FEATURE

Percussion Research

A Visual Window to Tone Production

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Norman Weinberg presented the following article on November 9, 1990 in Philadelphia, Pennsylvania as part of the PASIC '90 Scholarly Paper Presentations.

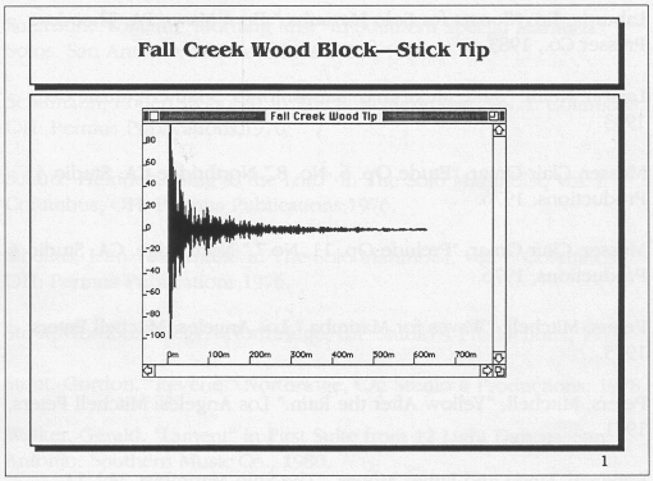
The following experiments in timbre/visual analysis were designed to help student performers explore the application of digital sample editing software to the area of tone production on acoustic percussion instruments. This technology gives the percussionist a visual representation of the physical aspects that determine tonal quality. Differences between tonal qualities of instruments, beaters, techniques, and performers can now be compared and contrasted easily—not only aurally, but visually.

Technical Specifications—These experiments were conducted in Del Mar College's Wolfe Recital Hall. This is an intimate 300-seat auditorium with wood paneling along the front, back, and sides. Each instrument was sampled using a Shure *SM91* microphone located ten feet away from the source instrument at a height of six feet. The signal from the microphone was routed to an E-Mu System's *E-Max* Sampler (with 12-bit linear resolution) and sampled at 41,000 samples per second. After sampling, the sounds were analyzed on an Apple *Macintosh SE* computer using Digidesign's *Sound Designer* and Passport's *Alchemy* visual editing programs.

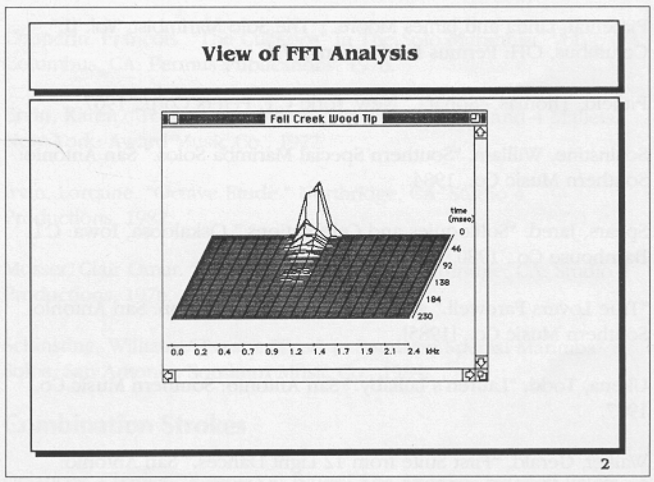
Visual Information—Example No. 1 and Example No. 2 show the two most common forms of visual feedback. In the first example, the overall view of the woodblock's amplitude "envelope" is shown. An envelope is a graphic representation of an aural aspect of the sound over a period of time. In this view, the amplitude is measured vertically as a percentage of full value, while the elapsed time is shown horizontally (in this case, the scale is calibrated in milliseconds).

The second example is an FFT (fast Fourier transform) analysis in three dimensional form. The editing program divides the sound into several separate frequency bands. The result is an accurate representation of the sound's frequency content, as well as changes, over a certain time span. Height indicates amplitude, time is measured from back to front, and frequency is horizontal.

Woodblocks—In this experiment, a Fall Creek woodblock was compared with a Ludwig woodblock using a variety of beaters. Example No. 3 shows that the



Example 1



Example 2

Ludwig block is higher in pitch (the strongest energy is grouped between 1.2 and 1.5 kHz) than the Fall Creek (approximately .9 to 1.1 kHz). This example also points out that the Fall Creek block has a slightly faster decay when struck with the tip of a wooden stick.

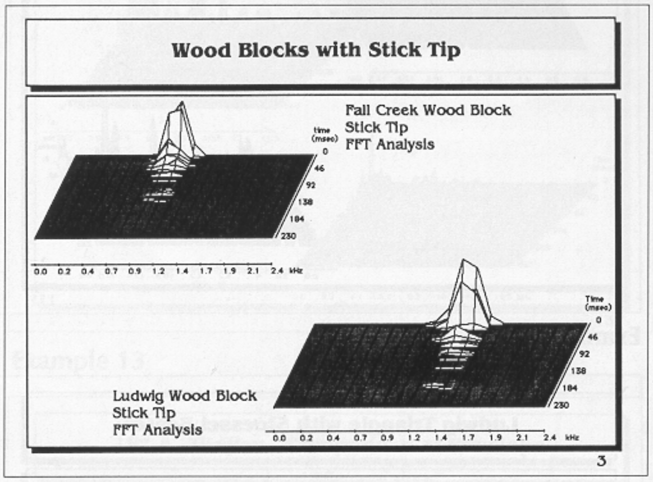
In Example No. 4, the stick's shank is used to initiate the sound. When comparing this example to the previous one, we can see that the Fall Creek block exhibits a more focused pitch at the time of attack along with a smoother decay. Example No. 5 is an overall view of the same strokes. Notice how the Ludwig block now decays more quickly, even though both instruments start at the same volume.

The mallet used in Example No. 6 was a Musser model M4. Depending on the musical situation, this example indicates this mallet might be viewed as the "stick of choice". Both blocks have a sharp attack with a smooth decay, and a tightly focused pitch center.

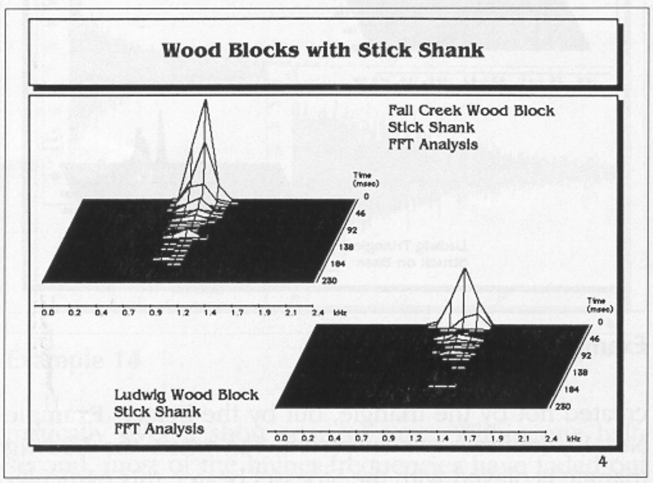
Triangles—The next experiment dealt with triangles. Here, a Grover triangle was compared with a vintage Ludwig instrument. In Example No. 7, the Grover is struck on the side and the base with an aluminum beater. Notice how both strokes contain a strong amount of energy at about 12.4 kHz. Another significant aspect of this example is the increase in the number of overtones when the triangle is struck on the base. When the same triangle is played with a Stoessel beater in Example No. 8, many of the overtones are much stronger, yet the frequencies around 12.4 kHz are extremely weak.

Examples No. 9 and No. 10 represent a different type of FFT analysis. These views display the exact harmonic spectrum in terms of the actual frequency and relative strength. Notice how the Stoessel beater produces a more complex network of frequencies.

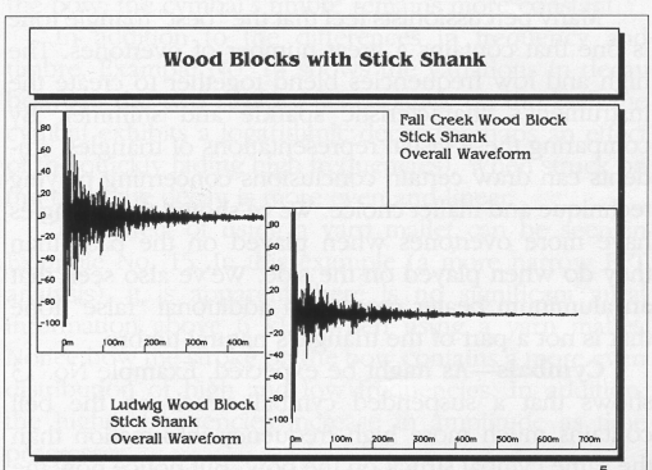
Example No. 11 compares the timbres of the Ludwig



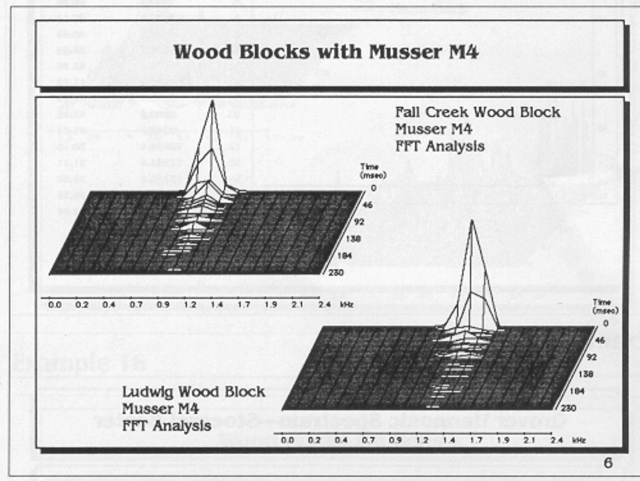
Example 3



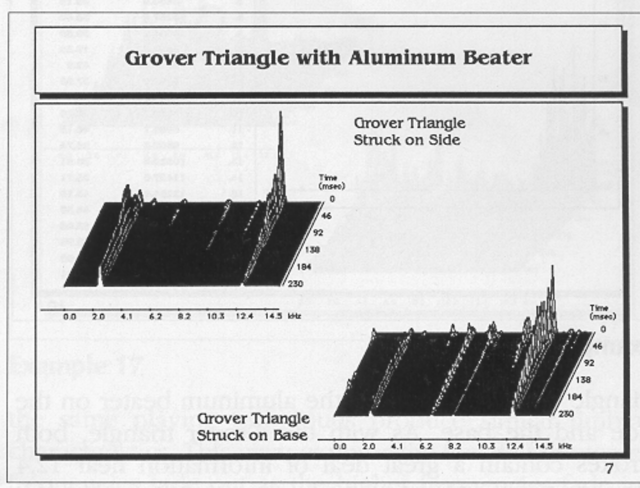
Example 4



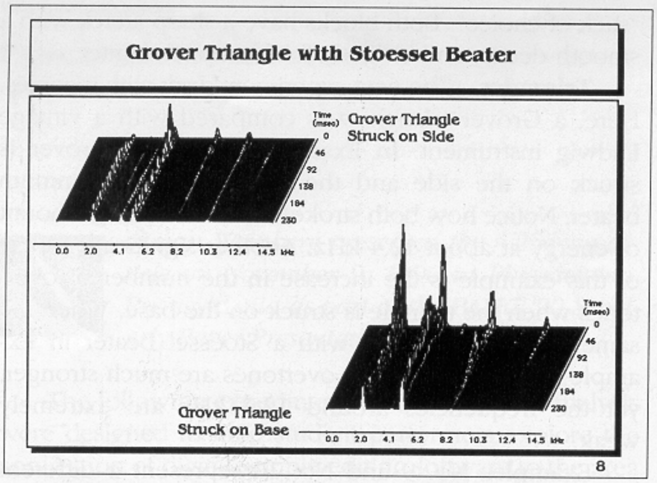
Example 5



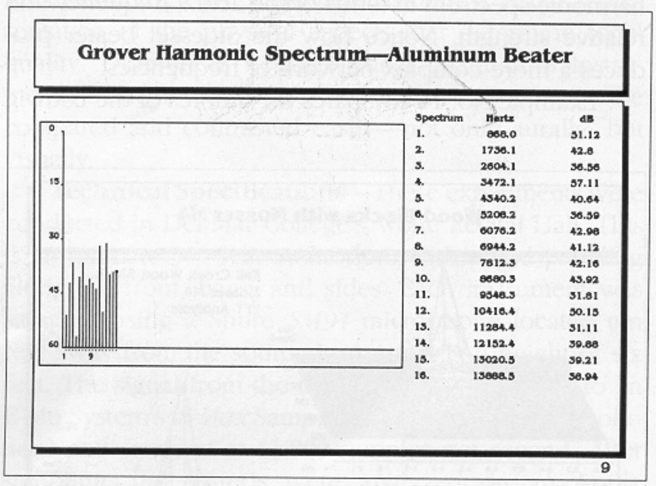
Example 6



Example 7

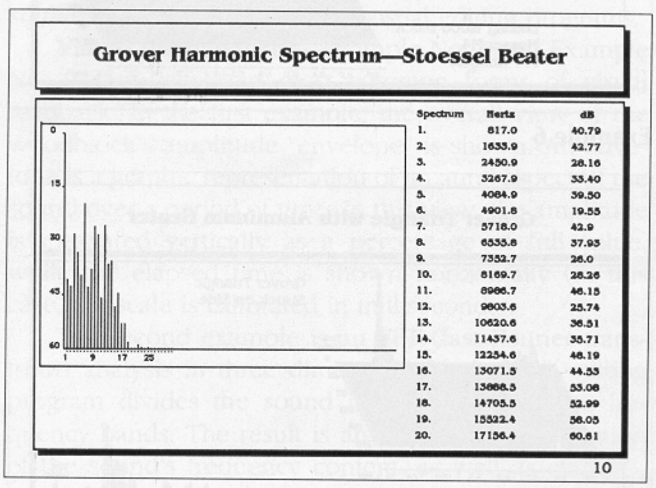


Example 8



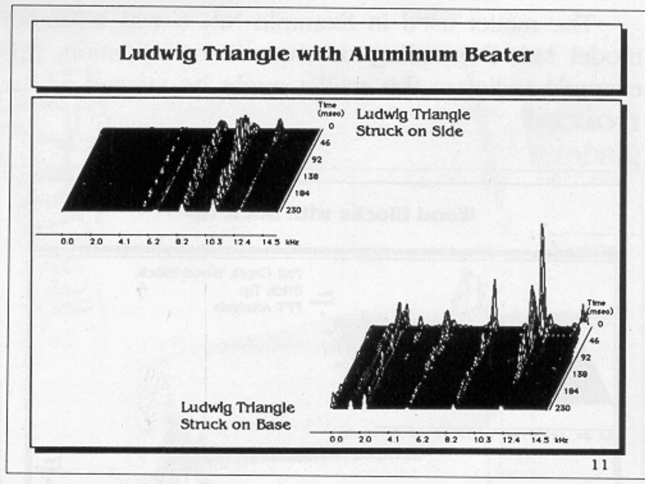
Spectrum	Hertz	dB
1.	868.0	51.12
2.	1736.1	42.8
3.	2604.1	36.56
4.	3472.1	57.11
5.	4340.2	40.64
6.	5208.2	36.59
7.	6076.2	42.98
8.	6944.2	41.12
9.	7812.3	42.16
10.	8680.3	43.92
11.	9548.3	31.81
12.	10416.4	50.15
13.	11284.4	31.11
14.	12152.4	39.88
15.	13020.5	39.21
16.	13888.5	38.94

Example 9

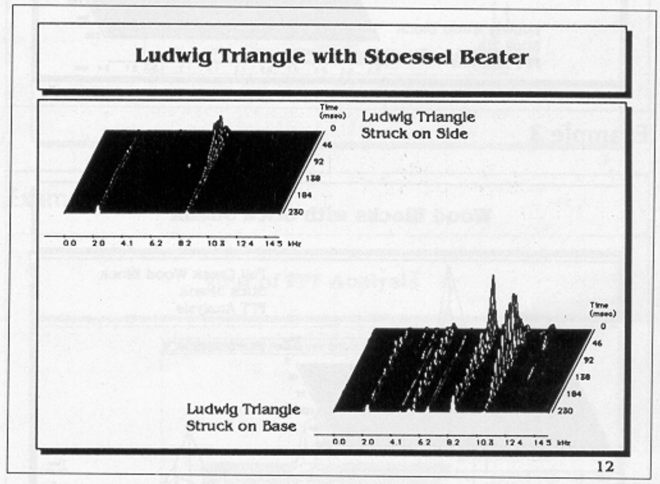


Spectrum	Hertz	dB
1.	817.0	40.79
2.	1633.9	42.77
3.	2450.9	28.16
4.	3267.9	33.40
5.	4084.9	39.50
6.	4901.8	19.55
7.	5718.0	42.9
8.	6535.8	37.93
9.	7352.7	28.0
10.	8169.7	28.26
11.	8986.7	46.15
12.	9803.6	25.74
13.	10620.6	36.51
14.	11437.6	35.71
15.	12254.6	48.19
16.	13071.5	44.53
17.	13888.5	53.06
18.	14705.5	52.99
19.	15522.4	56.05
20.	17156.4	60.61

Example 10



Example 11

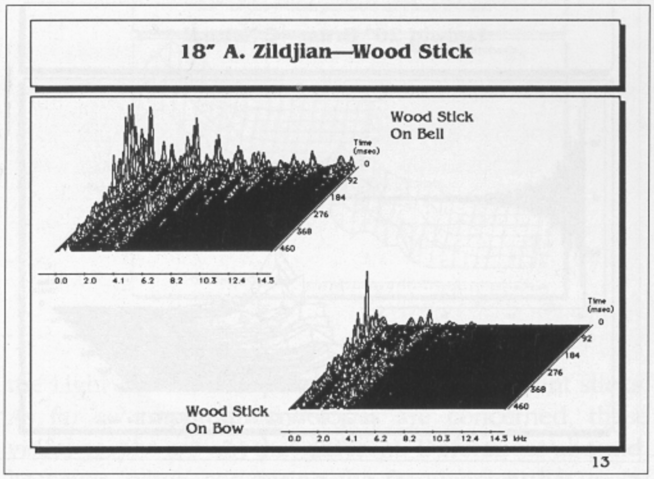


Example 12

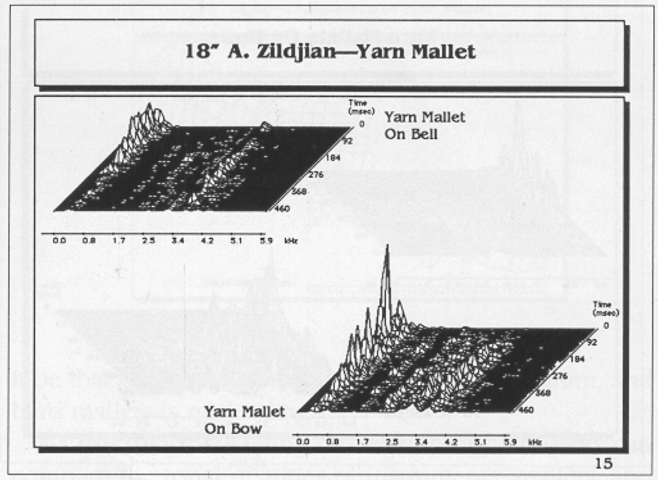
triangle when played with the aluminum beater on the side and the base. As with the Grover triangle, both strokes contain a great deal of information near 12.4 kHz. Is it possible that this portion of the sound is created not by the triangle, but by the beater? Example No. 12 confirms our suspicion, for when the Ludwig triangle is played with the Stoessel beater, this particular frequency is all but missing.

Many percussionists feel that the "best" triangle tone is one that contains a great number of overtones. The high and low frequencies blend together to create the instrument's characteristic sparkle and shimmer. By comparing these visual representations of triangles, students can draw certain conclusions concerning playing technique and mallet choice. We've shown that triangles have more overtones when played on the base than they do when played on the side. We've also seen that an aluminum beater creates an additional "false" tone that is not a part of the triangle's natural timbre.

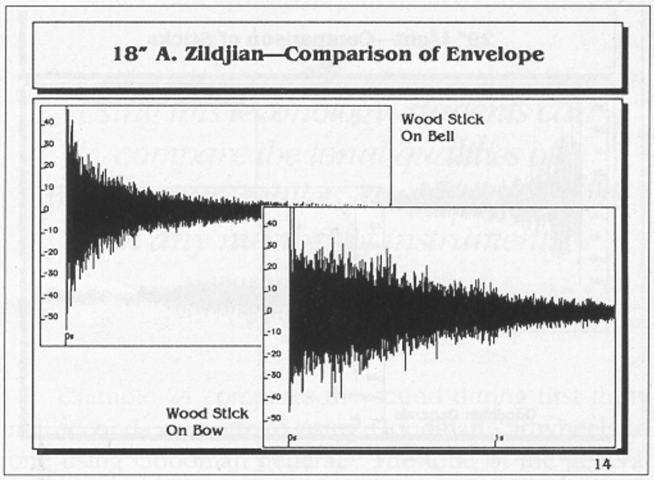
Cymbals—As might be expected, Example No. 13 shows that a suspended cymbal struck on the bell contains much more high frequency information than the same cymbal struck on the bow. But notice now the stroke on the bell of the cymbal changes timbre dra-



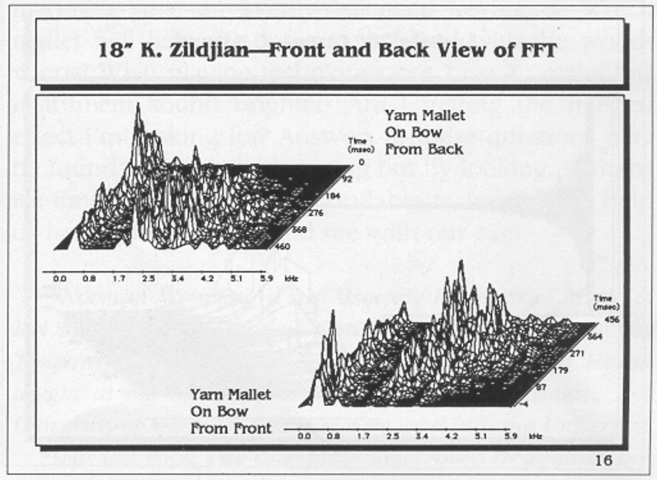
Example 13



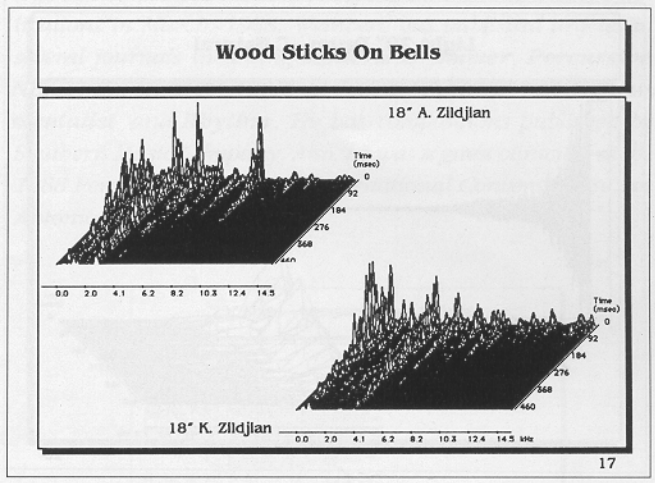
Example 15



Example 14



Example 16



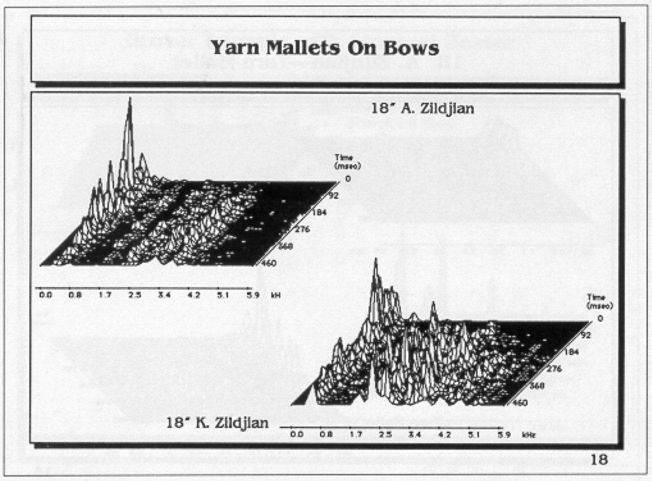
Example 17

matically over a short span of time. Within one half-second, most of the higher frequencies have faded out and only the lower frequencies remain. When struck on the bow, the cymbal's timbre remains more constant.

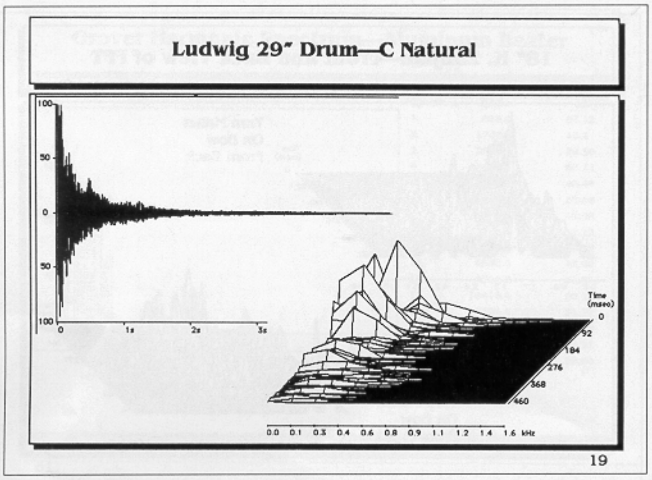
In addition to the differences in frequency and timbre, Example No. 14 shows the variations in decay between the two strokes. When stuck on the bell, the cymbal exhibits a logarithmic decay (perhaps an effect of the quickly fading high frequencies). When struck on the bow, the decay is more even and linear.

The effect of using a yarn mallet can be seen in Example No. 15. In this example (a more narrow FFT analysis), it is apparent there is no significant aural information above 6 kHz when using a yarn mallet. Notice how the stroke on the bow contains a more even distribution of high and low frequencies. In addition, the higher frequencies increase in amplitude as time progresses.

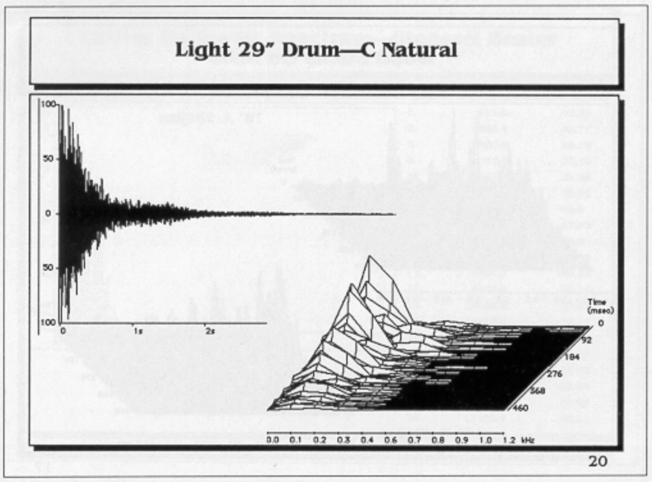
A similar "surge" in upper frequencies can be seen in Example No. 16. Even when using a different cymbal, the same playing techniques produce similar timbral characteristics. This view exposes the fact that the lower frequencies fade out as the higher frequencies fade in. Examples No. 17 and 18 compare and contrast the



Example 18



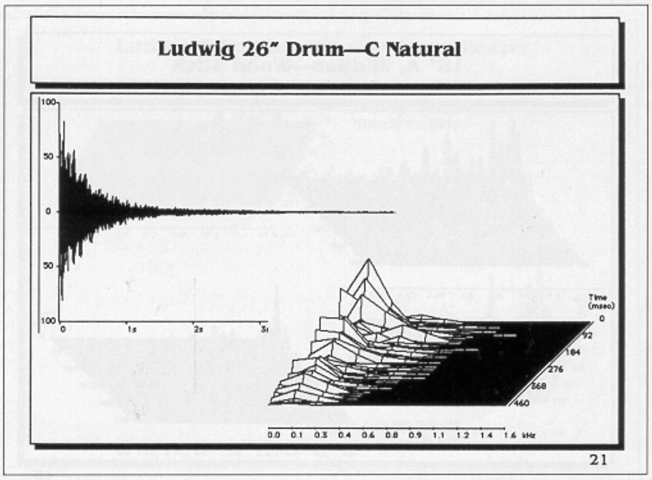
Example 19



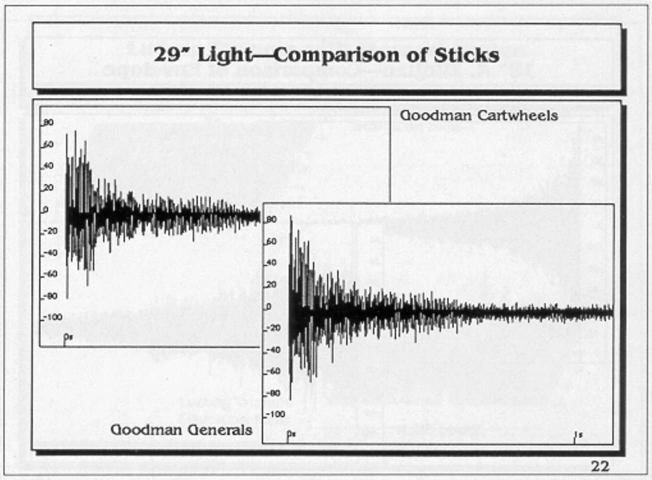
Example 20

sound of both cymbals side-by-side.

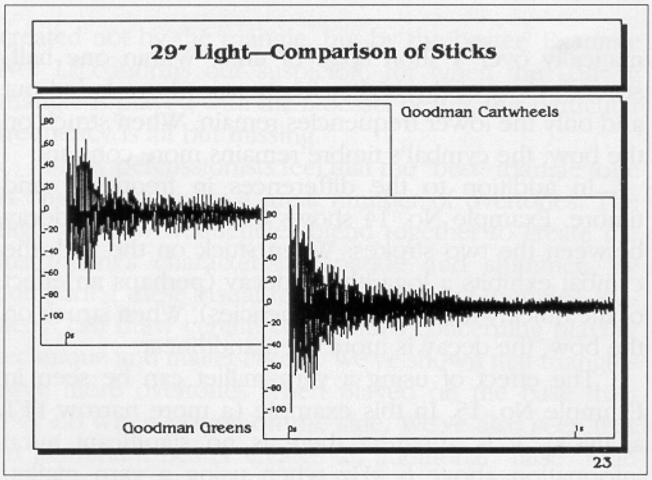
Timpani—Examples 19, 20, and 21 display the tonal "finger prints" of three different timpani tuned to the same pitch (C=130.81 cycles per second). All three



Example 21



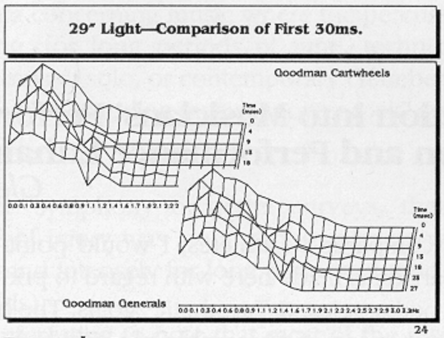
Example 22



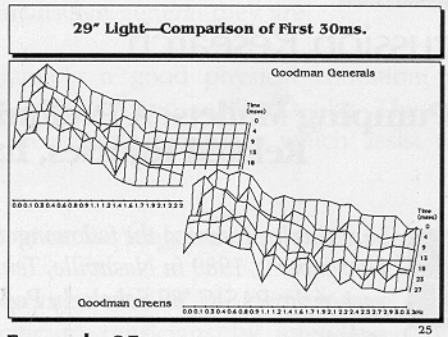
Example 23

examples show a slight drifting in pitch (although the Light drum is a bit more stable), and point out the differences in decay characteristics.

Examples 22, and 23 show the overall envelope of



Example 24



Example 25

the Light drum when played with three different sticks. As far as amplitude envelopes are concerned, these visual graphs are not that different. Differences abound, however, when comparing the frequencies that make up the timbre of each stroke.

Using this technology, students can compare the tonal qualities of instruments, mallets, and playing styles on any number of instruments.

Example 24 compares the sound during first thirty milliseconds of a stroke using Goodman cartwheels to one using Goodman generals. The tone of the general sticks exhibits more high frequency information at the time of attack. Example No. 25 performs the same comparison with Goodman generals and Goodman staccato sticks. Notice how the staccato sticks produce even more high frequency information than the generals.

Examples No. 26 and 27 show that, even after 750 milliseconds, harder sticks produce timpani timbres that contain higher frequencies and more overtones. Could it be that our standard terminology of soft, medium, and hard mallets is misleading?

Conclusions—Using this technology, students can compare the tonal qualities of instruments, mallets, and playing styles on any number of instruments. Does this marimba have an evenly balanced keyboard? Which mallet will help this instrument blend with the woodwinds? What playing techniques can I use to make this instrument sound brighter? Am I getting the musical effect I'm looking for? Answers to these questions may be found, not only by listening but by looking. Perhaps it's time to use the newly available technology to help us hear with our eyes and see with our ears.

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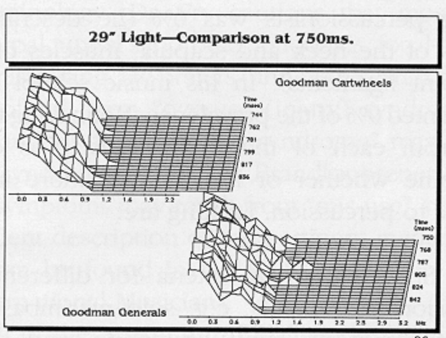
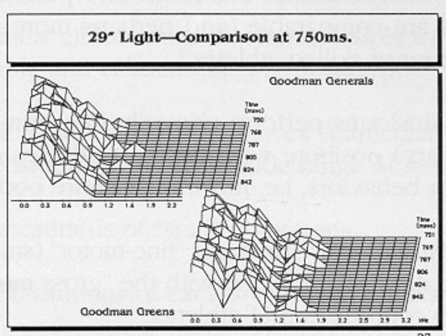
His last book, ***The Complete Electronic Drummer****, has recently been published by Modern Drummer Publications, and* ***The Last MIDI Book****, was published by Alexander Publications in March, 1988. Weinberg has published articles in several journals including* ***Modern Drummer****,* ***Percussive Notes****,* ***Percussive Notes Research Edition****,* ***The Instrumentalist*** *and* ***Rhythm****. He has compositions published by Southern Music Company. Also, he was a guest clinician at the 1988 Percussive Arts Society International Convention in San Antonio, Texas.* ■



Example 26



Example 27