

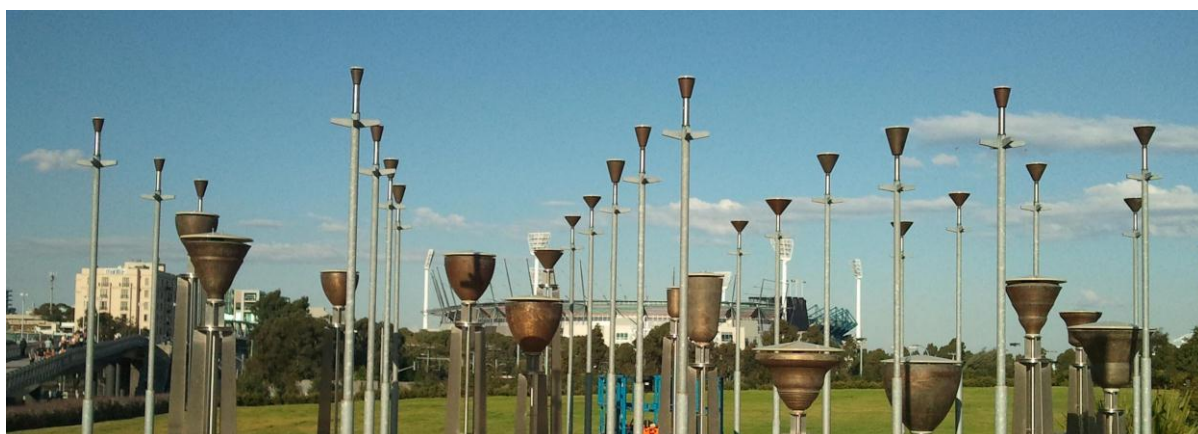
Federation Bells Composers' Manual



**CITY OF
MELBOURNE**

Federation Bells Composers' Manual

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Overview

The Federation Bells are a collection of 39 bronze upturned bells mounted on poles in a grid arrangement at Birrarung Marr in central Melbourne. They can be played using a sophisticated electromechanical system, in which internal hammers strike the bells, triggered by simple MIDI commands.

This composer's manual attempts to give both novice and experienced composers an insight into the bells and the striking system, and will hopefully contribute to a satisfying musical experience composing for this unique instrument.

Whilst the Federation Bells is a MIDI controlled instrument, a number of factors mean that the installation does not behave like other MIDI instruments. Composers who are used to artificial instruments like drum machines and synthesizers can easily create music that is extremely complex and difficult to play with physical instruments. It is important to remember that this collection of bells is a physical instrument, and as such has physical limitations. Conversely the Federation Bells has great possibilities and an understanding of the system will allow the composer to fully exploit the instrument.

It is possible to play the Federation Bells live with any MIDI controller or it can be pre-programmed with MIDI files to be "rung" at specified times. This guide is designed to assist composers creating music to be performed by the Federation Bells using pre-programming.

Computer Composition

A computer is required to create compositions for the Federation Bells.

There are two methods by which you can create compositions:

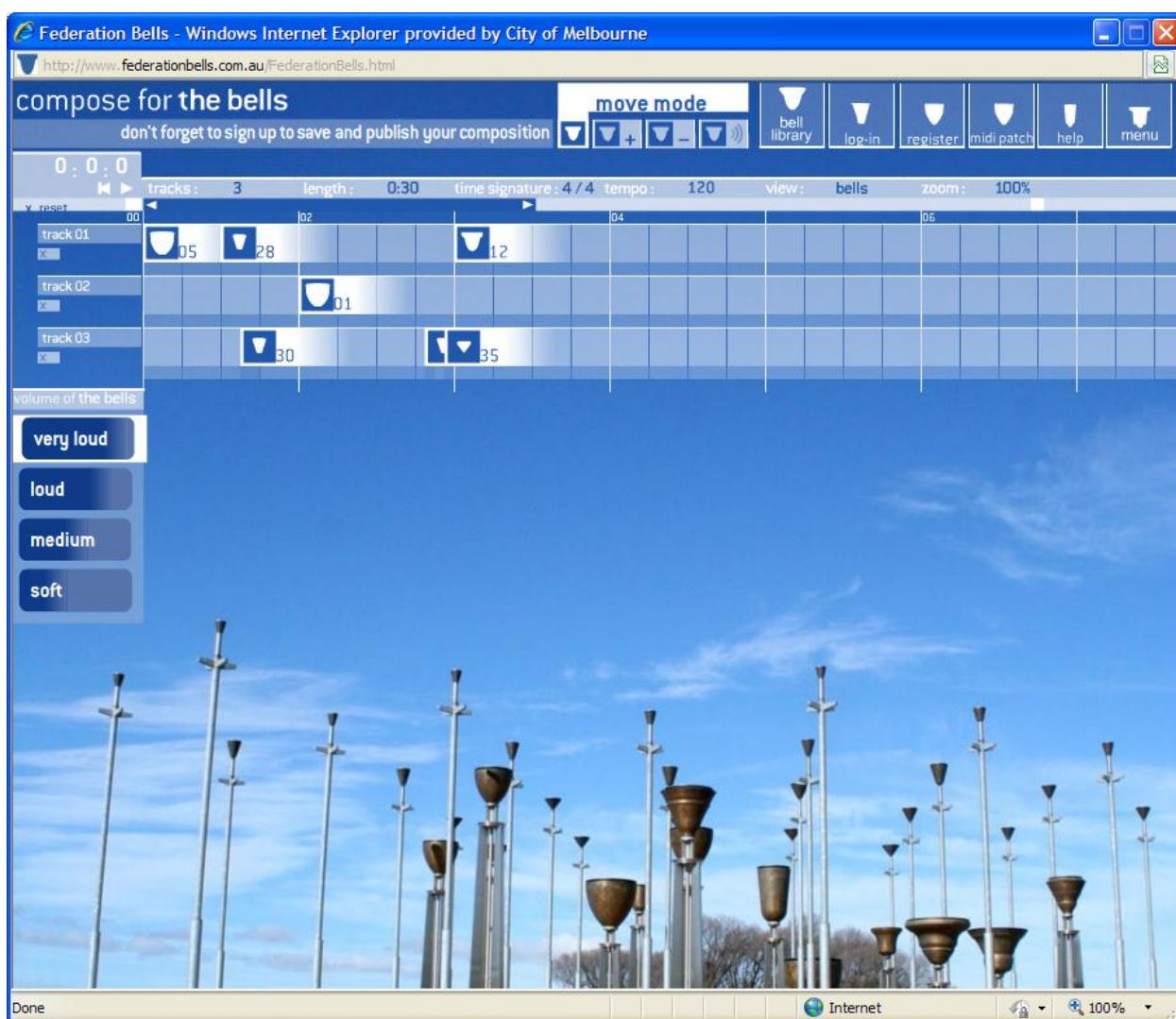
- 1) using the on-line composition timeline at www.federationbells.com.au
- 2) downloading a patch into a sampler that you run on your own computer.

On-line Composition

To use the on-line compositional tool, you will need to use a computer with a sound card and an internet connection. The connection to the internet needs to be consistent: whilst occasional drop-outs won't have a big effect, a poor internet connection may lead to frustration.

To begin using the on-line composition timeline:

1. visit www.federationbells.com.au
2. Click *Launch the Bells*. This will take a little while to load. Please be patient.
3. Click the *Compose* button to reveal the bell timeline.
4. Simply drag and drop bells from the photo into the timeline.
5. It is worth spending a few minutes reading the *Help* section. The tool is designed to be easy for novices to use. However, many of the advanced facilities of the compositional tool require a little bit of exploring. The tool can produce fast and complex rhythms and can play up to eight bells at once
6. Save your piece regularly and when complete, *Publish* your composition



MIDI Patch

There are some functions that the on-line compositional tool cannot do:

- Changes of speed
- Changes of time signature
- Play more than eight bells at once
- Play faster than eight notes in one beat
- Play at the softest possible dynamic level

These issues can be dealt with by composing off-line using a MIDI sequencer program (such as Cubase, Logic or ProTools) with a sampler (such as Kontakt). This is recommended for people who have experience using samplers and sequencers or are willing to invest time in learning how to use them. A version for Ableton Live is also available.

1. visit www.federationbells.com.au
2. Click *Launch the Bells*. This will take a little while to load. Please be patient.
3. Click the *Compose* button to reveal the bell timeline, then click the *MIDI patch* button.
4. Download the toolkit and follow the instructions on the website
5. Create your composition
6. E-mail your completed MIDI file to fedbells@melbourne.vic.gov.au



A Dead Forest Index perform live with the Federation Bells for *The Bells of Friday 13th* in April 2012

Tuning

The Bells are tuned in 'just' intonation. In theory each bell's Nominal tone is a whole number ratio multiple of Bell 1, which is a Nominal D.

Practically speaking this means that this set of bells does not correspond to the modern European equitempered scale. Certain combinations of bells may sound out of tune to the modern ear. However other combinations sound more in tune than usual because the beats commonly heard are absent, due to the precise mathematical relationships in just intonation.

Just intonation is usually associated with modal music, which stays in the same key from the beginning to end of a piece. However the Federation Bells go one step further, with two partially chromatic octaves from Bell 15 to 39. You may notice below there are two C naturals in each octave, about $\frac{1}{4}$ tone apart. These are designed to be used in different scales, one in the scale of D, the other in B flat.

In the table below you will also see Equi(tempered) -pitch and Just Pitch. This shows the deviation from **A 440 equitempered** and **D modal Just temperament**, in cents, of each bell, and in some cases, details of the most obvious harmonics and their tuning, which may help you understand how to use the chromatic portion of the bells. They are not all designed to be played melodically in the same piece, or at the same time.

Of course, composers using a sequencer patch or the on-line composition tool are free to side-step an intellectual understanding of just temperament and let their ears guide them.

* * *

Volume - Loudness

Each of the thirty-nine Federation Bells can play five distinct velocities (levels of loudness).

Velocity 1 is the quietest and Velocity 5 the loudest. Each bell has its own loudness profile, but in general, the five levels can be equated to:

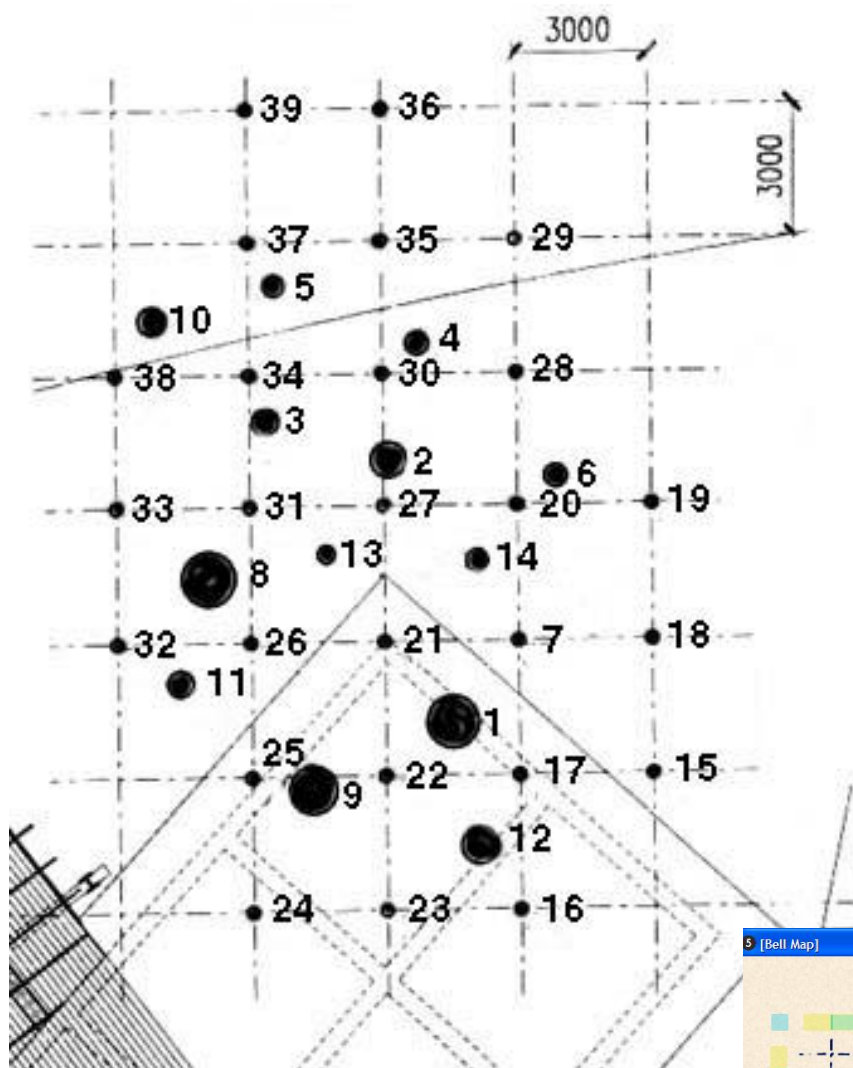
(1) very soft	<i>pp</i>	MIDI velocity values: 1-25
(2) soft	<i>p</i>	MIDI velocity values: 26-50
(3) medium	<i>mf</i>	MIDI velocity values: 51-75
(4) loud	<i>f</i>	MIDI velocity values: 75-100
(5) very loud	<i>ff</i>	MIDI velocity values: 101-127

As at May 2012, the on-line web composition facility found at www.federationbells.com.au has four velocity levels that correspond to velocities 2 to 5.

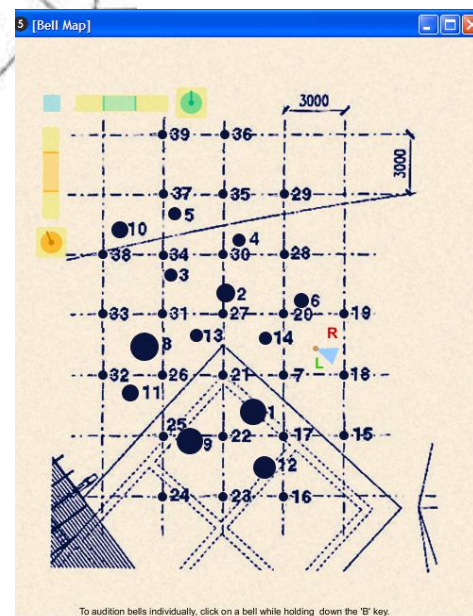
Spatiality

Unlike a conventional carillon, which is usually mounted in a tower with each bell close to the next, and heard from a distance, these bells are distributed in a grid, and listeners are able to walk among the bells, inside the instrument. Some have likened it to walking in a small musical forest. Composers are encouraged to experience and exploit the spatial aspect of the installation. This can be achieved by constructing rhythmic or melodic phrases that appear to move above the heads of the listeners in a co-ordinated fashion.

The following diagram shows the relative locations of the Federation Bells.



Terry McDermott has created software that gives a virtual spatial representation of MIDI files, allowing the listener to “walk through” the bells installation. City of Melbourne has a license to use this software (available both for PC and Mac). Please contact info@fedbells.com.au if you are interested in using this facility.



MIDI Specifications

Bells are played using MIDI notes 24 (C0) lowest to 62 (D3) highest.

They respond to five dynamic levels.

Velocity 1 (quietest) responds to MIDI velocity	1	to	25
Velocity 2 responds to MIDI velocity	26	to	50
Velocity 3 responds to MIDI velocity	51	to	75
Velocity 4 responds to MIDI velocity	75	to	100
Velocity 5 (loudest) responds to MIDI velocity	101	to	127

MIDI velocity 0 has a special meaning in MIDI and is not used.

Note duration has no effect and each bell will resonate and decay naturally.

Only MIDI Channel 1 is used for playing the bells.

MIDI Controller and sysex information are ignored by the playing system. Tempo is the only additional control to be recognised and used.

Please specify the tempo. Default tempo is crotchet = 120. Tempo changes are possible.

The MIDI files should be exported as type 0.

Timing and Articulation

There are hammers of different weights, some more than a kilogram, that start moving when a MIDI command is received. The larger hammers take slightly longer to reach the bell than smaller hammers. Similarly, a hammer moves more slowly when playing softly. The difference between the strike times is compensated for by a “pre-delay” function that allows the quieter, slower notes to ‘catch up’ with the faster ones. The “pre-delay” function is generally in-use; however, it can be switched off by the Federation Bells Curator.

It should be noted that as a spatially dispersed instrument, the perception of when a bell strikes does alter slightly according to where the listener is positioned. The “pre-delay” function assumes that the listener is located near the main signage, near the bridge.



Forces at *The Bells of Friday 13th*, April 2012

Repetition Rate

In the table below you will find midi note number, note name, nominal pitch, tuning variation and repetition rate.

Repetition rate is the number of times a particular bell can sound in one second.

For example, the number 8 means the maximum number of strikes that bell can sound in one second is exactly eight.

Intervals between successive notes in this example can be no closer than 125 milliseconds.

i.e. 1000 divided by 8.

If you program a repeated note at 124 milliseconds (or less) from any given note it will be ignored.

8 notes in one second corresponds exactly to semi-quavers (sixteenth-notes) at 120BPM

* * *



Trills and Drones

It is possible to create some effective drones by repeating notes, as long as they are not closer together than the **repetition rate**.

Additionally, remember that when played repeatedly, a bell will reach a “saturation” point beyond which it can’t physically get any louder. The system will automatically thin out and finally not play excessive repetitions of loud notes.

Trills on one note might be limited by the repetition rate. Consider using two or more bells alternately to achieve really fast trills, which may also sound more musical.

Creating a drone can best be achieved by using Velocity 2 or 3.

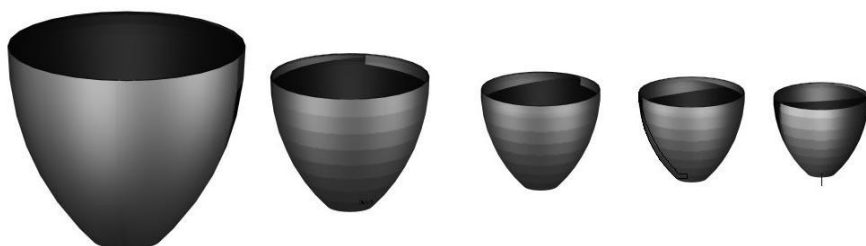
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The Nine Types of Bells



From a compositional point of view, it is useful to understand the sets of bells. Each set has a different characteristic tone colour and offers different possibilities.

This is analogous to the various instruments in a string orchestra. While the violins, violas, cellos and basses may look superficially the same, each has unique characteristics which if understood allow the composer to create a wide range of effects.



Bells 1- 5. At the bottom of the scale we have five wineglass shaped bells. These warm sounding bells are arranged in a pentatonic scale. The lowest two bells are given slightly more brilliance at higher velocities to create a dramatic effect.

Bell set One	MIDI NOTE	Note Name	Nominal	Nominal Frequency	Just Intonation pitch variation, Cents	Equal Temperament pitch variation, cents	Repetition Rate, Hz	Notes
1	24	C0	D 3	150	+37	+37	3	
2	25	C#0	A 3	220	-2	0	3	
3	26	D0	D 4	299.5	+34	+34	6	
4	27	D#0	E 4	331.5	+6	+10	8	
5	28	E0	F# 4	378	+51	+37	8	



Bells 8 and 9 are 'triple tone' bells. The unusual shape creates three notes. They work well together or as a bass for some scales

Bell set Two	MIDI NOTE	Note Name	Nominal	Nominal Frequency	Just Intonation pitch variation, Cents	Equal Temperament pitch variation, cents	Repetition Rate, Hz	Notes
8	31	G0	D4,G4,B4	289 - 401.5 – 501	-28,+43,+40	-28,+41,+25	4	
9	32	G#0	D4,Bb4, A5	290.5 – 476.5 – 859.5	-19,+20,-43	-19,+38,-41	6	



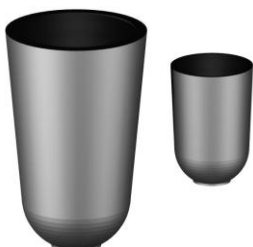
Bells 10,11. These are 'two tone bells' - each bell sounds two notes. They are useful as colour tones

Bell set Three	MIDI NOTE	Note Name	Nominal	Nominal Frequency	Just Intonation pitch variation, Cents	Equal Temperament pitch variation, cents	Repetition Rate, Hz	Notes
10	33	A0	D4,C5	300.5 – 520.5	+40,+22	+40,-9	6	
11	34	A#0	D4,C5,(A5)	293.5 - 525 – 873	-1,+37,-16	-1,+6,-14	6	



Bell 12 is a ships bell – a classic European Bell

Bell set Four	MIDI NOTE	Note Name	Nominal	Nominal Frequency	Just Intonation pitch variation, Cents	Equal Temperament pitch variation, cents	Repetition Rate, Hz	Notes
12	35	B0	D5,F5	590 – 708	+8,+8	+8,+23	6	



Bells 13,14 'Asian Temple Bells' - these bells offer another distinctive round singing tone quality

Bell set Five	MIDI NOTE	Note Name	Nominal	Nominal Frequency	Just Intonation pitch variation, Cents	Equal Temperament pitch variation, cents	Repetition Rate, Hz	Notes
13	36	C1	D4, F#5	293, 721	-4,-31	-4,-45	6	
14	37	C#1	D4,G5	291, 801	-16,+39	-16,+37	8	



Bells 6,7,15 - 20. These bells are mounted on 6 Meter poles – apart from bell 6. They are ‘wide cone’ bells and project sound directionally. Underneath them, their tone disappears, but as you move away from their pole, their note becomes apparent. They have a very mellow, round tone, with few high harmonics, and are generally the quietest bells, due to their shape.

Bell set Six	MIDI NOTE	Note Name	Nominal	Nominal Frequency	Just Intonation pitch variation, Cents	Equal Temperament pitch variation, cents	Repetition Rate, Hz	Notes
6	29	F0	A4	438	-10	-8	6	
7	30	F#0	A3, B4	216, 500	-34,+37	-32,+21	6	
15	38	D1	D5,A5	584.5, 865	-8,-32	-8,-30	6	
16	39	D#1	E4	325.5	-26	-22	8	
17	40	E1	F5	698.5	-16	0	8	
18	41	F1	F#5	732	-5	-19	8	
19	42	F#1	G5	781	-5	-7	8	
20	43	G1	Ab5	820	-5	-22	6	



Bells 21 - 25. These ‘medium cone’ bells are all on poles. They also project directionally, but their field of sound is wider. Their tones are brighter than set 6.

Bell set Seven	MIDI NOTE	Note Name	Nominal	Nominal Frequency	Just Intonation pitch variation, Cents	Equal Temperament pitch variation, cents	Repetition Rate, Hz	Notes
21	44	G#1	A4	436.5	-16	-14	10	
22	45	A1	Bb4	467	-11	+3	10	
23	46	A#1	B4	487	-9	-24	12	
24	47	B1	C5	510	-13	-44	12	
25	48	C2	C5	523	+30	-1	12	



Bells 26 - 31. These steep cone bells are bright and project well. Their harmonics are well balanced.

Bell set Eight	MIDI NOTE	Note Name	Nominal	Nominal Frequency	Just Intonation pitch variation, Cents	Equal Temperament pitch variation, cents	Repetition Rate, Hz	Notes
26	49	C#2	C#5	550.5	0	-12	10	
27	50	D2	D5	587	-1	-1	10	
28	51	D#2	E5	659.5	-3	+1	12	
29	52	E2	F5	702	-7	+9	10	
30	53	F2	F#5	730	-10	-24	12	
31	54	F#2	G5	780.5	-6	-8	12	



Bells 32 - 39. These 'hand-bells' are similar to the ones that may be hired from Museum Victoria. They are also steep cones, but small ranging in size from 157 to 116 mm. Their tone is very bright and penetrating, with a short decay time.

Bell set Nine	MIDI NOTE	Note Name	Nominal	Nominal Frequency	Just Intonation pitch variation, Cents	Equal Temperament pitch variation, cents	Repetition Rate, Hz	Notes
32	55	G2	Ab5	816	-13	-31	12	
33	56	G#2	A5	873	-16	-14	12	
34	57	A2	Bb5	929	-20	-6	12	
35	58	A#2	B5	971.5	-13	-29	12	
36	59	B2	C6	1034	10	-21	12	
37	60	C3	C6	1051.5	+39	+8	12	
38	61	C#3	C#6	1102	1	-11	12	
39	62	D3	D6	1170.5	-7	-7	12	

Bell Harmonic Glossary

Describing a Bell's pitch is not straightforward. Each bell has a unique set of harmonics, also known as overtones or partials. Sometimes the Nominal, the note you think you hear, is not really present in the sound and is suggested by the combination of the higher partials.

Bell makers have gradually created a body of knowledge from theory and practice during the past two thousand years or so. The Federation Bells represent a brave step with several totally new bell shapes. Australian Bell has invented a series of bells with harmonic overtones. These are currently being patented in Europe and the USA. Harmonic bells have the clearest pitch salience yet achieved in any bell or other tuned percussion instrument, and can be played in any musical key without dissonance caused by inharmonic partials.

The main notes heard in a bell are

Hum – very quiet, what in another instrument would be called the fundamental. You can usually only hear this very near to the bell. Frequency = f_0

Prime – sometimes discernable, the first octave. $2 \times f_0$

Tierce – A low warm note, major third $5/2 \times f_0$

Quint – the fifth – a pure tone $3 \times f_0$

Nominal – the note you would sing if asked 'what is the pitch of that bell?' $4 \times f_0$

Superquint – octave of the quint – bright ringing tone $6 \times f_0$

Octave Nominal - octave of the nominal! – penetrating tone. $8 \times f_0$

And so it goes on, up and up.

The Large Bells have many significant harmonics, and thus if used as a basis for composition need careful consideration.

The unique design of the conical bells – all the ones on the poles - give them a fairly uniform set of harmonics. Some only have two or three predominant tones, which is rare in any bell. They work well in defining melody, and rhythm.

Consolidated Bell Table

	MIDI NOTE	Note Name	Nominal	Nominal Frequency	Just Intonation pitch variation, Cents	Equal Temperament pitch variation, cents	Repetition Rate, Hz	Notes
1	24	C0	D 3	150	+37	+37	3	
2	25	C#0	A 3	220	-2	0	3	
3	26	D0	D 4	299.5	+34	+34	6	
4	27	D#0	E 4	331.5	+6	+10	8	
5	28	E0	F# 4	378	+51	+37	8	
6	29	F0	A4	438	-10	-8	6	
7	30	F#0	A3, B4	216, 500	-34,+37	-32,+21	6	
8	31	G0	D4,G4,B4	289 - 401.5 – 501	-28,+43,+40	-28,+41,+25	4	
9	32	G#0	D4,Bb4, A5	290.5 – 476.5 – 859.5	-19,+20,-43	-19,+38,-41	6	
10	33	A0	D4,C5	300.5 – 520.5	+40,+22	+40,-9	6	
11	34	A#0	D4,C5,(A5)	293.5 - 525 – 873	-1,+37,-16	-1,+6,-14	6	
12	35	B0	D5,F5	590 – 708	+8,+8	+8,+23	6	
13	36	C1	D4, F#5	293, 721	-4,-31	-4,-45	6	
14	37	C#1	D4,G5	291, 801	-16,+39	-16,+37	8	
15	38	D1	D5,A5	584.5, 865	-8,-32	-8,-30	6	
16	39	D#1	E4	325.5	-26	-22	8	
17	40	E1	F5	698.5	-16	0	8	
18	41	F1	F#5	732	-5	-19	8	
19	42	F#1	G5	781	-5	-7	8	
20	43	G1	Ab5	820	-5	-22	6	
21	44	G#1	A4	436.5	-16	-14	10	
22	45	A1	Bb4	467	-11	+3	10	
23	46	A#1	B4	487	-9	-24	12	
24	47	B1	C5	510	-13	-44	12	
25	48	C2	C5	523	+30	-1	12	
26	49	C#2	C#5	550.5	0	-12	10	
27	50	D2	D5	587	-1	-1	10	
28	51	D#2	E5	659.5	-3	+1	12	
29	52	E2	F5	702	-7	+9	10	
30	53	F2	F#5	730	-10	-24	12	
31	54	F#2	G5	780.5	-6	-8	12	
32	55	G2	Ab5	816	-13	-31	12	
33	56	G#2	A5	873	-16	-14	12	
34	57	A2	Bb5	929	-20	-6	12	
35	58	A#2	B5	971.5	-13	-29	12	
36	59	B2	C6	1034	10	-21	12	
37	60	C3	C6	1051.5	+39	+8	12	
38	61	C#3	C#6	1102	1	-11	12	
39	62	D3	D6	1170.5	-7	-7	12	