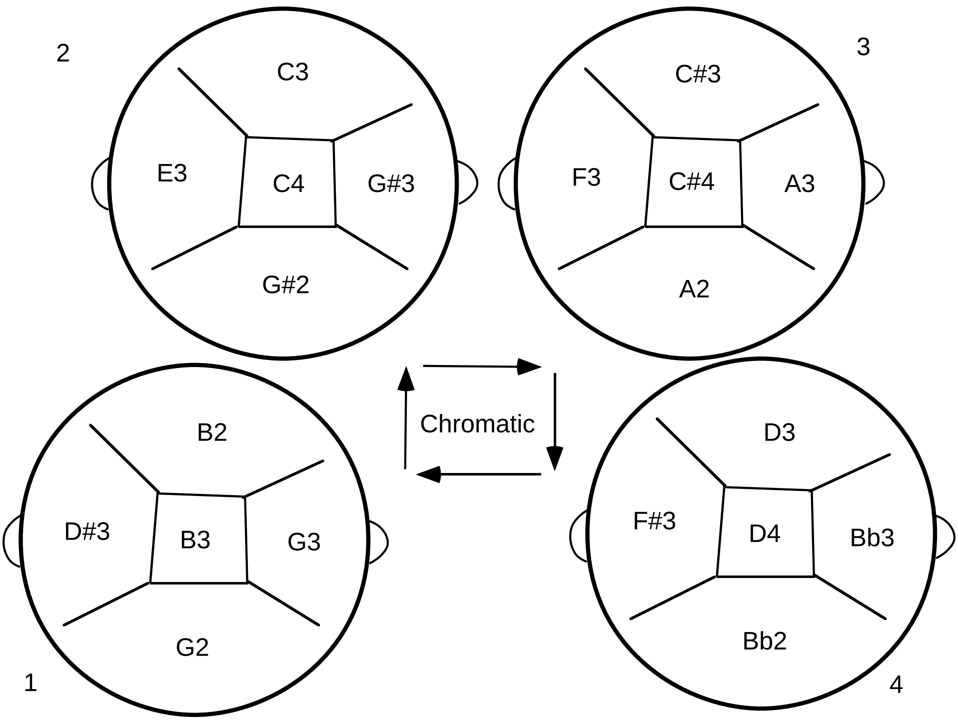
Templates for Triple Cello inner notes



TENOR BASS

The tenor bass consists of four drums cut at two thirds of their length (62 cm). Each drum contains five notes. The tonal range is one and a half octaves, from G2 to D4. The notes are distributed systematically left to right on drums 1-2-3-4 on a chromatic scale (see figure). This will result in each drum ringing in major chords as with the quadrophonic pan.

Overview of the Tenor Bass pan



Special crafting techniques

No separate sinking is done on the basses. The surface is lowered at the same time as the pan is backed. It is important that the borders (the grooves) of the notes have a straight slope (not convex or concave) down towards the middle. The width of the groove is usually a bit broader than on the higher pans, but it seems to work with the same width.

During the softening part of the tuning of basses, a club-like wooden wedge is used to raise the notes, see fig. B.12. This wedge has a long handle to make it easier to reach down to the note surface inside the drum.

Measures for the Tenor Bass pan

The tenor bass was measured during a research trip to Trinidad 1990.

Notes		Drum			Groove		
Number of notes	Tonal Range	Depth of playing surface [mm]	Length of side [mm]	Hole pos. from rim [mm]	Width [mm]	Radial length [mm]	End from rim [mm]
20	G2-D4	100	620	80-100	6-7	300	60

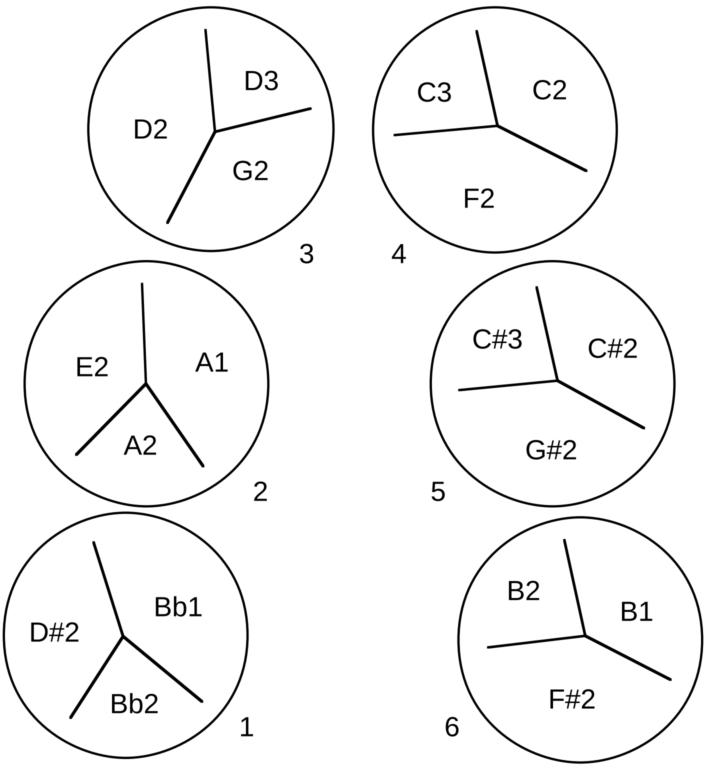
Measures for Tenor Bass pan notes

Note	Drum	Radial length	Tangential length	Length along rim
G2	1	255	395	570
G#2	2	245	390	570
A2	3	240	400	560
Bb2	4	240	400	560
B2	1	230	350	500
C3	2	230	350	490
C#3	3	230	340	480
D3	4	230	340	480
D#3	1	220	300	390
E3	2	220	280	390
F3	3	220	290	390
F#3	4	220	290	390
G3	1	205	230	300
G#3	2	210	230	300
A3	3	200	230	300
Bb3	4	205	230	300
B3	inner 1	200	200	
C4	inner 2	200	200	
C#4	inner 3	200	200	
D4	inner 4	200	200	

SIX BASS

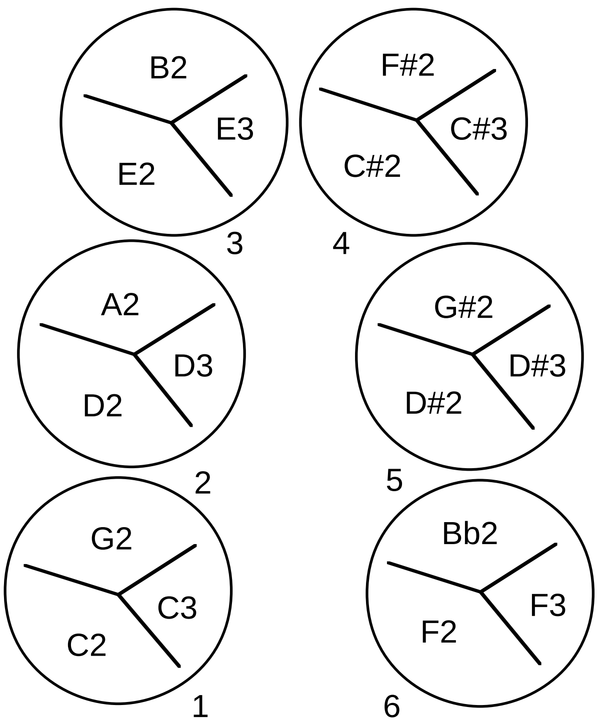
The six bass is made out of six whole drums with three notes in each. The tonal range is 18 notes, starting from A1. The Trinidad layout of the six bass is designed to put notes with fourth or fifth intervals in the same drum as often as possible. This is done to make the notes support the harmonical spectra of each other. But it will result in the notes being distributed quite ”arbitrarily” over the drums, see the layout figure.

Overview of Six Bass, Trinidad style



The tuner Clifford Alexis uses an alternative layout that presumably seeks to combine the goals of putting harmonic intervals in the same drum and a logical structuring of the notes. The result is a six bass that has intervals of fifths in the three first drums and fourths in the last three.

Overview of Six Bass, Clifford Alexis style



Special crafting techniques

No separate sinking is done on the basses. The surface is lowered at the same time as the pan is backed. A six bass is sunk down to 9 cm in the middle. It is important that the borders of the notes have a straight slope (not curved) down towards the middle. To raise the notes of a bass a special tool is often used; a paddle-like wooden stick that is long enough to reach down to the bottom of the drum, see fig. B.12.

Measures for the Six Bass

The measured six bass was made by Rudy Smith in 1990. The position for the lowest note is left out and the measures for the highest note are extrapolated, due to the difference in range between Smith's and Alexis' layouts. Position of notes is given according to Clifford Alexis' scheme.

Notes		Drum			Groove		
Number of notes	Tonal Range	Depth of playing surface [mm]	Length of side [mm]	Hole pos. from rim [mm]	Width [mm]	Radial length [mm]	End from rim [mm]
18	C2-F3	90	883	100-150	5-6	210-230	60

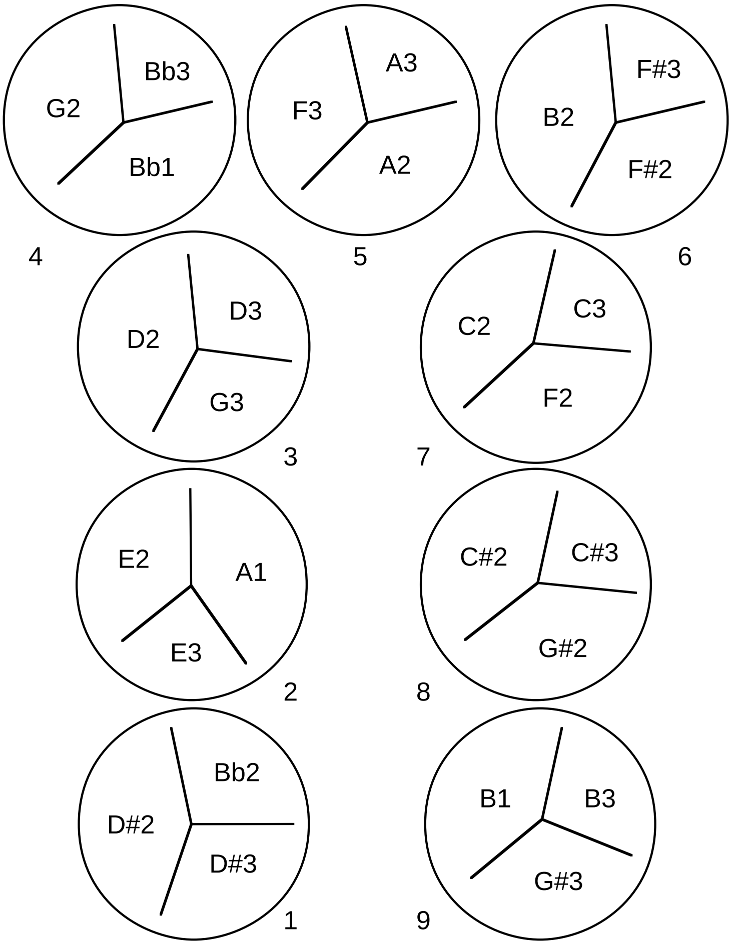
Measures for Six Bass notes

Note	Drum	Radial length	Tangential length	Length along rim
B1		275	450	650
C2	1	275	440	650
C#2	4	270	430	640
D2	2	270	430	650
D#2	5	280	420	660
E2	3	265	450	640
F2	6	260	430	620
F#2	4	265	460	620
G2	1	265	430	630
G#2	5	270	430	630
A2	2	260	410	610
Bb2	6	260	430	610
B2	3	240	360	470
C3	1	240	370	470
C#3	4	235	360	470
D3	2	240	360	470
D#3	5	240	360	480
E3	3	240	360	470
F3	6	240	360	470

NINE BASS

The nine bass is the lowest regular instrument of the steelband. The nine drums accommodate altogether 27 notes, ranging from A1 to B3. To get a set-up of nine drums to be playable, three of the drums have been hung in a tilted position in front of the player.

Overview of the Nine Bass



Special crafting techniques

No separate sinking is done on the basses. The surface is lowered at the same time as the pan is backed. A nine bass is sunk down to 9 cm in the middle. It is important that the borders of the notes have a straight slope (not curved) down towards the middle. To raise the notes of a bass a special tool is often used; a paddle-like wooden stick that is long enough to reach down to the bottom of the drum, see fig. B.12.

Measures for the Nine Bass

No nine bass has yet been available for measurements, but to give a brief idea of the measures for a nine bass, data from the six bass and the tenor bass have been compiled.

Notes		Drum			Groove		
Number of notes	Tonal Range	Depth of playing surface [mm]	Length of side [mm]	Hole pos. from rim [mm]	Width [mm]	Radial length [mm]	End from rim [mm]
27	A1-B3	90	883	100-150	6	210-230	60

Measures for Nine Bass notes

Note	Drum	Radial length	Tangential length	Length along rim
A1	2	275		650
Bb1	4	275		650
B1	9	275		650
C2	7	275		650
C#2	8	270		640
D2	3	270		650
D#2	1	280		660
E2	2	260		640
F2	7	260		620
F#2	6	265		620
G2	4	265		630
G#2	8	270		630
A2	5	270		610
Bb2	1	260		610
B2	6	240		470
C3	7	240		470
C#3	8	235		470
D3	3	240		470
D#3	1	240		480
E3	2	240		470
F3	5	240		470
F#3	6	210		300
G3	3	205		300
G#3	9	200		300
A3	5	200		300
Bb3	4	200		300
B3	9	200		300

NOTE SIZES

To get an overview of how the note size is related to the pitch of the note, I have compiled note-size data from all measured pans (except the nine bass) into one diagram.

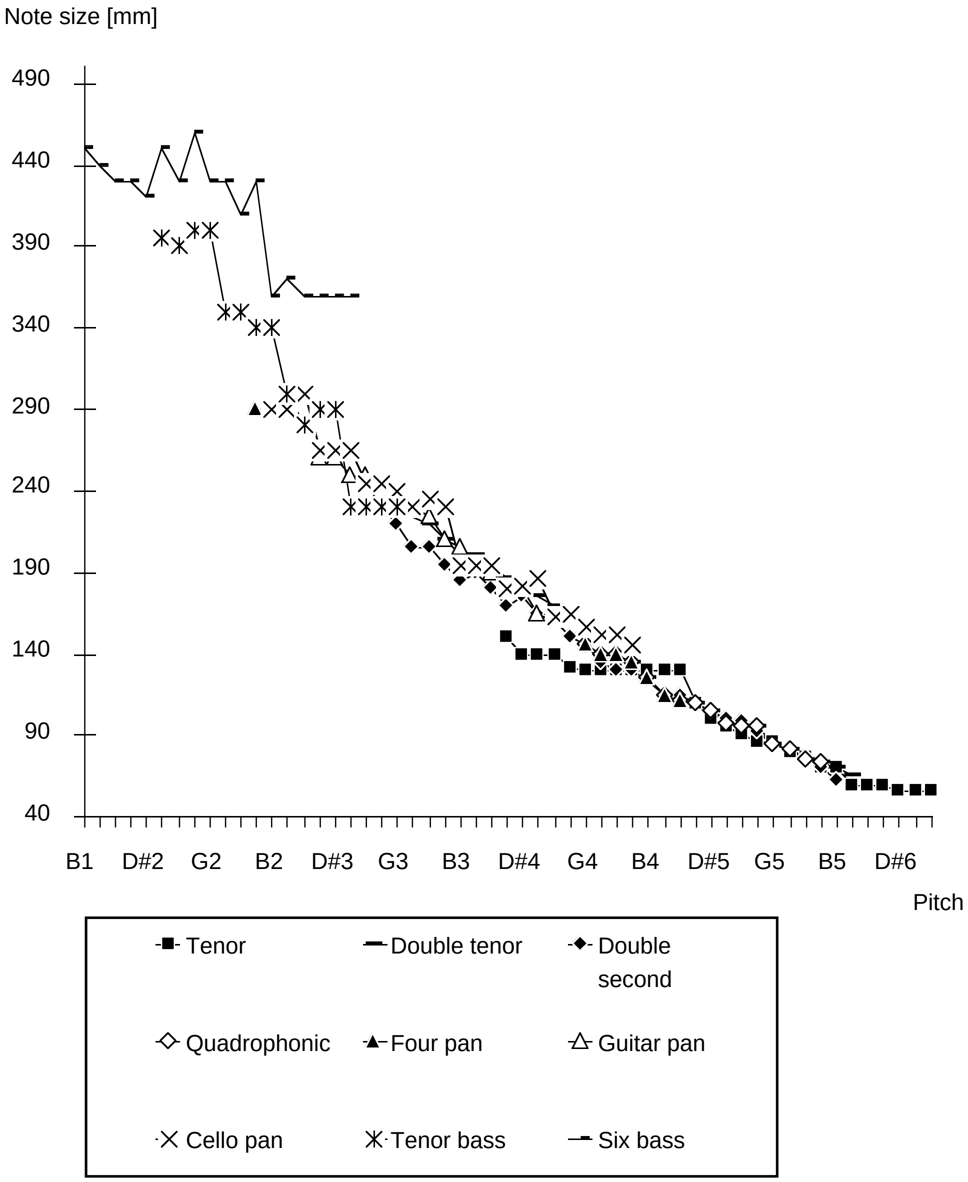


Fig. A.3 Diagram relating note size to pitch.

TEMPLATES FOR SINKING

The shape of the overall sink is of vital importance for the later backing and tuning. The main idea is to make the surface between the notes concave spherical in shape. But, in order to make the notes in the outer circle raise properly during the later backing, there must be a deviation from the concave shape near the rim. The surface should be straight or slightly convex here, resembling the final shape of the outer notes.

When the pan is backed, the surface between the outer notes should be lowered down to form a uniform spherical shape. Since the outer notes of the lower tuned pans are bigger and higher, the height of the convex part near the rim has to be higher in a degree corresponding to the height of the final note dents.

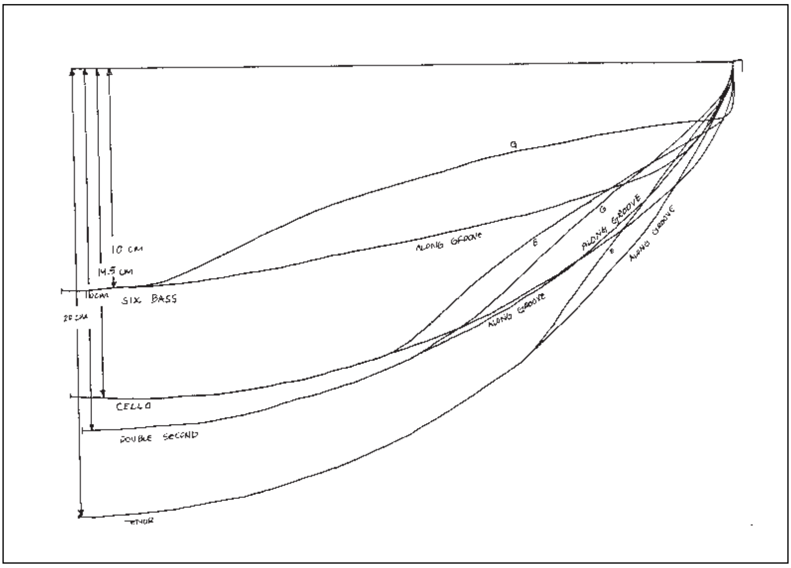
The template graphs given in fig. A.4 and A.5 have a special design. The pattern for each pan involves two shapes: one for the shape of the surface *between* the notes of the finished pan and one showing the shape measured *through* the highest note. The shape to be used during the sinking phase is the higher one, because at this stage material should be left to form the notes later. This template is the most important one.

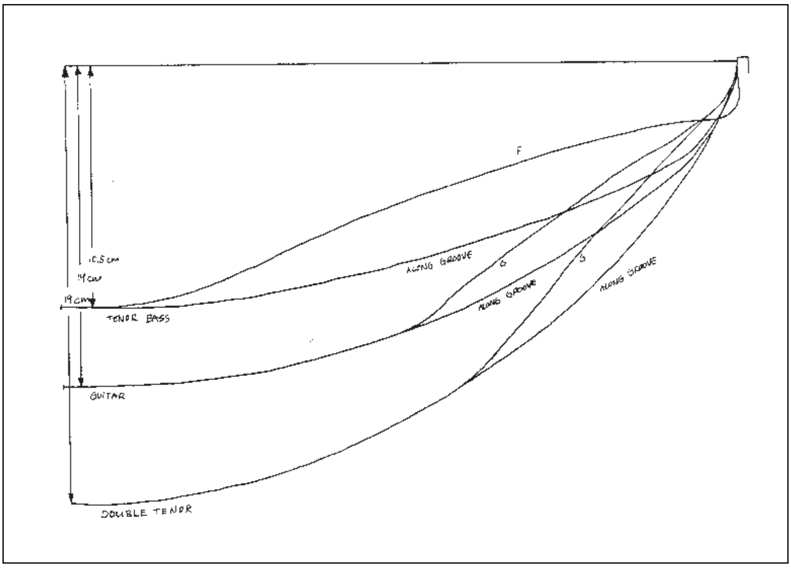
The second shape is given to show what the overall shape should be after backing, grooving and levelling. This template can be used after the backing to check that the surface between the notes has an even, spherical shape.

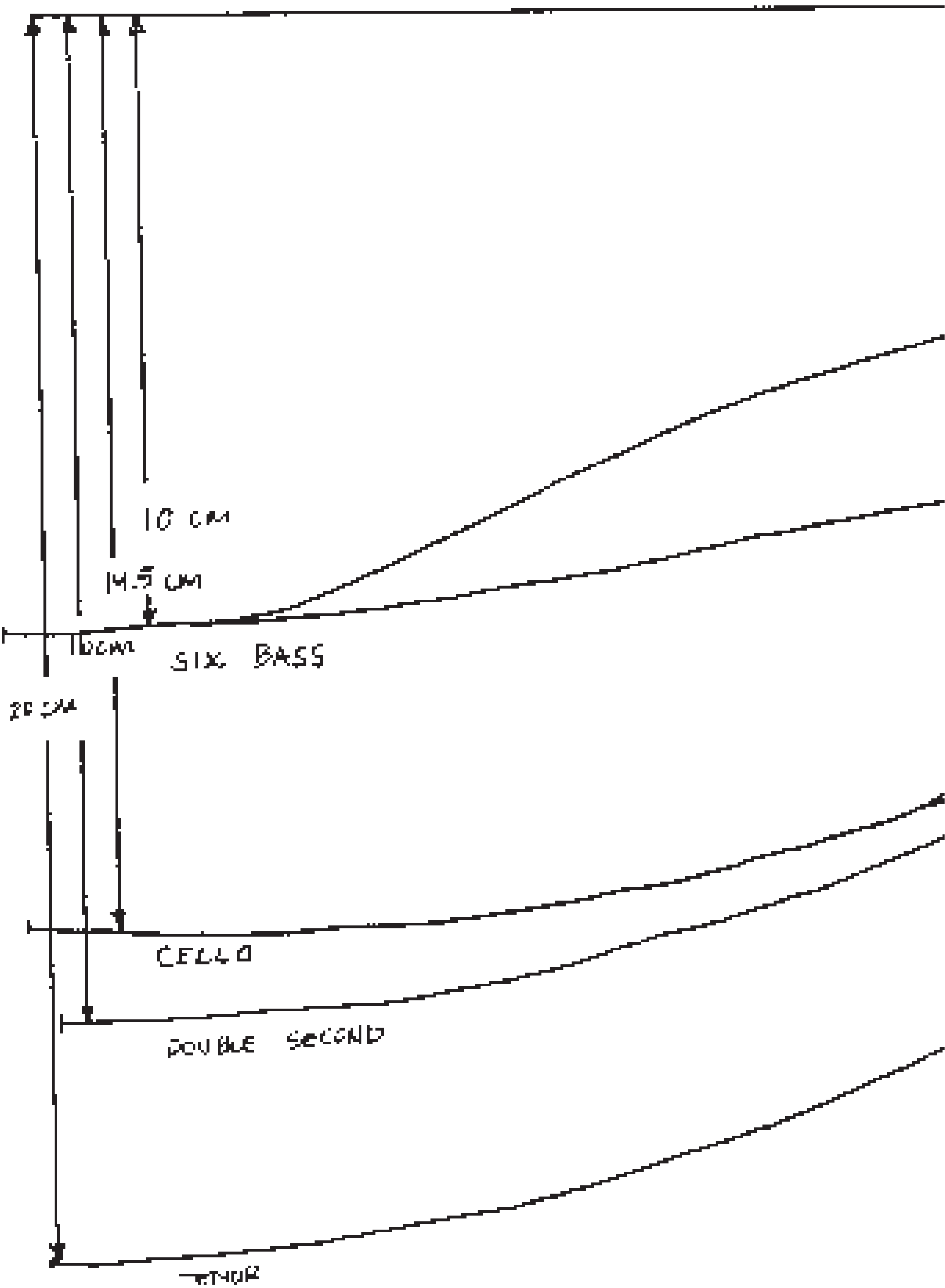
The best way to make sinking templates out of the patterns below is to copy the page twice for each pattern. Then take one of the copies and turn it back to front, to form a left and right side of the template. Paste the left and right shapes together, carefully adjusting them to match the correct depth of the basin for the intended pan. The next thing is to paste the template to some stiff material that can serve as a guiding template during the sinking.

The straight lines at the top of the patterns should not be included in the template, they are there just to serve as a reference to the vertical outer side of the drum. These lines should be vertical when you paste the left and right parts together. Last, cut the template after the shape lines.

Outline of sinking templates






10 CM
14.5 CM
10CM
SIX BASS
CELLO
DOUBLE SECOND

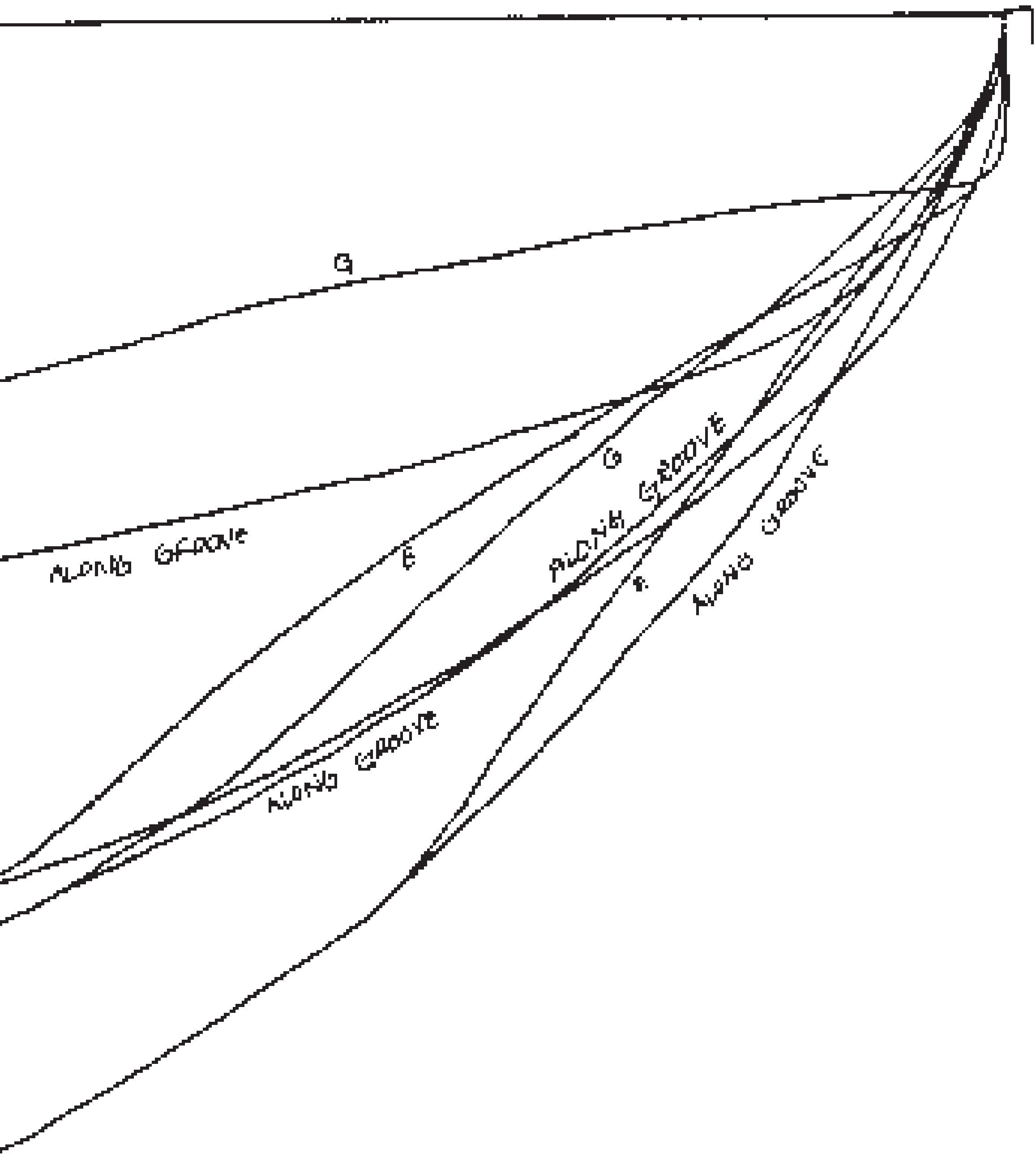
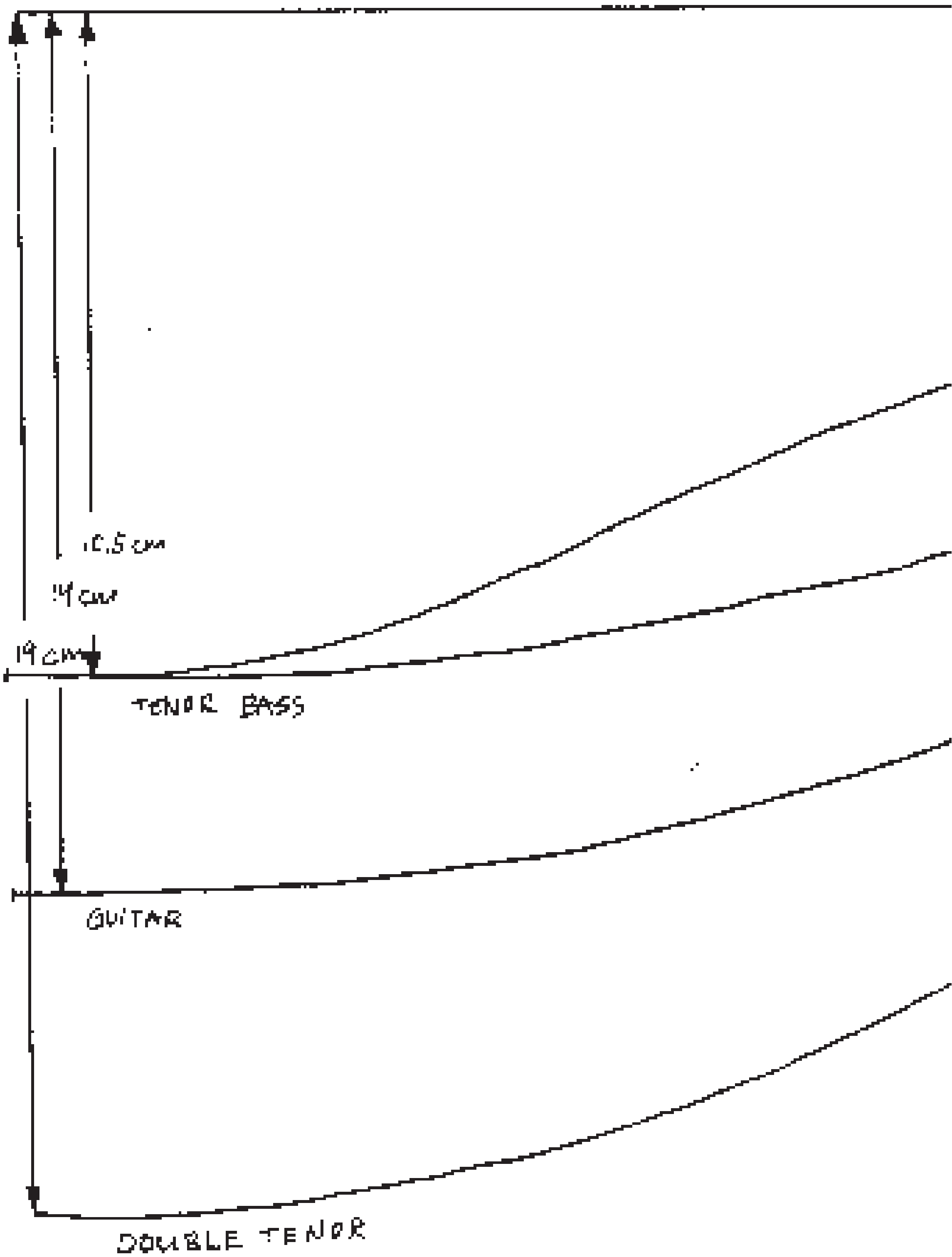


Fig. A.4 Sinking templates for tenor, double second, cello and six bass. Full scale right side. Cross-section of the surface along the groove and through the most convex note for each pan. *Drawing by Johan Larsson.*


10.5 cm
14 cm
19 cm
TENOR BASS
GUITAR
DOUBLE TENOR

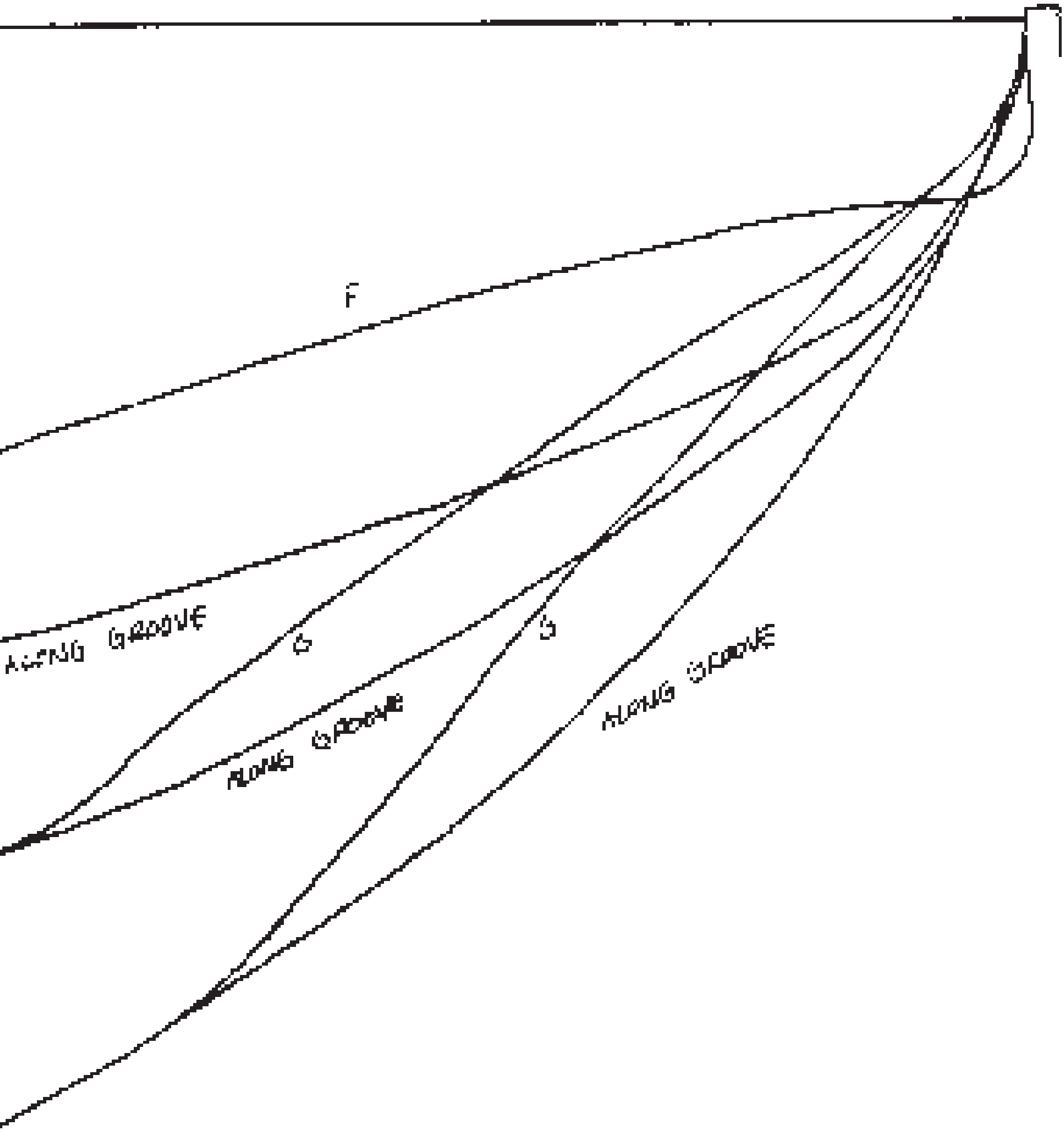


Fig. A.5 Sinking templates for double tenor, guitar and tenor bass. Full scale right side. Cross-section of the surface along the groove and through the most convex note for each pan. *Drawing by Johan Larsson.*

B. Tools for pan making

LIST OF TOOLS

This is a short list of the panmaking tools in the order you will need them:

Sinking

- Sinking sledge-hammer or a shot-put
- Protecting gloves
- Something to protect your ears from the noise
- Ruler and pencil – to mark sinking circles
- A compass – to make circles

Backing

- Backing sledge-hammer
- Smoothing hammer with a soft plastic head

Marking

- Flexible ruler – to measure the notes along the surface and the rim
- Note templates
- Pen, preferably an overhead marker to stick to the drum surface

Grooving

- Punch
- Grooving hammer

Cutting

- Marking stick or ruler
- Electric hacksaw or cutlass
- Plate shears and a file – for trimming

Tempering

- Fireplace of some kind
- Clock – for timing
- Brush, soap and water – to clean the pan

Tuning

- Tuning hammers
- Bending iron and a cutlass – to raise the outer notes, or
- Wooden wedges – specially shaped to raise the outer notes
- Wooden stick to raise the notes of basses.
- Tuning stick
- Padded stand or a truck tyre – to put the pan on while tuning
- A tuned instrument – as reference while tuning
- Drill – to make holes for strings
- Electronic tuning device – for fine tuning
- A sticky or magnetic sheet – to damp interfering notes

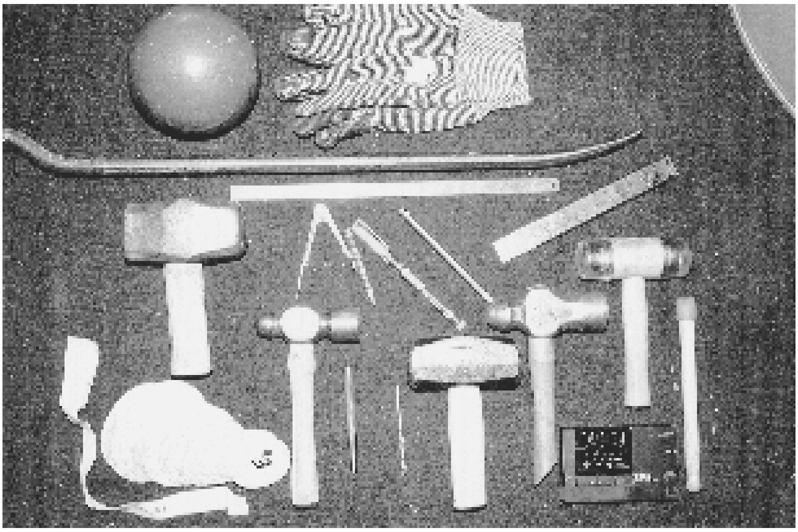


Fig. B.1 Main part of the tools needed for panmaking.

SINKING SLEDGE-HAMMER

The sinking sledge-hammer is a small 2.5-3 kg. sledge-hammer with the handle cut-off at approximately 22 cm. The handle is cut off to enable you to reach down in the sink with the head perpendicular to the concave surface. The end of the handle is cut at an angle to make it longer, so you can work with both hands, see figure B.2. The head must be well rounded off, preferably with a convex shape that matches the concave surface of the sunk pan.

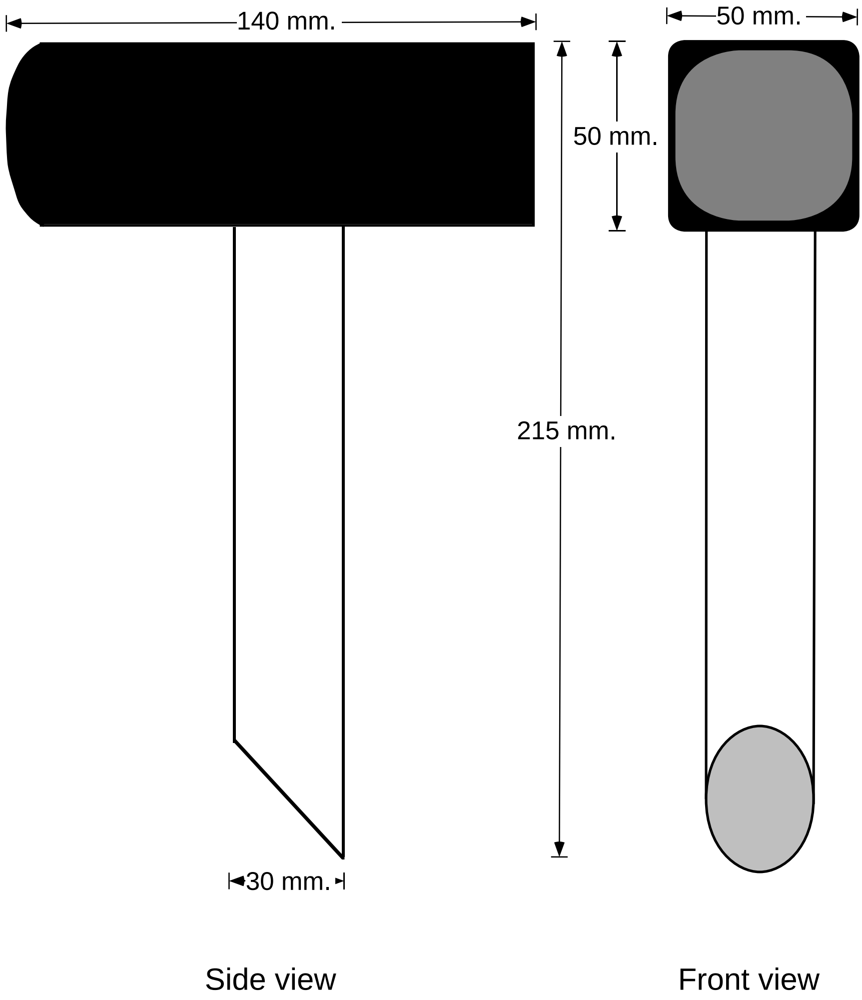


Fig. B.2 Sinking hammer seen from side and front, 50% of actual size.

SHOT-PUT

A common tool for the sinking work is a shot-put (or a cannon ball) of smooth, solid iron. The weight should be about 5 kg and the diameter approx. 11 cm, see fig. B.3. As in the case with the hammer, it is very important that the surface is smooth. A raw surface of cast iron will make marks in the metal that may cause cracks later.

Fig. B.3 Shot-put.

BACKING HAMMER

The backing hammer is almost the same rounded-off sledge-hammer as the sinking hammer, but the handle here is shortened down to 16 cm, to make it possible reach down and work on the notes in the sunk pan. The weight should be 2-2.5 kg and the head has to be well rounded off and very smooth.

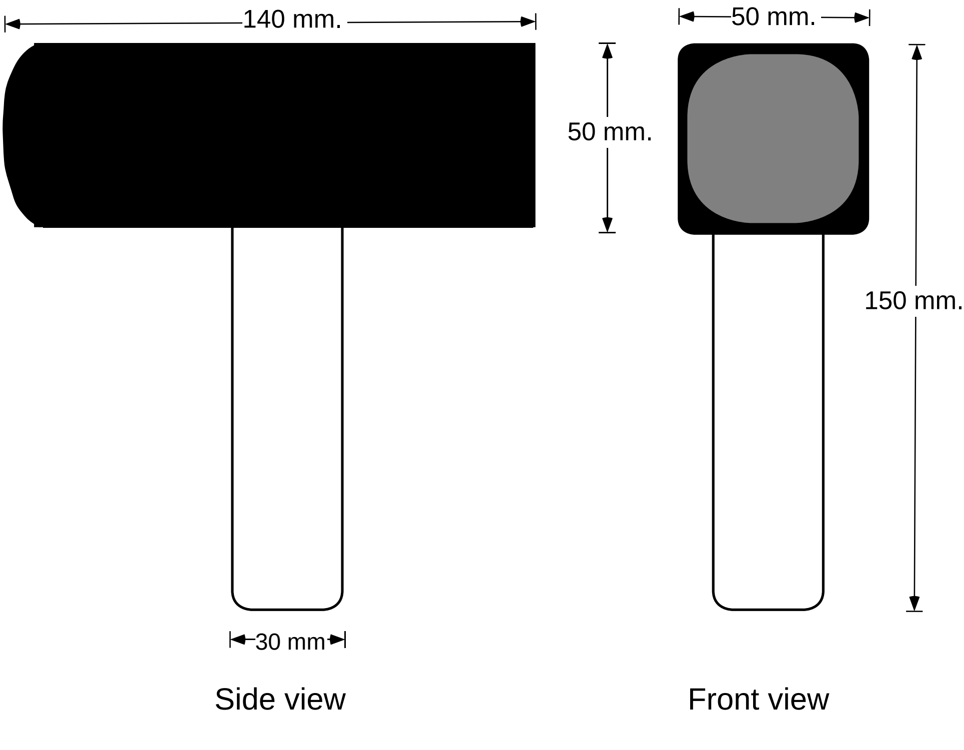


Fig. B.4 Backing hammer seen from side and front, 50% of actual size.

PUNCH

The punch used for grooving should be approximately 10 cm long and have a head diameter of 4-7 mm. The best way to make an appropriate punch is to take an ordinary nail-punch and cut it down to the right length. The head diameter is usually smaller for the higher pans and larger for basses and other low pans. Some tuners also use different punches for different notes in the same pan – for example 4 mm for inner notes and 5.5 mm for outer notes.

It is important that the punch is short enough so you can rest your hand on the surface while using it and still have good control over the upper end. The head should have a rather sharp edge to make distinct marks in the metal.

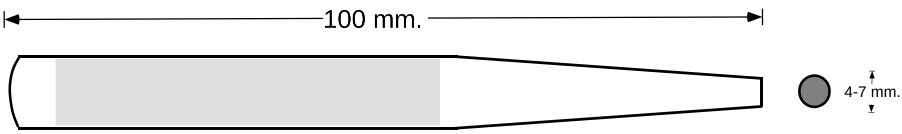


Fig. B.5 Punch seen from side and front, actual size.

GROOVING HAMMER

The grooving hammer is an ordinary hammer, weight about 0.5 kg, with a cut handle. The length of the handle is preferably 18-19 cm. It is very important that the head is tightly fastened to the handle, so choose a hammer of good quality. If the head jolts it will be difficult to control the strokes.

SMOOTHING HAMMER

If you do any separate smoothing, a suitable smoothing hammer is a small club with soft plastic heads. The handle should be cut of at the same length as the backing hammer, i.e., approx. 17 cm. This hammer is also usable for the tuning of medium-sized notes. The weight should be approx. 0.3 kg.

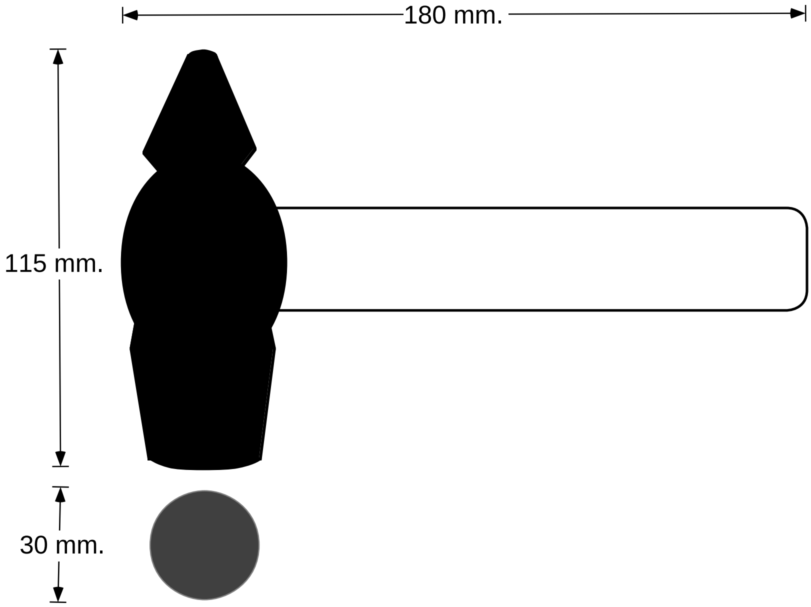


Fig. B.6 Grooving hammer seen from side and head front. 50% of actual size.

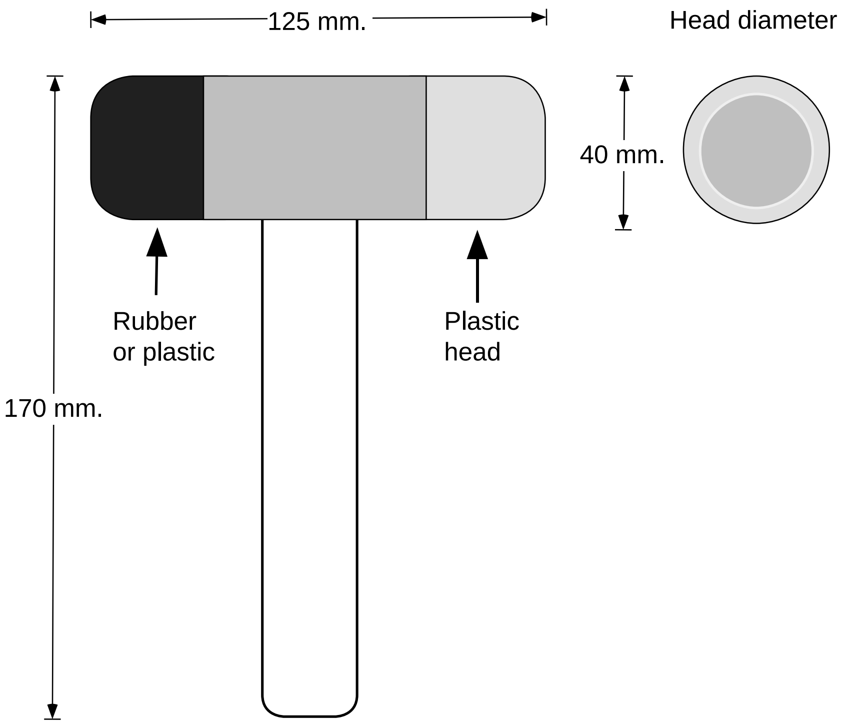


Fig. B.7 Smoothing/ tuning hammer seen from side and head front. 50% of actual size.

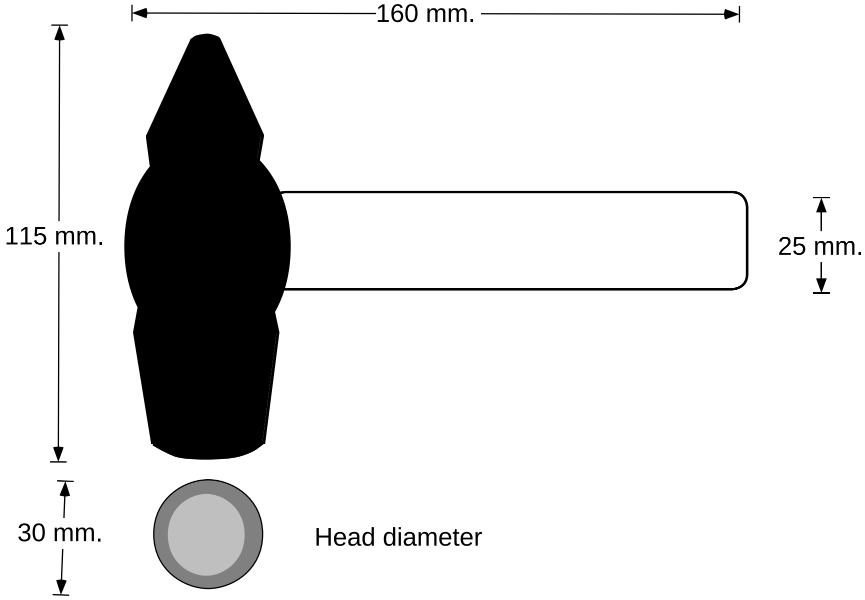


Fig. B.8 Tuning hammer for small notes.

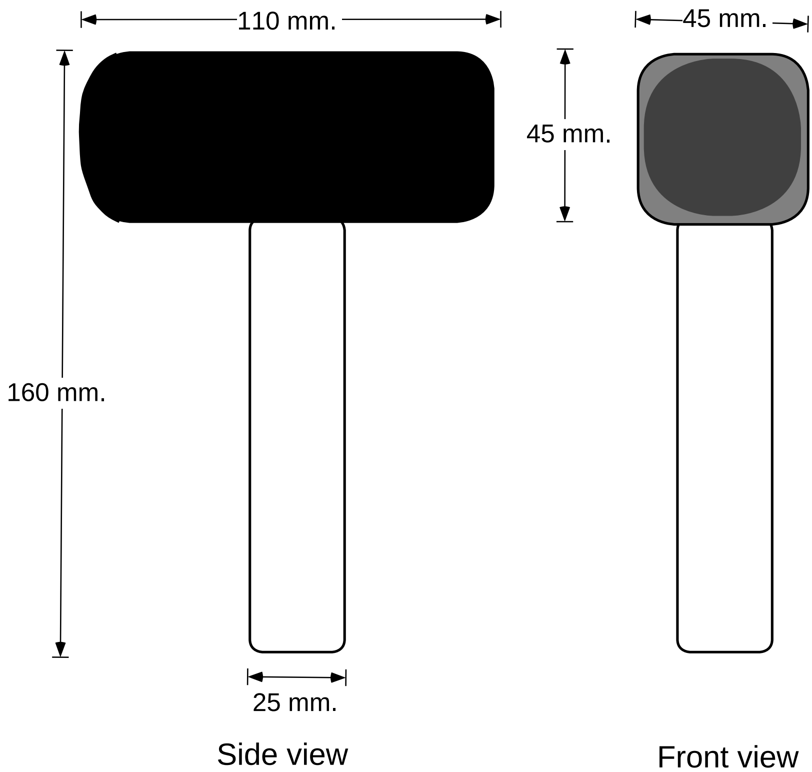


Fig. B.9 Tuning hammer for large notes.

Fig. B.10 A collection of hammers used by tuner Lawrence Mayers. Left to right: Small tuning / smoothing hammer, large tuning hammer, punch together with grooving hammer (also used for tuning of the smallest notes), backing hammer and shot-put. *Photograph by Linus Torell.*

TUNING HAMMERS

The hammers covering the needs for the tuning of the whole range of steel pans should preferably be a set of three; a small steel hammer for the smallest notes in tenors and double tenors, the plastic smoothing club, described as smoothing hammer above, for the medium sized notes, and a large, 1.5 kg hammer for the large notes of guitars and basses. The small steel hammer may actually be the same hammer as the one you do the grooving with, but the head should be smoothed if it is used for tuning.

BENDING IRON

When you tune the outer notes of tenors, double tenors and double seconds it can be difficult to hit on the inside of the pan with the tuning hammer, because of the great slope of the sink. To raise the outer notes a bending iron can be used instead of the hammer.

The bending iron looks similar to an ordinary crowbar. It is important that the iron has the right shape and is well rounded off at the top to avoid marks in the side of the pan. Sometimes the blade of a cutlass is used to protect the skirt while bending with the iron. The length of the iron should be about 35 cm.

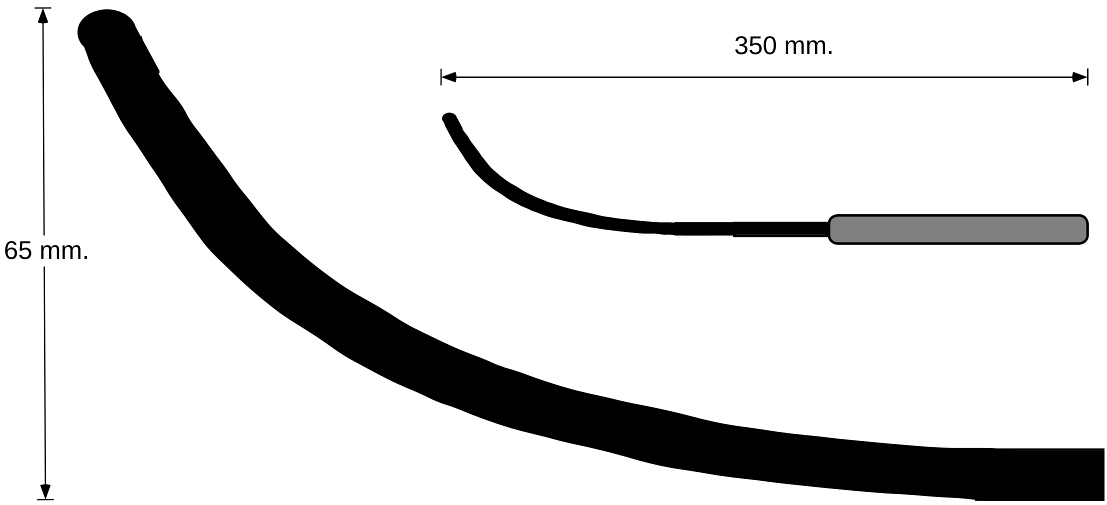


Fig. B.11 Shape of the curved part of the bending iron. Actual size.

WEDGES TO RAISE NOTES

Instead of an iron, wooden wedges can be used to raise outer notes. This is done by resting the wedge against the skirt and then hammering on the top of it to force the surface to re-shape.

TUNING STICK

The tuning stick is usually an ordinary stick used for the pan to be tuned. But sometimes it can be beneficial to use a stick that is a bit harder and heavier than the ordinary one. A harder stick will generate more harmonics and make it easier to tune. The extra weight makes it possible to check the pitch stability of the notes and even to do minor adjustments of the pitch with hard strokes. This means that the stick has to be heavier than any stick used while playing and the test or tuning stroke has to be harder than any playing stroke, otherwise the pan will later go out of tune while playing.

For the lower pans you will need a soft, ordinary stick so as not to get confused by the large amount of harmonics produced by a hard stick.

TUNING DEVICE

When you get to the later part of the tuning, an electronic tuning device is needed determine the exact pitch of the note. There are several good tuning devices on the market, but when you chose one, you should make sure that it has a tonal working range that is large

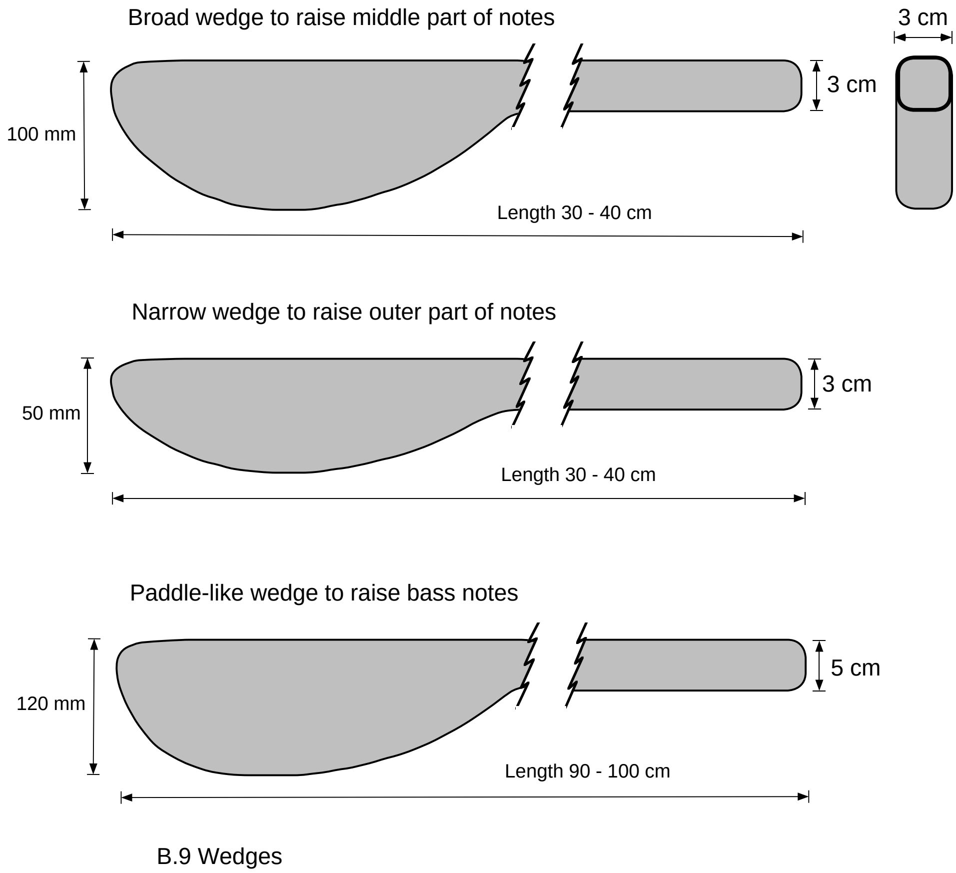


Fig. B.12 Wooden wedges used to raise notes.

enough to cover the whole steel pan ensemble. The notes in the bass range will cause most problems.

Devices for tuning of pianos will be sufficient as the piano covers a tonal range that is bigger than the steel pan ensemble. Devices designed for the tuning of guitars are usually no good, because the range is too small and it usually has pre-sets for the pitches of the guitar strings.

Tuner Rudy Smith uses a KORG DT-1 tuning device, and I use a KORG DT-2 (1991). This small tuning device covers the whole steel pan range and it is good at calculating the pitches, but it is rather expensive.

C. Measures for sticks

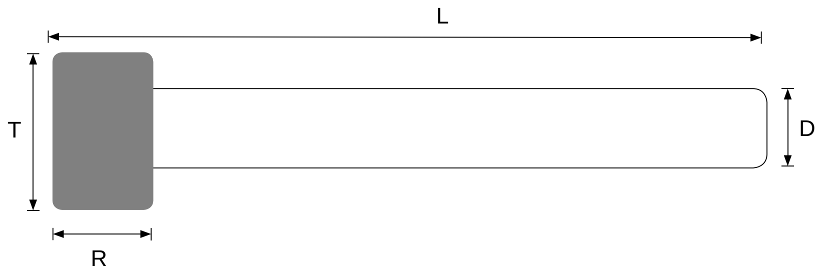


Fig. C.1 Definition of stick measures.

Steelpan model	L – Length	S – Stick diam.	T – Tip diam.	R – Rubber length
Tenor	150-180	11-13	15-17	15-20
Double tenor	170-200	11-13	18-20	15-20
Double second	170-200	11-13	19-22	18-25
Quadrophonic pan	180-220	12-14	20-24	20-25
Four pan	180-220	12-14	22-28	25-30
Double guitar	180-220	12-14	24-30	25-30
Triple cello	200-240	12-14	24-30	25-30
Tenor bass	300-350	12-15	ball, diam. 60-70	
Six bass	300-350	12-15	ball, diam. 60-70	
Nine bass	300-350	12-15	ball, diam. 60-70	

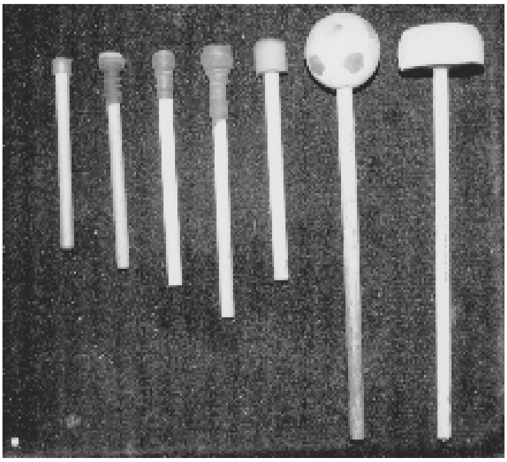


Fig. C.2 Examples of sticks of various types.

D. Steel drums for panmaking

Drums used for steel pan making are ordinary 55-gallon drums according to the standard ASA MH 2.1 or 2.2. The exact measures (according to the Swedish standard SIS 846201) are the following: internal diameter 571 mm, external diameter 595 mm (23 inches), height 840 mm (24.8 inches). The volume is 208 litres, which equals 45.8 Imperial gallons or 55 U.S. gallons, respectively.

The metal in the bottom is usually 1.0 or 1.2 mm thick. Below is a list of combinations of metal thickness in top/bottom and side and the corresponding weight of the drum. The weight might be used as a clue to the thickness of the metal.

THICKNESS <-> WEIGHT TABLE

Thickness side	Thickness top / bottom	Approx. weight
0.8 mm	1.0 mm	15 kg
1.0 mm	1.0 mm	18 kg
1.0 mm	1.2 mm	19 kg
1.2 mm	1.2 mm	22 kg

The best steel pans are probably made from drums with 1.2 mm steel in the bottom and 1.0 mm in the side, that is; 18/20 gauge. The bottom should not be less than 1.2 mm thick. A side that is 1.2 mm thick instead of 1.0 mm makes the pan a bit heavier but is acoustically acceptable.

CONVERSION TABLE; MM <–> GAUGE:

mm	gauge
1.0 mm	20 gauge
1.2 mm	18 gauge
1.4 mm	17 gauge

E. Definitions of vocabulary

THE INSTRUMENT

In this book I have chosen to use the term *Steel Pan,* or just *Pan* for short, referring to the whole instrument, regardless of whether it consists of one or several steel *drums*. A proposed Trinidad & Tobago standard also suggests that the instrument is called Steel Pan.

Outside Trinidad the name "Steel Drum" is often used. It is now due time that this name is eradicated, since it mainly refers to the raw material of the pan, thus implying that performance is made on raw, un-crafted drums. In recognition of the highly developed handicraft work in tuning, the notion that the pan is crafted can be stressed by consistently using the term steel pan for the instrument.

The proposed Trinidad & Tobago standard also suggests a short and precise *definition* of the instrument that is to be called steel pan (Ad Hoc Spec. Comm., 1989):

"A percussion instrument in the idiophone class, traditionally made from the unstoppered end and part of the wall of a metallic drum. The metallic playing surface is concaved with a skirt attached. The playing surface is divided into convex section by grooves, channels and/or bores; each section is a note tuned into a definite pitch. The convex sections are struck with pan sticks to produce musical tones."

NAMES OF THE STEEL PAN MODELS

The naming of the various pan models is a bit problematic. New names are introduced together with new or altered pan models. During

Trinidad common name	Trinidad proposed standard	Range name
Tenor	High tenor	Soprano
	Low tenor	C soprano
Double tenor	Double tenor	Alto
Double second	Double second	Tenor
Quadrophonic pan	Quadrophonic pan	
Four pan	Quadruple pan	
Guitar	Double guitar	
	Triple guitar	
Cello	Triple cello	Baritone
Tenor bass	Tenor bass	
Six bass	Low bass	
Nine bass		

later years, a standard set of pans has evolved and their names have been relatively fixed. A Trinidad standard of naming is now being proposed, but there are still some problems with the changing models.

Outside Trinidad, the names of the higher pans have sometimes been changed in an adaptation to the classical music nomenclature. The table above can be used as a "translation scheme" between the various names.

The reason for the confusion of the naming in the upper range of the steel pan family seems to be the following: In the early days of the pan the lead pan was a single drum with 8 to 10 notes, playing in the tenor range. As the tenor evolved, more notes were put in and the pitch was raised but the name remained the same.

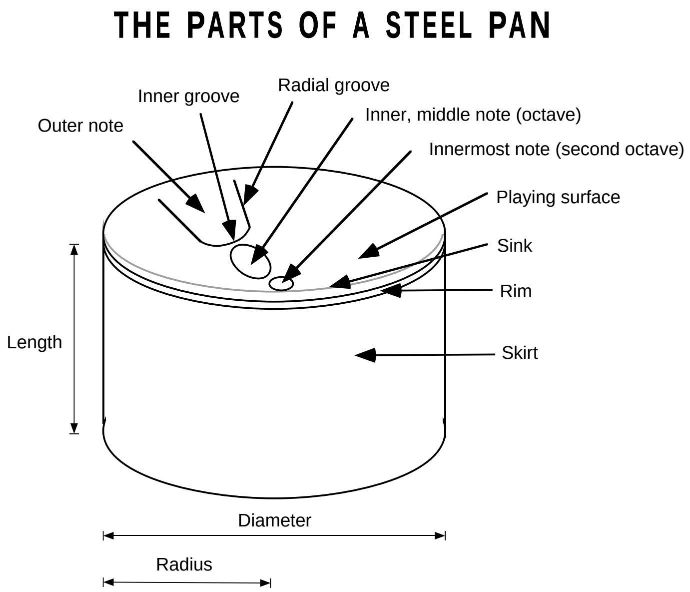


Fig. E.1 The parts of a steel pan.

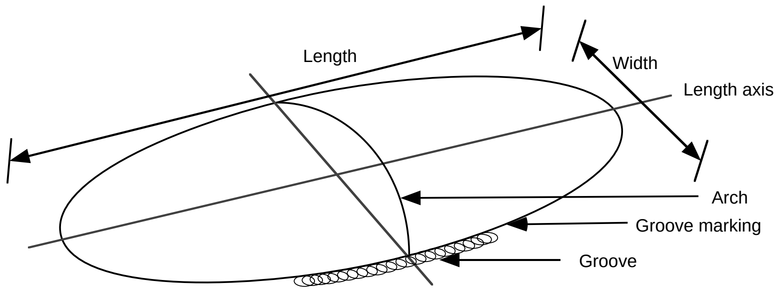


Fig. E.2 The parts of a note.

TECHNICAL TERMS

Arch The term *arch* is used to denote the vertical shape of a note dent.

Channel The area of the playing surface that is used to separate notes.

Concave Curved downwards, when seen from the top of the pan.

Convex Curved upwards, when seen from the top of the pan.

Dent The word *dent* is in this book used to describe the acoustically active areas of the steel pan. The notes are always convex, seen from the top of the pan, and could also be described using the synonymous words; bulge, dome or swelling. I have chosen to use the more technical word ”dent”, even if the regular use of it mostly refers to unintended, concave shapes.

Drum In this text, the word *drum* is used to denote the raw-material or the parts of a pan. This means that one *pan* can consist of several drums.

Groove An engraved line or indentation that marks the separation of notes.

Note A convex section tuned to a specific pitch.

Radial A direction along the radius of the drum, i.e., from the centre and outwards towards the rim or vice versa. Inner notes are usually oriented radially, i.e., with their length axis pointing towards the centre of the drum.

Skirt The wall of the steel drum, which acts as a resonator in the pan.

Tangential A direction along the *tangent* of the rim, i.e., following a straight line perpendicular to the radius. Outer notes are usually oriented tangentially, i.e., with their length axis pointing along the rim.

F. Names and addresses

This appendix lists some useful addresses to tuners, organisations and companies related to the steel pan.

PROFESSIONAL TUNERS

When you have tried to make your pan, failed and want a professional to do a better job for you, here is a list to make use of. This is an embryo to a list of professional tuners. Right now it contains only a few names and addresses. If you know the name and the address of a professional tuner, please report it to me, and he will be included in the next edition of the handbook.

Here are the addresses to the three tuners who have been involved in the research preceding the production of this book:

Rudy Smith, Parmagade 35, DK-2300 Copenhagen, DENMARK.

Lawrence 'Egar' Mayers, Sparrow Drive, Simeon Road, Petit Valley, TRINIDAD & TOBAGO

Denzil Fernandez, 5 Bank Hill Road, St. Francois Valley Road, Belmont, Port-of-Spain, TRINIDAD & TOBAGO

The names following below is an alphabetical list of respected tuners in Trinidad & Tobago that I have heard of, but of whose addresses I only have been able to get Jimmi Phillip's yet. It should be possible to reach the rest of the tuners through Pan Trinbago (see address below).

Jimmi Phillip Pan Workshop, Caroni Savannah Road, Charaguanas. TRINIDAD & TOBAGO

Stephen Aaron, Clifford Alfred, Patric Arnold, Wallace Austin, Leslie Bernard, Herman Brown, Felix Clark, Leo Coker, Joseph Collymore, Michael Cupidore, Vernon Dennis, Lennox Fortune, Lloyd Gay, Reynold Gillies, Roland Harrigin, Rolan Inniss, David Isaac, James Jackman, Norman James, Albert John, Michael John, Alwin

Jordan, Andrew Joseph, Bertram Kellman, Lennox Lewis, Michael Lindsay, Carlton Lynch, Vernon Manette, Bertrand Marshall, Andrew Morris, Lincoln Noel, Kenrick Parmell, Edward Peters, Augustus Peterson, Michael Phillips, Kelvin St. Rose, Youis Smith, Frank Stanisclaus, Aaron Thomas, Bertram Thomas, Leroy Thomas, Wilfred Thompson, Calvin Whyte, Patrick Worrell, and Barry Yates

ORGANISATIONS

Pan Trinbago – Steelband Association of Trinidad and Tobago
47 Edward Street
Port of Spain
TRINIDAD & TOBAGO
Assistant secretary: Mr. Richard Forteau

CARIRI – Carribean Industrial Research Institute
Tunapuna Post Office
TRINIDAD & TOBAGO

Trinidad and Tobago Bureau of Standards
Century Drive
Trincity Industrial Estate
Macoya, Tunapuna
P.O. Box 467
TRINIDAD & TOBAGO
Phone: 662-4482

COMPANIES

MIC – Metal Industries Company Ltd.
Company working with industrial maufacturing of steel pans.

Metal Industries Company Ltd.
Century Drive, Trincity
TRINIDAD & TOBAGO
Phone: 809 663-1274; 663-1279; 663-1269; 663-8479
Fax: 809 663-6055

LINCOLN ENTERPRISES LTD.
A company selling steel pans and acessories.

Lincoln Enterprises Ltd.
68 Ariapita Avenue
Woodbrook
Port-of Spain
TRINIDAD & TOBAGO
Phone: 625-5806; 674-7131

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