

12-TONE
CHROMATIC
EBAA
Mallet Percussion Experimental Science

BASS MARIMBA

Engineering Development Specification
Revision A

Prepared By _____

CCBanta

Christopher C. Banta
Cognizant Design Engineer

September 1990

CCBANTA PUBLICATIONS

232 Wyoming St.
Pasadena, CA 91103

1029
Doc. No.: CCB-1045

TABLE OF CONTENTS

	<u>Page</u>
1.0 PURPOSE	TBD
2.0 DEFINITIONS	TBD
3.0 GENERAL INFORMATION	TBD
4.0 MARIMBA BARS	TBD
5.0 RESONATORS	TBD
6.0 FRAME	TBD
7.0 FINISHES	TBD
8.0 MISCELLANEOUS	TBD

1.0 PURPOSE

This specification establishes the baseline criteria which shall be utilized when designing a class of musical instrument keyboard percussion known as an EXTENDED BASS MARIMBA (EBM).

2.0 DEFINITIONS

2.1 MARIMBA - A melodic bar percussion musical instrument having notes systematically arranged like a piano keyboard while taking on the appearance of a large xylophone with resonators.

2.2 BASS - Low-pitched tones, generally starting within the bass clef and extending down to Cello "C" which is two ledger lines below the bass clef of the musical staff. "EXTENDED" indicates that the bottom note of the bass has been expanded below Cello "C" by some degree.

2.2 BAR - A rigid body, of rectangular shaped material, capable of vibrating with extreme regularity. The bar represents the pitch producing component.

2.3 RESONATOR - A device used for increasing the loudness of a bar's pitch by resonance. The resonator represents the amplification component.

2.4 CENT - A small unit of measurement or division between two notes. There are 100 cents between half-steps, and 1200 cents between octaves.

2.5 NODE - A high pressure point where no vibration or movement occurs.

3.0 GENERAL INFORMATION

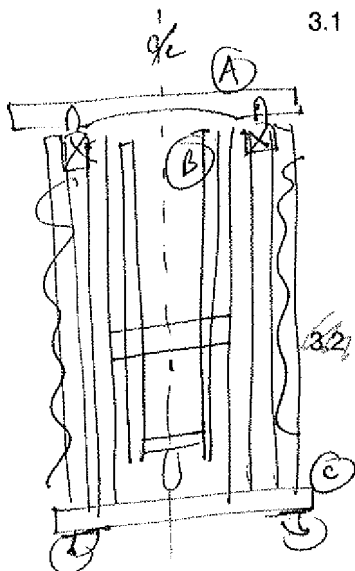
3.1 The EBM shall consist of the three following sub-systems:

3.1.1 Mechanical (Bars) (A)

3.1.2 Acoustical (Resonators) (B)

3.1.3 Supportive (Frame) (C)

The three sub-systems shall be packaged in such a manner to the EBM becomes a completely integrated system. (See FIGURE 1)



Frame - the structural component of the instrument that ALIGNS ~~the~~ resonator ~~under~~ the bar's center position and ~~is~~ directly under

3.3 The EBM's physical size and dimensional parameters shall be dictated by physical laws while maintaining human factors considerations. There shall be no un-necessary parts, contours, or materialities.

3.4 ^{Bar Member} Range

3.4.1 The EBM shall cover a musical range of G1 to G3 (48.9Hz to 196.0Hz). 25 independent pitches (or notes) shall make up this range.

3.4.2 The EBM shall be tuned to the pitch standard of A-440Hz.

3.5 ^{Configuration} The marimba shall consist of two halves.

3.5.1 One half shall contain the so called "Natural" notes, as follows:

~~G, A, B, C, D, E, F, G, A, B, C, D, E, F, & G~~

3.5.2 The other half shall contain the "Accidental" notes, as follows:

~~G#, A#, C#, D#, F#, G#, A#, G#, D#, & F#~~

3.5.3 When the two halves are joined together, the bars on the "Accidentals" half shall overhang the "Natural" bars *in mainly/syloplan fashion.*

3.5.4 Both Halves shall be fastened together using positive locking mechanisms or fasteners ^{such as} (bolts, washers, and wing nuts).

3.6 ^{PLAYING HEIGHT} The EBM shall be constructed so the distance between "Naturals" bar top and the ground measures between ~~34"~~ ^{34 1/2"} and ~~35 1/2"~~ ^{37"}. *Accidentals shall be placed at a height sufficiently above the naturals so bar will "bottom out" on the bar directly beneath.*

3.7 ^{MOBILITY} The marimba shall be made mobile. Each half shall have it's own set of casters for independent ease of mobility.

4.0 MARIMBA BAR

^{4.1} ~~4.1~~ ^{DIMENSIONAL FACTORS MATERIAL CHANGE}

4.1.3 Bar material shall be that of the straight-grained hard wood class, cut in "quarter-sawn" bar blanks.

"Energy Trigger" Component

Frequencies Expand
C# _____
D# _____
E# _____
F# _____
etc.

formula $880 \cdot 0^{\circ}$
 $12\sqrt{2}$ ↑
A-440 Hz
↓
 $220 \cdot 0^{\circ}$
 $110 \cdot 0^{\circ}$
 $55 \cdot 0^{\circ}$

MHAWA BN

DIMENSIONAL FACTORS

LENGTH Bar length is responsible for the overall transverse motion of the bar. This transverse motion is contributory to the the fundamental (sometimes called the 1st harmonic) mode of vibration. Length is a relative factor generally tied to frequency. Lower frequencies require "longer" bar lengths whereas higher frequencies require "shorter" bar lengths.

WIDTH Bar width provides the phasing attribute. Since one side of the bar is always 180 out of phase with its opposite side, sound propagation will be cancelled. A "wider" bar will have less cancellation effect than a "narrower" bar. The wider bar is also associated with increased amplitude. Amplitudal increase is possible by the additional surface area which imparts its energy to the surrounding molecules, thus causing a raised energy level causing the amplitude increase.

THICKNESS Bar thickness contributes to its elastic restoration. This restoration is a force that causes the bar to come to rest with decreasing amplitude from each successive cycle during vibration. A "thicker" bar will recover from vibration in a rapid time period. This time period is termed "frequency". The "thinner" bar will not recover as quickly, thus slowing the frequency's time down.

4.2 Material Type

4.2.1 Wood - Preferred type:

- A) African Padouk
- B) Honduras Rosewood

4.2.2 Wood - Acceptable type:

- A) Macacauba
- B) Bubinga

4.3

4.3.4

BAR SIZES
Bar lengths, widths, and thicknesses, are derived from the engineered dimensions of the following notes: (See TABLE I for complete EBM bar sizing.)

4.3.1 Cello "C" (65.4Hz) = 22-1/2" long by 4-1/2" wide by 7/8" thick.

4.3.2 Tenor "C" (130.8Hz) = 18" long by 3-3/4" wide by 7/8" thick.

4.4.5

BAR SHAPING APPEARANCE rounded corners
Each bar shall be shaved from the underside (opposite the playing side) in the form of a long shallow arch. (See FIGURE 2) The final pitch shall be determined by the degree of shaving and depth of arch.

4.5.6

Bar Tuning
Each bar shall be tuned to the following modes of vibration:

4.5.1 1st harmonic = Fundamental = Ratio - 1:1

4.5.2 4th harmonic = Two octave unison = Ratio 1:4

4.5.3 10th harmonic = One octave plus a major third = Ratio 1:10

Bar Tuning Accuracy
4.6 Tuning accuracy shall be maintained within the following tolerances:

4.6.1 1st harmonic ± 1 cent* - 20¢ cents

4.6.2 4th harmonic + 2 cents - zero cents

4.6.3 10th harmonic + 5 cents - zero cents

NOTE: Tuning accuracy may be achieved by utilizing a tuning instrument having one cent resolution. The "Stroboscopic" class of tuning instruments are recommended.

5.0 RESONATOR

Resonator Type
5.1 The resonator shall be the quarter-wavelength column type.

5.1.1 One end (opposite the open end) shall be plugged by means of an adjustable stopper. This is characteristic of the quarter-wavelength resonator.

5.1.2 Resonator length shall be determined using the formula:

$$L = \frac{v}{4f}$$

Where: L = Length in feet

f = Frequency in Hertz

λ = (Greek letter - Lambda)

Speed of Sound. Approximately 1129 ft/sec @ 70 degrees F.

** = value to calculate quarter wavelength*

See TABLE II for resonator Lengths and cross-sectional dimensions.

stopper - 2 purposes "tuning" and "end plug".
5.2 The stopper shall fit snug in the column thus creating an airtight fit. (See FIGURE 3)

material
5.3 The resonator material shall be White Pine with a material thickness of 3/4".

shape
5.4 The cross-sectional shape shall be square.

construction
5.5 Construction shall consist of butt-jointed method. (See FIGURE 4)

Airtight integrity

Length

5.6 The length of all resonators shall be dictated by their corresponding frequencies. The longer resonators will require mitering so they can fit under the bar thus maintaining the specified playing height. (See FIGURE 5)

5.6.1 The miter angle shall be 22-1/2 degrees.

Acoustical Alignment

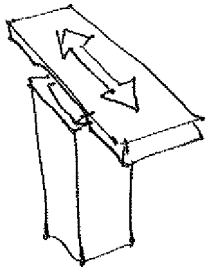
6.0 FRAME

*Acoustical alignment and structural support component
Alignment: 3 AXIS
Coordinate
x ~~back~~ back for the
y side to side
z up and down*

6.1 The frame shall be constructed in such a manner that it supports both the pitch producing components (bars) and the pitch amplifying components (resonators).

Self system Containment

6.2 Each bar shall be suspended directly over its corresponding resonator. The distance between the top of the arch and the opening of the resonator shall be 1-1/4". (See FIGURE 6)

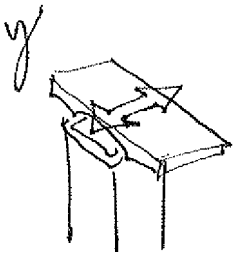


6.3.1 Bar Containment

Self system Containment

6.3.1 The bar shall be held in place by means of a suspension system.

6.3.2 The suspension shall consist of a length of 1/8" diameter cotton cord looped through drilled holes in the bar in such a manner to join with the supports on the bar support rail. (see FIGURE 7)

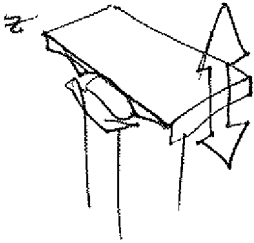


6.3.3 Two width running holes shall be placed at the fundamental node points (quantity = 2) of each bar.

no node spacing shall determine bar support and spacing beneath

6.3.4 Bar supports shall be placed between bars at the node points. (See FIGURE 8)

6.3.5 Each end of the cord shall terminate into two tension springs linked together to keep the slack out of the length of cord.

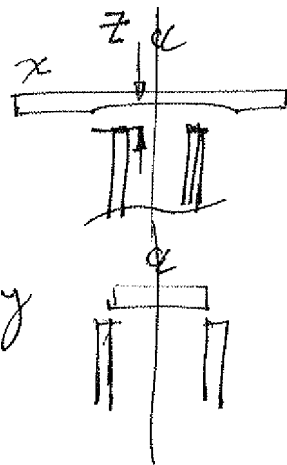


6.3.2 Resonator Containment

6.3.1 The resonator shall be held in place using a combination of a drilled "L" angle bracket and aluminum doweling. Dowels shall be securely mounted in two resonator support rails. (See FIGURE 9) The angle brackets (mounted to each resonator) shall mate with the dowels using the resonator's weight and natural gravity.

*structural - load path anywhere on rail shall be rigid to withstand mallet strike downward pressure
Acoustically align border bar.*

6.3.2 The spacing between adjacent resonators shall not exceed 1/8 inch.



6.4 Strips of felt shall be placed between interfacing parts to eliminate buzzes and rattles. Felts shall be placed at the following locations:

6.4.1 Between resonator and resonator support rails.

6.4.2 Between angle bracket and resonator support rails.

structure & support all resonator without soft, structure failure.

7.0 FINISH

7.1 All components in the EBM shall have a protective finish.

7.1.1 BARS - Varithane (Gloss #90 on Satin #91).

7.1.2 RESONATORS - Varithane (Gloss #90).

7.1.3 FRAME - Medium "Charcoal" metallic automotive (Satin)

8.0 MISCELLANEOUS

8.1 When deliverable, the EBM shall be equipped with the following items:

8.1.1 Shallow drop cover.

A) Black vinyl with soft interior.

8.1.2 Two pairs of mallets.

A) One pair of Mike Balter No. 17 (Bass Marimba)

approx 2 1/2" width wrapped with foam around ^{soft} mallet heads (simba to rubber) ball

B) One pair of Mike Balter No. 16 (Soft - low register standard marimba).

(approx 1 1/2" width)

8.1.3 Documentation.

owner manual see Figure 10

- A) Unpacking Instructions
- B) Assembly Instructions
- C) Basic Specifications
- D) Maintenance Instructions
- E) As required pre-cautionary notes to ensure instrument integrity

TABLE I - BAR SIZING (EXTENDED BASS MARIMBA)

	Note	Bar Length (Inches)	Bar Width (Inches)
Bass CCC (C1)		25 1/2	TBD
	CCC#	TBD	TBD
	DDD	TBD	TBD
	DDD#	TBD	TBD
	EEE	TBD	TBD
	FFF	TBD	TBD
	FFF#	TBD	TBD
	GGG	24 3/8	4 13/16
	GGG#	24	4 3/4
	AAA	23 5/8	4 11/16
	AAA#	23 1/4	4 5/8
	BBB	22 7/8	4 9/16
Cello CC (C2)		22 1/2	4 1/2
	CC#	22 1/8	4 7/16
	DD	21 3/4	4 3/8
	DD#	21 3/8	4 5/16
	EE	21	4 1/4
	FF	20 5/8	4 3/16
	FF#	20 1/4	4 1/8
	GG	19 7/8	4 1/16
	GG#	19 1/2	4
	AA	19 1/8	3 15/16
	AA#	18 3/4	3 7/8
	BB	18 3/8	3 13/16
Tenor C (C3)		18	3 3/4
	C#	17 5/8	3 11/16
	D	17 1/4	3 5/8
	D#	16 7/8	3 9/16
	E	16 1/2	3 1/2
	F	16 1/8	3 7/16
	F#	15 3/4	3 3/8
	G	15 3/8	3 5/16
	G#	TBD	TBD
	A	TBD	TBD
	A#	TBD	TBD
	B	TBD	TBD
Middle C (C4)		TBD	TBD

TABLE II RESONATOR LENGTHS AND CROSS-SECTIONAL DIMENSIONS

Note	Cross Sectional I.D. (Inches)	Frequency	Quarter Wavelength w/o O.E.C. (70 degree F) (Inches)
Bass CCC (C1)	TBD	TBD	
CCC#	TBD	TBD	
DDD	TBD	TBD	
DDD#	TBD	TBD	
EEE	TBD	TBD	
FFF	TBD	TBD	
FFF#	TBD	TBD	
GGG (G1)	4 1/16"	48.99Hz69.14"	
GGG#	4	51.91	65.25"
AAA	3 15/16"	55.00	61.58"
AAA#	3 7/8"	58.27	58.13"
BBB	3 13/16"	61.74	54.86"
Cello CC (C2)	3 3/4"	65.406	51.78"
CC#	3 11/16"	69.295	48.87"
DD	3 5/8"	73.42	46.13
DD#	3 9/16"	77.78	43.55
EE	3 1/2"	82.41	41.10
FF	3 7/16"	87.31	38.79
FF#	3 3/8"	92.49	36.62
GG	3 5/16"	97.99	34.56
GG#	3 1/4"	103.83	32.62
AA	3 3/16"	110.00	30.79
AA#	3 1/8"	116.54	29.06
BB	3 1/16"	123.47	27.43
Tenor C (C3)	3"	130.81	25.89
C#	2 15/16"	138.59	24.44
D	2 7/8"	146.83	23.07
D#	2 13/16"	155.56	21.77
E	2 3/4"	164.81	20.55
F	2 11/16"	174.61	19.40
F#	2 5/8"	184.99	18.31
G	2 9/16"	195.99	17.28
G#	TBD	TBD	
A	TBD	TBD	
A#	TBD	TBD	
B	TBD	TBD	
Middle C (C4)	TBD	TBD	

FIGURE 1 BASS MARIMBA (Range G1 to G3)

FIGURE 2 MARIMBA BAR - Side View

FIGURE 3 QUARTER-WAVELENGTH RESONATOR - Air-Tight Stopper

FIGURE 4 QUARTER-WAVELENGTH RESONATOR - Butt-joint construction

FIGURE 5 QUARTER-WAVELENGTH RESONATOR - Mitering Configuration

FIGURE 6 MARIMBA BAR AND RESONATOR - Centering and Suspension Height

FIGURE 7 MARIMBA BAR - Drilled Mounting Holes

FIGURE 8 MARIMBA BAR - Node Points

FIGURE 9 RESONATOR - Containment System

EXTENDED BASS MARIMBA
ENGINEERING DESIGN SPECIFICATIONS

1.0 PURPOSE

1.1 This specification establishes the baseline criteria when designing a class of keyboard percussion musical instruments known as an EXTENDED BASS MARIMBA.

2.0 DEFINITIONS

2.1 Bar - A rigid body of long rectangular shaped material capable of vibrating with extreme regularity.

2.2 Resonator - A device used for increasing the loudness of a pitch by resonance.

2.3 Cent - A small unit of measurement of division between two notes. 100 cents between half-steps. 1200 cents between octaves.

3.0 GENERAL

3.1 The Extended Bass marimba shall consist of three systems:

3.1.1 Mechanical (Bars)

3.1.2 Acoustical (Resonators)

3.1.3 Supportive (Frame)

3.2 The three systems shall be integrated to complete the Marimba as a whole.

3.3 Physical parameters shall be dictated by design with no useless or wasted parts, contours, or materialities.

3.4 Range

3.4.1 The Extended Bass marimba shall cover a musical range of G1 to G3 (48.9Hz to 196.0Hz).

3.4.2 The marimba shall be tuned to the pitch standard of A-440Hz unless specified otherwise.

3.5 Make-up

3.5.1 The marimba shall consist of two halves.

A. One half shall contain the so called "Natural" notes.

G, A, B, C, D, E, F, G, A, B, C, D, E, F, & G

B. The other half shall contain the "Accidental" notes.

G#, A#, C#, D#, F#, G#, A#, C#, D#, & F#

3.5.2 When the two halves are joined together, the "Accidentals" half shall have the bars over hang the "Naturals" bars.

3.5.3 Both Halves shall be fastened together by means of four bolts and four wing nuts.

3.6 The marimba shall be constructed so the "Naturals bar height to ground level measures between 34' and 35-1/2".

3.7 The marimba shall be made mobile.

Each half shall have it's own set of casters for independent ease of mobility.

4.0 MARIMBA BAR

4.1 The marimba bar represents the pitch producing component of the Extend Bass marimba.

4.2 The bar material used shall be that of the straight-grained hard wood class. (Depends on availability and quality.)

4.2.1 Wood - Preferred type:

- A. African Padouk
- B. Honduras Rosewood

4.2.2 Wood - Acceptable type:

- A. Macacauba
- B. Bubinga

4.3 The bar's length shall be determined from the engineered dimensions of the following notes:

4.3.1 Cello "C" (65.4Hz) = 22-1/2" long by 4-1/2" wide by 7/8" thick.

4.3.2 Tenor "C" (130.8Hz) = 18" long by 3-3/4" wide by 7/8" thick.

4.3.3 Table - Bar sizing

	Note		Bar Length (Inches)	Bar Width (Inches)
Cello	GGG	(G1)	24 3/8	4 13/16
	GGG#		24	4 3/4
	AAA		23 5/8	4 11/16
	AAA#		23 1/4	4 5/8
	BBB		22 7/8	4 9/16
	CC	(C2)	22 1/2	4 1/2
	CC#		22 1/8	4 7/16
	DD		21 3/4	4 3/8
	DD#		21 3/8	4 5/16
	EE		21	4 1/4
	FF		20 5/8	4 3/16
	FF#		20 1/4	4 1/8
	GG		19 7/8	4 1/16
	GG#		19 1/2	4
	AA		19 1/8	3 15/16
	AA#		18 3/4	3 7/8
	BB		18 3/8	3 13/16
	Tenor	C	(C3)	18
C#			17 5/8	3 11/16
D			17 1/4	3 5/8
D#			16 7/8	3 9/16
E			16 1/2	3 1/2
F			16 1/8	3 7/16
F#			15 3/4	3 3/8
G		(G3)	15 3/8	3 5/16

4.4 The bars shall be shaved from the underside (opposite the playing side) in the form of a long shallow arch. (See Figure 1) The degree of shaving and depth of arch shall be determined by the final pitch.

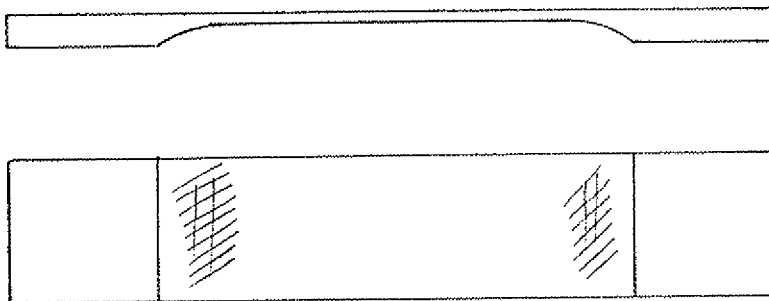


Figure 1

4.5 The bars shall be tuned to the following modes of vibration:

4.5.1 1st harmonic = Fundamental = Ratio - 1:1

4.5.2 4th harmonic = Two octave unision = Ratio 1:4

4.5.3 10th harmonic = One octave plus a major third = Ratio 1:10

4.6 Tuning accuracy shall be maintained within the following tolerances:

4.6.1 1st harmonic ± 1 cent*

4.6.2 4th harmonic + 2 cents - zero cents

4.6.3 10th harmonic + 5 cents - zero cents

*NOTE: Tuning accuracy can be maintained by utilizing a tuning instrument having one cent resolution.

5.0 RESONATOR

5.1 The resonator represents the amplification component of the Extended Bass Marimba.

5.2 The resonator shall be the quarter-wavelength column type.

5.2.1 One end (opposite the open end) shall be plugged by means of an adjustable stopper. This is characteristic of the quarter-wavelength resonator.

5.2.2 Resonator length shall be determined using the formula:

$$L = \frac{\lambda}{f}$$

Where: L = Length in feet
f = Frequency in Hertz
λ = (Greek letter - Lambda)
Speed of Sound. Approximately 1129
ft/sec @ 70 degrees F.

5.2.3 Table - Resonator Lengths and cross-sectional dimensions.

Note		Cross Sectional I.D. (Inches)	Frequency	Quarter Wavelength w/o O.E.C. (70 degree F) (Inches)
Cello	GGG (G1)	4 1/16"	48.99Hz	69.14"
	GGG#	4	51.91	65.25"
	AAA	3 15/16"	55.00	61.58"
	AAA#	3 7/8"	58.27	58.13"
	BBB	3 13/16"	61.74	54.86"
	CC (C2)	3 3/4"	65.406	51.78"
	CC#	3 11/16"	69.295	48.87"
	DD	3 5/8"	73.42	46.13
	DD#	3 9/16"	77.78	43.55
	EE	3 1/2"	82.41	41.10
	FF	3 7/16"	87.31	38.79
	FF#	3 3/8"	92.49	36.62
	GG	3 5/16"	97.99	34.56
	GG#	3 1/4"	103.83	32.62
	AA	3 3/16"	110.00	30.79
	AA#	3 1/8"	116.54	29.06
Tenor	BB	3 1/16"	123.47	27.43
	C (C3)	3"	130.81	25.89
	C#	2 15/16"	138.59	24.44
	D	2 7/8"	146.83	23.07
	D#	2 13/16"	155.56	21.77
	E	2 3/4"	164.81	20.55
	F	2 11/16"	174.61	19.40
	F#	2 5/8"	184.99	18.31
	G (G3)	2 9/16"	195.99	17.28

5.3 The stopper shall fit snug in the column thus creating an airtight fit. (See Figure 2)

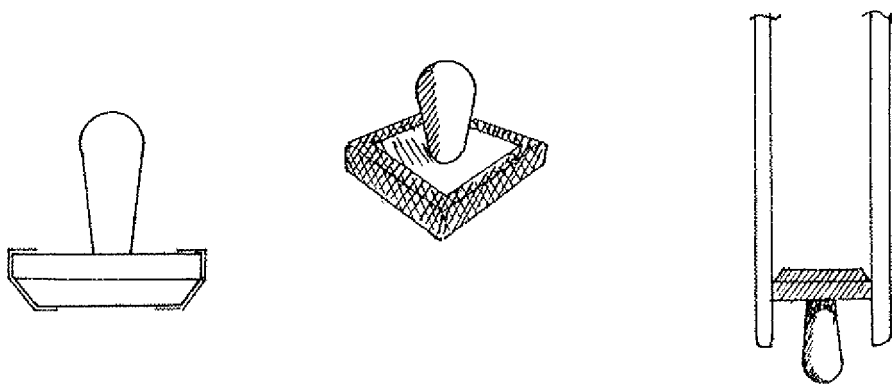


Figure 2

5.4 The resonator material shall be White Pine.

5.4.1 The material thickness shall be 3/4".

5.5 The cross-sectional shape shall be square.

5.6 Construction shall consist of butt-jointed method. (See Figure 3)

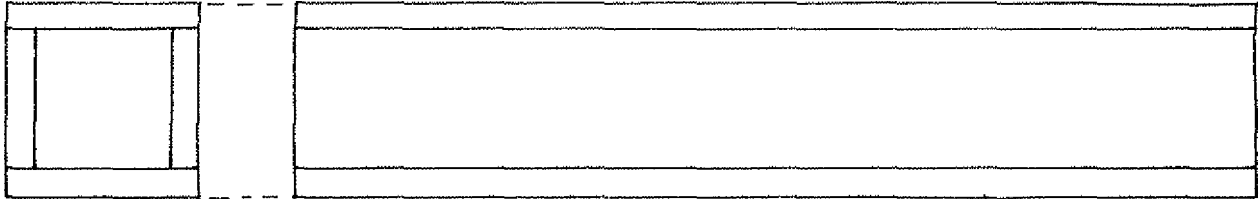


Figure 3

5.7 The length of the lower pitch resonators shall be dictated by the frequency of the note. These lower pitch resonators will require mitering so they can fit under the bar thus maintaining the specified playing height. (See Figure 4)

5.7.1 The miter angle shall be 22-1/2 degrees.

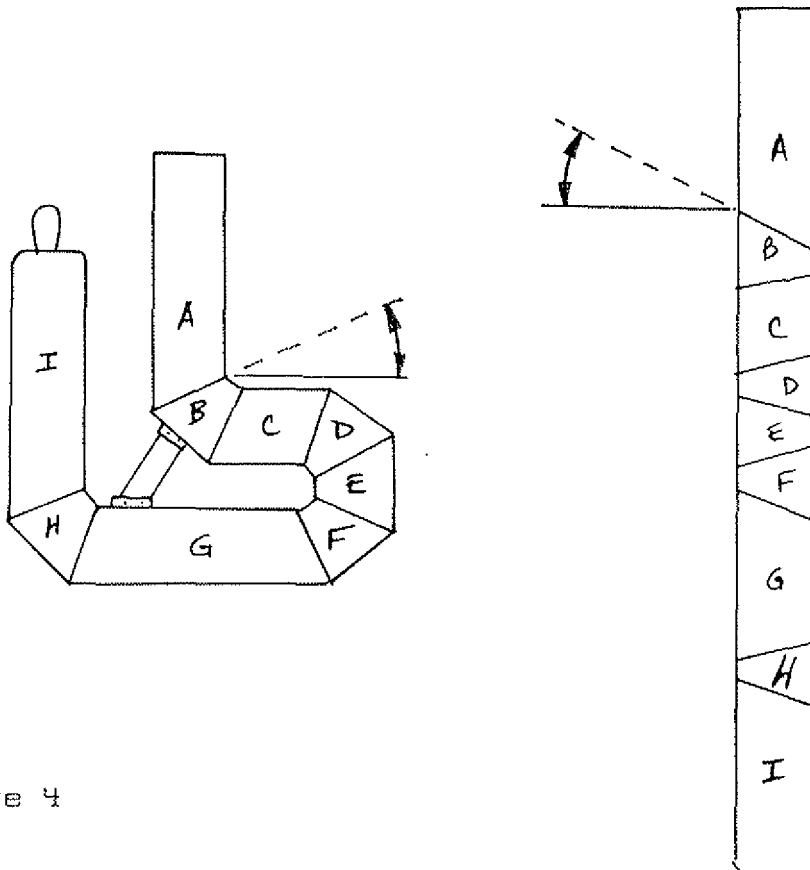


Figure 4

5.8 Applicable resonators shall be mitered using the "Resonator Cutting/Assembly Diagrams" (available through CCBANTIA CO.) for Extended Bass Marimba.

6.0 FRAME

6.1 The frame shall support both pitch producing components (bar) and pitch amplifying components (resonator).

6.2 Bar

6.2.1 The bar shall be held in place by means of a suspension system.

6.2.2 The suspension shall consist of a length of 1/8" diameter cotton cord looped through drilled holes in the bar in such a manner to join with the supports on the bar support rail. (see Figure 5)

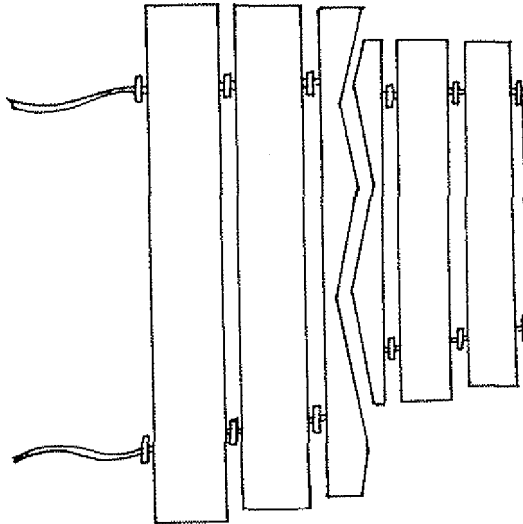


Figure 5

A. The bar supports shall be placed between bars at the node points. (See Figure 6)

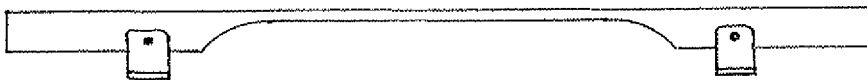


Figure 6

6.2.3 Each end of the cord shall terminate into two tension springs linked together to keep the slack out of the length of cord.

6.3 Resonator

6.3.1 The resonator shall be held in place, on two resonator support rails, using a combination of a drilled angle bracket and an aluminum dowel. This systems utilizes a gravity to hold the resonator in place. (See Figure 7)

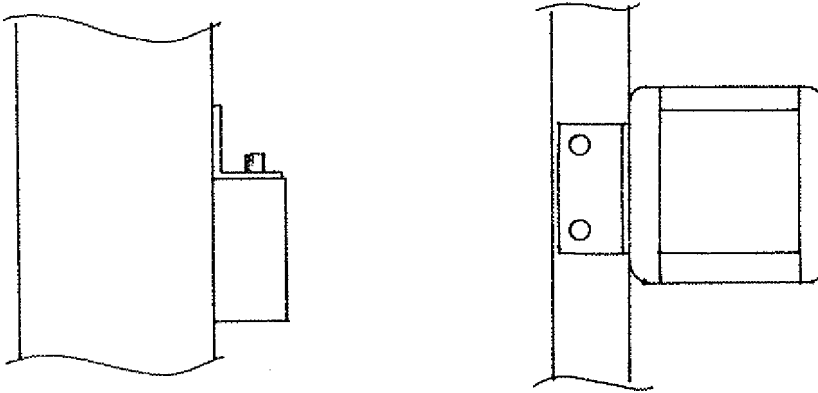


Figure 7

6.3.2 The spacing between adjacent resonators shall not exceed 1/8 inch.

6.4 Strips of felt shall be placed between interfacing parts to eliminate buzzes and rattles.

6.4.1 Felts may be placed in the following locations:

- A. Between resonator and resonator support rails.
- B. Between angle bracket and resonator support rails.

7.0 FINISH

7.1 All components in the Extended Bass marimba shall have a protective finish.

7.1.1 Bars - Varithane (Gloss #90 on Satin #91).

7.1.2 Resonators - Varithane (Gloss #90).

7.1.3 Frame - Medium "Charcoal" metallic automotive (Satin)

8.0 MISCELLANEOUS

8.1 The Extended Bass Marimba shall be equipped with the following items:

8.1.1 Shallow drop cover.

A. Black vinyl with soft interior.

8.1.2 Two pairs of mallets.

A. One pair of Mike Balter No. 17 (Bass Marimba)

B. One pair of Mike Balter No. 16 (Soft - low register standard marimba).

8.1.3 Instructions and documentation.

9.0 ILLUSTRATION

9.1 Front view as seen by the audience.

