An Acoustical Study on Bass Bridge Adjusters

By Andrew W. Brown

Of all parts of a stringed instrument, which one is the most important for the instrument's tone and playability? Though it is impossible to isolate one element as "most important," the bridge is worthy of consideration. It seems unlikely that a virtuoso violin soloist would cut through the legs of his instrument's bridge in order to improve his instrument's playing performance, yet that is exactly what 60-80 percent of North-American bassists do by installing bridge height adjusters on their instruments.

Goals of the study

There are naturally many questions that I hope to answer with the completion of my forthcoming dissertation on this subject. But with this study, I wanted to establish reliable, scientific information to answer the following questions:

1. Do bridge height adjusters affect the sound of the double bass compared to a bridge with solid feet, and if so, how?
2. Are there acoustical differences to be heard between various adjuster models?
3. Do bridge height adjusters affect the pizzicato characteristics of the bass, and if so in what way?
4. Do players' opinions about bridge adjusters vary from scientific proof?

String Height Adjustment

Double bass string height is dramatically affected from season to season, especially in North America. The dimensions of the double bass contribute to a large fluctuation in its string height. While it has been traditionally thought that swelling and shrinking of the softwood top influences string height, recent information shows that the heel of the neck is also affected by humidity and causes the angle of the neck to fluctuate.

Traveling to auditions or being on tour in regions where conditions vary can make playing difficult; strings become either too high or low for ideal playability. Bass players also need to adjust to various styles of music quickly, using the same instrument. Classical repertoire includes orchestral, solo and chamber music, all of which may require different string heights. In general, the "set-up" for orchestral playing is oriented towards power and response, with high string action and tension, while chamber bassists may prefer a warmer, blending tone with somewhat lower tension and action. Solo playing demands a brilliant sound with high tension but low action for technical passages in thumb position. Outside the classical realm, jazz bass playing is characterized by a pizzicato technique, often amplified, where acoustical volume and "bowability" of the instrument are secondary to its sustain and the "twangy" sound of extremely low string action. Bassists increasingly find themselves playing in a variety of styles, as western art music of the last four centuries blends with contemporary popular and multi-cultural forms. It is not unusual for a bassist to have symphonic rehearsals during the day, and a "gig" at a hotel or the local jazz club the same evening using a single instrument to meet the demands of these diverse styles.

Bridge Height Adjusters in Detail

The most common method of adjusting string height is by using wheel-and-axle height adjusters. Based on the idea of screw-type bridge height adjusters for mandolins and guitars, New York area bass makers such as Chuck Traeger, Samuel Kolstein, and Lou DiLeon applied bridge adjusters to the bass as far back as the 1960's. Today, as many as 80% or more of U.S. bassists use wheel-type bridge adjusters.

Many types of adjusters are commercially available, varying in material from woods like maple, ebony, cocobolo and lignum vitae to metals like brass and aluminum. Dimensions range from a shaft 1/4" (6.4 mm) to 3/8" (10.7mm) in diameter and 1 1/2" (41.7mm) to 1 7/8" (55.5mm) long, and a wheel from 1" (28.5mm) to 1 5/8" (39.5mm) in diameter. Exact measurements of the adjusters I tested are listed below:

Type material and name /code name	Weight	Wheel Diameter	Axle Diameter/length
Massive Bridge/ NO	–	–	–
Aluminum Standard/ AS	11.5g	28mm	6mm/ 42mm
Brass Standard / BS	34.6g	28mm	6mm/ 42mm
Aluminum Boehm/ AB	17.3g	32mm	8mm/ 45mm
Polyamide Boehm/ PB	9g	32mm	8mm/ 45mm
Maple DiLeone/ MD	7.8g	39mm	11mm/ 48mm
Lignum Vitae Kolstein/ LK	10.2g	35mm	11mm/ 55mm

Other ideas for materials that were mentioned in the preliminary research (such as steel, nylon and carbon fiber composite) led us to create a new bridge height adjuster. Alexander Meyer of the Institute für Wiener Klangstil in Vienna created a plastic version of the Boehm model from polyamide stock, turned on the workshop lathe. The tested models are pictured in Fig. 1:

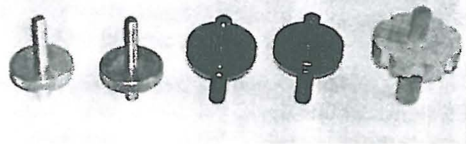


Fig. 1 Aluminum standard, brass standard, aluminum Boehm, polyamide Boehm and maple DiLeone models (lignum vitae Kolstein not shown)

Test Methods

There were 3 phases to the testing procedure. The first phase involved an international email survey sent to bass players to ascertain their opinions and ideas about using bridge adjusters. The second testing phase was scientifically based, using electronic equipment specifically set up for this experiment, to measure and analyze the overtone spectrum and volume of each bridge. And finally, a listening test was performed to determine if audible differences could be perceived among the various bridges. The results of each phase were quite dramatic.

E-Mail survey

With the help of the Internet, over 300 questionnaires were sent to bassists on the e-mail address list of the International Society of Bassists (ISB). The survey had four questions:

A) What are the playing advantages of wheel/ screw bridge adjusters?

B) What effect on the sound of a bass does the mounting of such adjusters cause?

C) Do you find the use of such adjusters necessary, helpful, unnecessary, or detrimental to bass playing?

D) Do you have any further comments on bridge height adjusters?

Thirty-two bassists replied to the survey, citing climate changes, traveling, and adjusting height for different style "gigs" as reasons for using bridge adjusters. Americans and Canadians were the most numerous among respondents, though answers also came from England, Germany, Australia, Brazil, and Italy. Most bassists replying from outside of North America said they do not use bridge height adjusters themselves, but know of them.

A) There were six advantages cited for using bridge adjusters. These, listed in order of popularity, were a) to adjust to variable climate conditions, b) to adapt to style changes, c) for adjustments while traveling (most often involving changing climatic conditions), d) for practicing solo repertoire while on orchestral tour, e) to experiment with bridge height in playing situations for the left hand and with the "field of tension" applied to the table of the instrument, and f) for the easy adjustment of school instruments.

B) Opinions varied widely on how adjusters affect the sound of a bass. It seems that the majority of players who enjoy the convenience of bridge height adjusters find the sound detriment negligible. In contrast, the few who don't use them wrote they felt some loss of sound must occur. Interestingly, only the fewest bassists claimed to have heard an actual difference in sound before and after mounting adjusters, or to have a strong opinion based on observation of the sound. Most opinions on sound were founded on personal reasons and preferences, and "what they had heard" from colleagues on the subject.

C) Of the respondents, 31% claimed bridge adjusters were necessary and another 31% found them helpful, whereas 11% found them unnecessary, and 24% considered them detrimental. Many of the reasons players cited adjusters necessary or helpful have already been mentioned above. Those who claimed that the advantages outweigh the disadvantages used phrases like "no great affect" or "no significant damping of sound." The most common reason why adjusters were found detrimental is that respondents felt that they affect the sound in a negative, or at least unnatural, way. One colleague wrote that bridge height adjusters may cause permanent damage by putting an uneven pressure on the table, and another warns of improperly installed adjusters which cause damage in a variety of ways. Two players said they were going back to a solid bridge as soon as they could, because they were unsatisfied with the bridge adjuster sound.

D) Among the other comments, the ideal material of adjusters was discussed. 10 respondents preferred wood adjusters, while 3 liked the metal ones (aluminum). Ebony adjusters were reported to be aesthetically pleasing, easier to use because of their larger dimensions, and "organic-sounding" compared to metal models, but have the disadvantages that they are fragile and relatively expensive. The Lignum Vitae model is claimed to be convenient to use because it is "self-lubricating," and tougher than ebony. Maple was mentioned less often, but was cited as the logical choice since the bridge is also made of this wood. Whether instinctively, empirically or aesthetically, players seem to prefer "wood in contact with wood".

Metal adjusters on the other hand, and most often the aluminum ones, are controversial. While some bassists reported that aluminum "deadens the sound" or adds a "metallic" character to the tone, others wrote that this material's lightness and stiffness is ideal for the transmission of vibrations through the bridge to the table. One luthier referred to the "evil" of steel, aluminum and brass adjusters, while another source reported that aluminum possesses the "most efficient transmitting density" for the purpose. The report that the smaller aluminum adjusters are difficult or even "painful" to turn because of their smaller dimensions is contrasted by praises of their durability and lower cost. It is interesting to note that although most respondents preferred wood adjusters, aluminum ones are in fact more widely used.

Sound analysis

For the sound tests, recordings used for the analysis were made by Andrew Rootes, of the Austrian Radio Symphony Orchestra in the anechoic (sound-absorbing) chamber of the Institute für Wiener Klangstil, in Vienna. Playing tasks included arco and pizzicato tones in all registers of the bass, and were recorded over a six hour period. The six types of adjusters were installed one at a time (in order from smallest to largest) into the same bridge. The session was conceived to monitor and regulate all conditions, such as temperature and humidity, bridge and soundpost position, bridge height, and tuning.

FFT spectrums (see below)

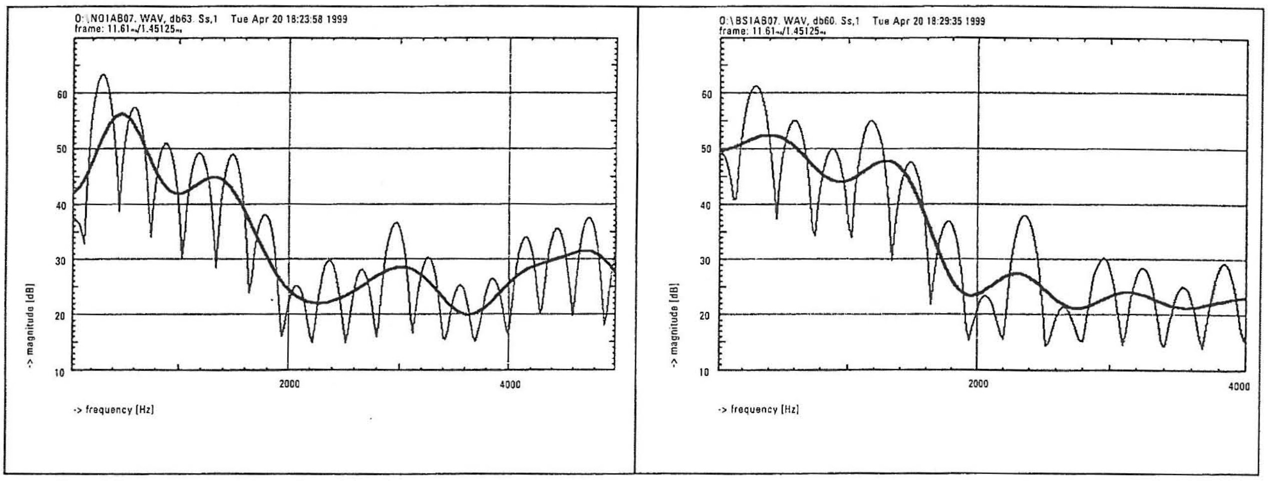
By using FFT Spectral analysis, one can represent the harmonics contained within a played sound. The harmonics, or "partials," (within the complex saw-tooth waves radiated by a double bass) define the tone color. The two examples shown are spectra of a high D in thumb position (293 Hz). The bridge without any adjusters, on the left, shows a more defined fundamental and a higher amplitude above 4 kHz, which corresponds with the impression that the heavy brass adjuster (at right) sounds relatively "weak" and "nasal" in this range. Various tendencies of tone color could be seen using the FFT Spectral analyses. But the interpretation of such diagrams is usually considered quite subjective, so it needs to be backed up with other methods of testing.

RMS Pizzicato (see Figure 2)

Root Mean Square (RMS) indicates the sound intensity (or "loudness") received by the recording equipment. In this test, the decay time for pizzicato tones was measured, to see how adjusters affect "sustain." Interestingly, though the wheels can make up to two and a half seconds difference in the time it takes to fall 40 dB, there seems to be no definite pattern. In Fig. 2, the Maple adjuster second from right sounds the longest with an open D string. But the plucked G string "dies" fastest with the two wood models. In contrast, the standard aluminum adjuster goes from shortest to longest sustain. These qualities apparently correspond to the damping qualities of the various materials, but do not allow generalizations about pizz sustain with or without adjusters.

Listening Test (see Figure 3, p. 13)

As a final phase to this study, a listening test was performed. Using recorded samples played through headphones, 20 musicians were asked to judge whether played examples sounded "the same" or "not the same." Only three pitches were used, and sound samples were played in pairs. The pairs were either the exact same samples (such as two separate hearings of a bowed low E with no adjusters), or samples of the same tone with different variables (i.e. different kinds of bridge adjusters). Listeners were almost always able to identify the identical pairs, while separate examples of the same variable were heard to be "the same" a third less often. In spite of this margin of error, the next closest adjuster variable sounded the same only 17% of the time. (see Fig. 3)Generally, it was concluded that bridge height adjusters make a substantial audible difference in sound when



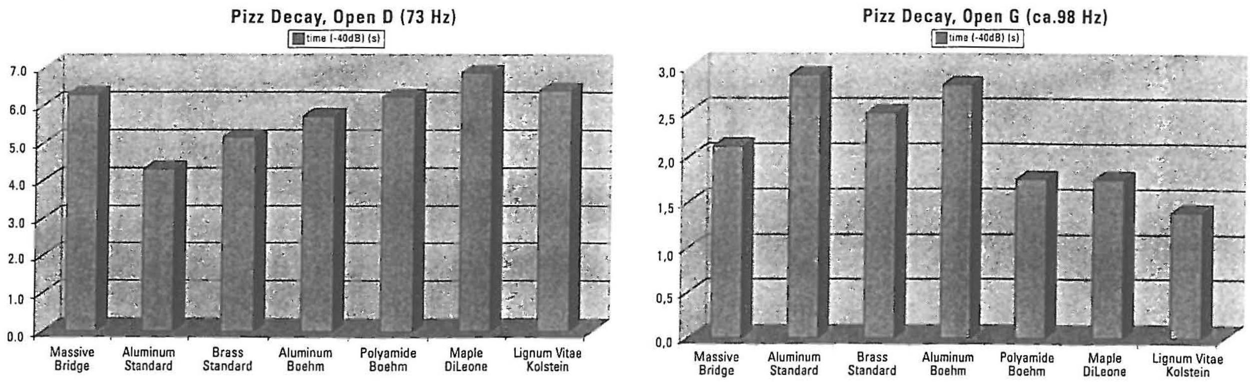


Fig. 2: The amount of time it takes an open string to fall 40 dB in intensity is shown in seconds (vertical axis). From left to right: Massive bridge, aluminum standard, brass standard, aluminum Boehm, polyamid Boehm, maple Delione, lignum vitae Kolstein.

compared to a "massive" (no adjusters) bridge, and these differences are more audible with bowed tones than with pizzicato.

Results and applications

Sound Characteristics

The sound of the individual bridge variations may be summed up as follows:

1. Massive Bridge (no adjusters): This generally sounds "darker" than a bridge with adjusters (with the exception of the brass model in the lower range and the wood models in the lower-middle range). The massive bridge is richer in fundamental tone and has a more even overtone distribution throughout the range of the instrument than any adjuster model, but may lack brightness or "directness" in comparison.

2. Aluminum Standard: This sounds consistently brighter, more nasal and louder than the massive bridge, but sounds thinner and weaker in the very high positions.

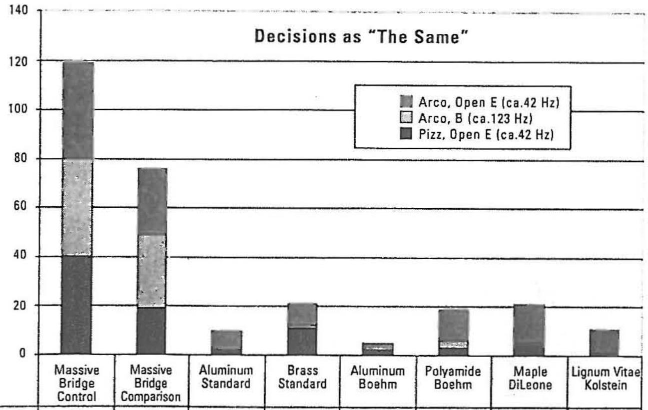
3. Brass Standard: This sounds full and focused in the low registers, but quickly loses overtones in the middle range of the bass and sounds thinner than the aluminum standard from there in the middle and high range.

4. Aluminum Boehm: This is somewhere between the sound of the aluminum standard and the massive bridge, sounding similar to a solid bridge in the low register, brighter and focused in the middle and high positions, yet rounder and less loud than the aluminum standard.

5. Polyamide Boehm (our test design): This was the least consistent of all variables, and was distinguished by an uneven palette of tone colors and a weak fundamental above the middle range.

6. Maple DiLeone: This is the closest overall match to the massive bridge sound in bowed tones.

7. Lignum Vitae Kolstein: This is almost as close in tone to the massive bridge, though somewhat more muted. Like the maple model, it sounds more focused but less fundamental in the lowest frequencies and darker in the middle range. The Lignum vitae Kolstein loses overtones in the higher registers, resulting in a more dampened tone.



	Massive Bridge Control	Massive Bridge Comparison	Aluminum Standard	Brass Standard	Aluminum Boehm	Polyamide Boehm	Maple DiLeone	Lignum Vitae Kolstein
Arco, Open E (ca.42 Hz)	39	27	8	9	3	13	16	10
Arco, B (ca.123 Hz)	40	30	0	1	0	3	1	0
Pizz, Open E (ca.42 Hz)	40	19	2	11	2	3	4	1

Fig. 3 At Left are the two control columns for the bridge without adjusters. All other bridge variations with adjusters were judged to sound the same significantly less often.

Recommendations for bridge height adjuster use

Though not the principal goal of this study, the question "which adjuster is best" is the most interesting for players and luthiers. To answer this question, one must first define some of the desired tone qualities. I think it is possible for players and luthiers to use the qualities of adjusters to compliment the sound character of their instrument and come closer to their ideal sound. The application of adjusters could help achieve the following sound concepts:

1. *A "natural, even tone" throughout the range of the bass.* I think there is no substitute for a massive bridge in this case. My first choice in adjusters for bowed bass in this category would be a maple adjuster with a larger diameter (DiLeone model).

2. *A "bright sound with fast response".* The aluminum standard is the choice here, which showed itself to have more harmonics in bowed tones than the massive bridge. These adjusters are somewhat louder than massive bridge, but the intensity is inconsistent through the range of the bass and lacking in fundamental.

3. *Long sustain of pizzicato notes.* Again, the aluminum standard is my recommendation, though all metal models have a relatively favorable sustain in the deep regions that jazz players need. The rich overtones of this model combined with its sustain make it ideal for that "twangy" jazz sound. The aluminum Boehm model, being of the same material but a larger dimension, could keep many positive qualities jazz while "toning down" the brilliance somewhat.

4. *A "dark" sound.* Brass sounds strong in low registers and has a similar spectrum to the massive bridge. But while it is rich in the fundamental, overtones and volume become increasingly weak the higher the played note is. For a sound not quite as dark but more even, the massive bridge or maple DiLeone is recommended.

5. *A "soloistic sound".* If this description means a brilliant sound, than aluminum is the choice. But my experience shows that aluminum can be "thin" or "scratchy" in the high registers. I rather think "robust," "compact," "even" and "overtone rich" are words to describe own my ideal solo sound, which are better achieved with a massive bridge. My next choices would be the maple DiLeone or aluminum Boehm.

6. *"General Purpose".* For the all-around player, I would follow the maxim stated by Lou DiLeone: maple is good for bowing and aluminum is good for jazz. If the player plays both styles, I recommend the aluminum standard model.

Andrew W. Brown moved to Vienna in 1991, where he studied with Ludwig Streicher, and received his performance degree from the Hochschule für Musik. He is currently doing acoustically research at the Institut für Wiener Klangstil, after which he intends to return to the United States.