String Tension: What It Means and How It Became Important

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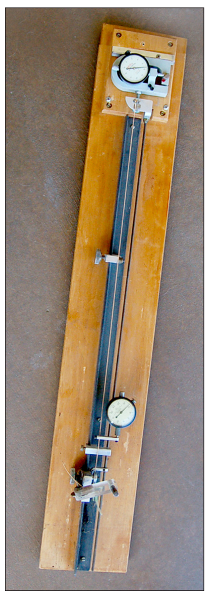
Sparking interest

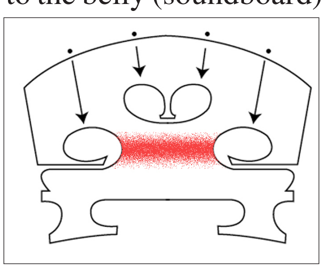
In my six decades of luthierie, string tension has always been a major focus for me. From a structural standpoint, it seems rather obvious that the strings exert sufficient tension to bend a neck, warp a body, or damage a bridge. This, of course, was not a revelation on my part; the structure of all string musical instruments – from pianos to ukuleles – and the compressive loads imposed by the strings' tension have been addressed by countless builders and designers who tried to find a way to control and counter the action of the strings' load, which attempts to distort the instrument into a twisted mess.

But, the acoustical issues related to string tension was one that I believed was sorely overlooked. I sought to learn more about the longitudinal peghead-to-tailpiece loads (or in the case of the acoustic guitar, the peghead-to-fixed-bridge loads) as well as gain a better understanding of how tone is affected by the down-pressure on the soundboards of those instruments with movable bridges, such as mandolins. This was an interest that Jim Rickard (1942-1996, former acoustical engineer at Ovation and columnist for *FRETS Magazine*, and I shared, and spent many hours discussing, testing, and pondering.

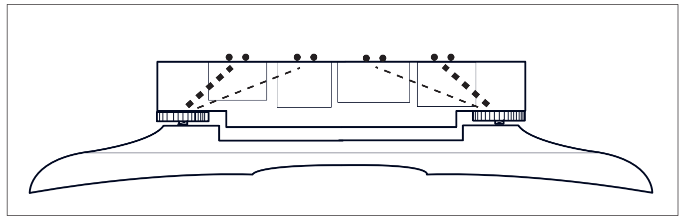


In the early 1970s, I performed some tests to measure string tensions at the bridge of fixed-bridge instruments, and the associated lateral down-pressure loads on those instruments with movable bridges and tailpieces. What I found was that the relative tension of each string in a set of strings was critically important to the timbre; amplitude, sustain, clarity, and most importantly, the string-to-string balance.

The early violin luthiers were obviously keenly aware of how energy was driven through the bridge to the belly (soundboard) of their violins. Bartolomeo Guarneri (1698-1774) is credited with the design of the modern violin bridge whose kidney and volute shapes do not allow any of the four strings to have a direct route to the belly. Instead, all strings are over openings, and the energy from each string is attenuated through the bridge's waist.



Consider for a moment the traditional mandolin bridge with two posts and adjusting knobs (based on Gibson's January 1921 patent) is designed so the two

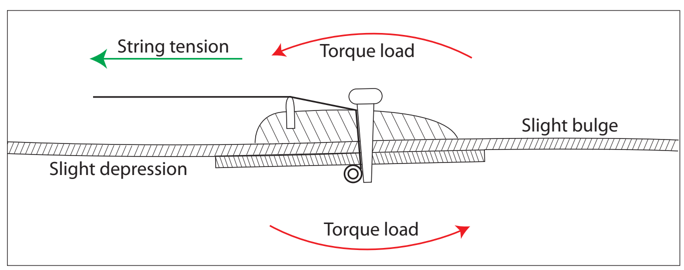


outer pairs of strings are close to the posts and the two inner pairs are closer to the center of the bridge's saddle. In this design, the outer pairs produce a different timbre than the inner pairs because of the flexibility of the saddle and the string pairs' proximity to the posts (and to the soundboard).

To counter this design flaw, the down pressure of the center two pair of strings on a mandolin should be different than the outer two pair, and this calls for a set of strings whose load, or tension, is calculated, compensated, and adjusted based on bridge design.

A similar unequal distribution of energy can happen on acoustic guitars with fixed bridges (i.e., Spanish and conventional steel string guitars). If one or more of the six strings exerts a greater pull at the bridge than neighboring strings, the string(s) with lesser tension will not be able to activate the bridge as readily because the load imposed by the strings with greater tension will overpower them.

It is important to note here that fixed-bridge instruments are not driven by the strings' down pressure. In fact, there is virtually no down pressure exerted



on the soundboard by the strings at the bridge. Fixed bridge guitars work on a torque or twisting moment in which the strings' tension causes the bridge and soundboard to be twisted toward the peghead as a result of string tension (load) at the bridge. This twisting effort is readily visible as a hollow or depression normally found in front of the bridge and a hump or bulge normally found behind the bridge. As a result, the total string tension coupled with the longitudinal energy sent to the bridge is critical to the amplitude, balance, and timbre of acoustic guitars.

Raising awareness for musicians

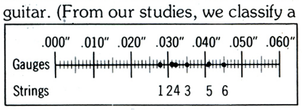
In many articles in *Pickin' Magazine*, I discussed string loads and tensions, and often suggested that it would be beneficial for musicians to select single strings rather than sets. In the 1970s, Gibson made its strings available to purchase individually by the gauge but, unfortunately, string loads (tension) were not listed on the packages so musicians could not make well-informed choices. In several articles, we prompted that string loads should be published on each string package along with the vague reference to light, medium, and heavy.

By 1979, when I started *FRETS Magazine*, I became more focused on bringing the subject of string tension to the forefront because I believed the issue was critical. With this in mind, we started a monthly column called "*FRETS* String Clinic" in which we measured the gauges and loads of every string in a set, and we reported the results to our readers. In addition, the editors (Jim Hatlo, Rick Gartner, and I) would play an instrument with the tested strings and comment on what we heard.

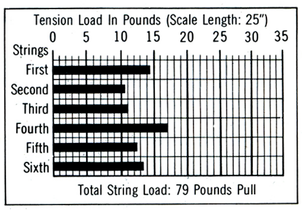
FRETS String Clinic

Testing: Nashville Straights C-1500 Classical Guitar Strings

The Nashville Straights C-1500 Concert Classic set is listed as a "high tension" silver-wound set for classical guitar. (From our studies, we classify a

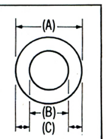


79-pound classical guitar string load as medium.) Like their steel-string Nashville Straights cousins, the strings are



packaged uncoiled. The company suggests that coiling wound strings within standard square string packages can distort the windings, to the detriment of the strings' tone and longevity.

String	Gauge(A)	Core(B)	Wrap(C)
First	.028"	—	
Second	.031"	—	
Third	.041"	—	
Fourth	.032"	x	.0055"
Fifth	.035"	x	.008"
Sixth	.045"	x	.012"



The C-1500s come in a slim box that is about 3-1/2′ long, which may discourage you from trying to keep a spare set in your guitar case. Inside the box, the strings are packaged in a single plastic sleeve. Their ends are color-coded to aid in differentiating between gauges.

The three treble strings are clear nylon and (unlike most traditional classical strings) their ends are not roughed up, leaving them a bit slippery during the tying procedure. The wrap wire on the three bass strings is wound on a nylon filament core (the reason for the "X" notations in our chart). The winding does open up at one end of each string to facilitate tying onto the bridge harness.

Analysis of the load levels indicates a slightly high *D* string, at 17 pounds.

We tested our sample set on a Madeira C600 classical guitar. We were impressed by the even string-to-string tonal balance. The clear nylon treble strings sounded uniformly bright, crisp, and full, without any of the dullness that sometimes plagues trebles.

The first six or seven columns evoked some comments from readers, but the column went seemingly unnoticed by the string manufacturers.

Then we began to get calls and letters from various string manufacturers whose tone ranged from, "This is interesting; can you tell me more?" to "All you are doing with this column is confusing the musicians!" A few were more emphatic: "Please stop this column! Do you realize what a mess you're making!" One manufacturer complained that monitoring, measuring, and reporting string loads, as well as printing new packages and ads would impose an enormous financial burden on its business. (See a redacted copy of a letter from a troubled advertiser at the end of this document.)

I'm pretty stubborn, especially when I believe strongly in something so the *FRETS* String Clinic column continued. More than once, Jim Crockett (publisher of *Guitar Player, Keyboard,* and *FRETS Magazines* at GPI Publishing) called me into his office to read a letter from another string manufacturer – who was also an advertiser (read that as $$$$). Jim wanted to double check that I was still on the right track. "Are you convinced that your findings are correct?" he'd ask. "Can you substantiate and replicate your tests?" And, each time I would look him in the eye and say, "Yes, Jim. I'm absolutely sure we're on track here and doing the right thing!" With that, Jim would write back to the advertisers and politely say, "Sorry, but the column stands."

Some believers

A few string manufacturers saw merit in what we were doing. I was a consultant to Gibson Inc. (in Kalamazoom, Michigan) at the time working on several instrument-related projects. There I met Bob Lynch, president of Gibson's string division in Elgin, Illinois, and caught his interest on the subject of string tensions. He engaged me in the process of measuring the loads of every string Gibson made and analyzing the relative loads of strings in their sets. We then prepared new string sets with balanced tensions and sent them to Bruce Bolen (Gibson's VP of R&D and Customer Relations at the time) for him to personally test as well as for him to distribute to prominent musicians he worked with to test Gibson strings. Within about seven or eight months of our work, Gibson began producing the "Equa" string sets with balanced* loads, and began reporting its string tensions on its packages.

Bringing it to the manufacturers

The concerns from other string manufacturers didn't go away. In fact, it got downright testy at times. On one occasion, two key members of Ovation's string division made the trek from Connecticut to California to visit with the *FRETS* staff and me to see how we were measuring the strings loads and to challenge why we felt this topic was important. Things were a bit uncomfortable in the morning, but by the time we got through with lunch, described our rationale, showed them our testing methods, and demonstrated a few instruments with balanced* and non-balanced strings, they had calmed down a little, but were still frustrated that all we were doing was "stirring the pot." At least they agreed with us that the naming of light, medium, and heavy left a lot to be desired.

With the hope of easing tension and getting some consensus, we thought it would be beneficial to gather all of the string manufacturers (something that had never been done before) at a meeting during the 1982 NAMM (National Association of Music Merchants) Show in Anaheim, California. The meeting was scheduled for February 7, 1982 at the Inn at the Park Hotel in Anaheim, and invitations went out to all of the prominent domestic string manufacturers;

most said they would attend, but a few could not. In attendance, representing *FRETS Magazine* were editors, Jim Hatlo and Rick Gartner, Jim Crockett (our publisher), and myself. Industry attendees were Dave Holcomb (GHS), Bob Lynch (Gibson), Ernie Ball (Ernie Ball), Chris Campbell (Dean Markley), Jim D'Addario (D'Addario), and Paul Damiano (Kaman/Ovation). John Dusinski (Martin) responded saying he wouldn't be able to attend, that he "believes there is already standardization between manufacturers," but he did think the subject should be pursued. Neil Lilien (Guild) had a meeting conflict and could not attend, and Stan Rendell, former president of Gibson, and Dick Sievert (both of Sterlingsworth strings) wrote back that they were "not attending this NAMM but very much wanted to be involved in future string tension efforts."

Lunch included the normal casual-but-guarded conversation among competitors, small talk, and tech talk. And, Jim Crockett was occasionally reminded, half-jokingly, that *FRETS* was financially supported by many of its advertisers sitting at the table. And there was some chatter about how *FRETS* could not possibly support its findings about string tension making a difference.

After lunch, armed with a bunch of flip-chart drawings and some photo enlargements of our *FRETS* String Clinic column, I reviewed much of the same findings that you read earlier in this article and went into some areas of string tensions and download pressures with greater detail. Stuart Mossman (1942-1999) contributed by making available what he felt were two "identical" guitars for us to borrow for the meeting. For the test, we measured a string's tension (load) right there to demonstrate our procedure and show the equipment we used for measuring (the long device shown on the previous page). On one guitar we installed a set of strings with balanced* tension, and on the other a standard set of strings (I'm intentionally omitting the string brand here). Our editor, Rick Gartner, an accomplished guitarist, demonstrated both guitars and put on a good show playing identical scores. He mentioned that he was making every effort to apply the same attack and emphasis in both performances. Just about everyone agreed that the guitar with balanced* strings sounded better. At that point there were all kinds of subjective comments along with some objections. The strongest common thread that emerged was, "Yes, those might be two 'identical' guitars, but everyone knows that no two guitars are alike." "The more balanced one," some said, "is most likely just a better sounding guitar!" after which you could hear the rush of a soft "YESSS" and mumbles of agreement along with nods of heads around the room.

It was something we hadn't planned for, but I believed in our data and was willing to take a calculated risk, so I turned to Jim Hatlo and Rick Gartner and asked, "How quickly can we move the strings from one guitar to another?" I told Jim Crockett our plan and he promptly got up to say a few things and provide some cover while Jim, Rick, and I feverishly swapped strings. (Fortunately, the strings were put on that morning and we left long tails in case we had to replace a string on the fly.) When we were done, and the guitars were up to pitch, Rick performed again.

There was now a hush, and within a minute or so, most sheepishly agreed that the balanced* sound moved with the string set from one guitar to another. We said nothing and just stood there and looked at our guests, allowing them time to reconsider.

Mixed mataphors

Obviously there several disparate topics here: balanced tensions; "light/medium/heavy"; random tensions, and reporting tensions on packaging. We clarified at the meeting that our intention was not to dictate gauges or to mandate that each string in a set should have the same tension. Our sole purpose was to urge that tension made a difference and that musicians should be able to make a choice based on specific information relative to their playing style and the structure of their instrument.

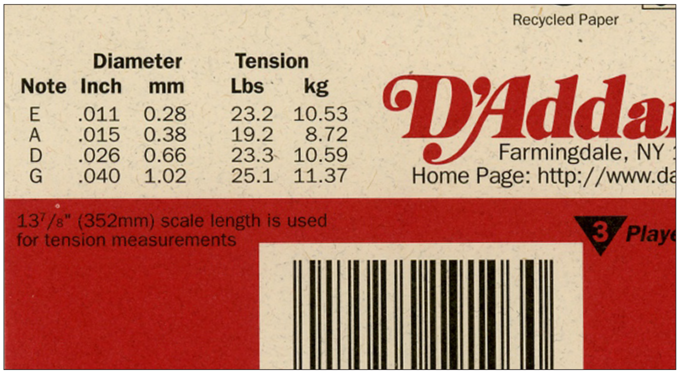
Change is slow

In the year following our meeting, there was a lot of follow-up discussion. We continued to do our *FRETS* String Clinic column, and the interaction with string manufacturers turned from negative comments to increased dialog about our findings. Some manufacturers sent us sample string sets to evaluate while a few others still pushed back hard. It took almost a

Jim Crockett remembers...

This was a very controversial project. Roger Siminoff's role at *FRETS Magazine* far surpassed that of simply doing interviews and writing articles. His innate curiosity, coupled with his engineering skill and boundless energy is brilliantly evidenced here. He took on a task that was often controversial and rarely even thought about, yet with his relentless perseverance (and talented staff), he was ultimately able to show the string industry that string loads were serious concerns, or should be, and his resulting impact and respect within the entire string instrument field has opened eyes and impacted manufacturers in ways no one could previously have imagined.

Jim Crockett, Founding Publisher of *Guitar Player, Keyboard,* and *Frets Magazines* April 2014



year before we noticed that many string manufacturers began to print string tension information on their packages, and today we find that most string manufacturers not only provide the data, but some have become highly proactive promoting string tension information. As of this writing, D'Addario's web site features a String Tension Chart for each set of strings, but no longer shows string tensions on its packaging. Several other manufacturers and private label brands – but not all – show the string tensions on their packaing. And some manufacturers, like GHS, still only report their gauges, not tensions.

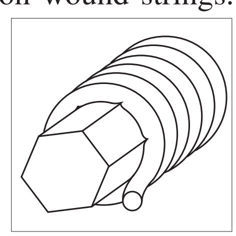
The upshot

Having string tension information available enables you to make better choices about the total loads you want to subject your instruments to, as well as provides you with data to achieve better string-to-string balance from your instruments.

For the luthier or musician

If you are a luthier, you'll want to consider how the overall string load or down pressure affects the structure of your instrument. The goal is to have strings with tensions that can produce balanced tone string to string and effectively excite the bridge and soundboard system. There are no specific rules for this since much depends on the bridge design and how you build and brace your instrument. But, being sensitive to string loads, coupled with a bit of experimentation, will get you a long way down the path to great-sounding instruments.

For the musician, being aware of string load data provides another method for you to know more about the strings you are selecting. String gauges alone do not tell the whole story – especially on wound strings. Your wound strings are made of a core or inner wire wrapped with a covering or "wrap" wire, and there are many ways to achieve the same overall gauge. For example, a .024″ (twenty four thousandths) string could be made of a .012″ core with a .006″ wrap wire (.012″ + .006″ + .006″ = .024″). Or you could make one with a .014″ core wire and a .005″ wrap wire (.014″ + .005″ + .005″ = .024″), and there are other practical possibilities. Each combination you come up with will have a .024″ result, but the tension and playability of each string will be greatly different.



Of further importance to the musician is to know how much string tension their instrument is designed for. If the luthier or manufacturer has designated their instruments "for medium gauge strings only" (for example), the musician needs to have some reference of what "medium" means.

* Balanced sets

In this white paper I previously mentioned "balanced" tensions, suggesting that each string in a set should have the same tension (notice the varying tensions of the strings in the *FRETS* String Clinic chart earlier in this document). That idea was the basis for Gibson's "Equa" sets developed in the mid 1970s. Balanced tensions proved to be much better than random tensions, but further evaluations from musicians showed that that sets with equal, or approximately equal tensions for all strings were not optimum. As a result we learned that balanced tensions were ideal for solid-body electric guitars where the strings energy and movement is sensed in the pickup's electro-magnetic field. However, while balanced tension sets were still better than string sets with random tensions, balanced sets were less than ideal for fixed bridge acoustic guitars and instruments with movable bridges (jazz guitars, mandolins, and banjos).

In 2016 I embarked on a consulting project for the Santa Cruz Company to develop what I believed to be the optimum set. The tensions I developed for their flat-top fixed-bridge guitars were plotted on a parabolic curve in which the tension of each string was considered relative to where the string sat on the bridge as well as what the tension was of the neighboring strings. The new string sets proved to be a great improvement over the strings the company previous used.

In 2017 I wanted to go further and apply some of the technology I had learned from working with string-winding machines at both Gibson and Fender. By manipulating core wire tension when being wrapped as well as wrap wire tension and feed speed I was able to make further advancements. Armed with what I believe to be the optimum string sets with compensated tensions depending on where strings sat on the bridge and compensating for the tensions of neighboring strings, we announced Straight Up Strings for the mandolin. These were followed with the announcement of Straight Up Strings for banjo in 2018, Straight Up Strings for acoustic steel-stringed guitar in 2019, and Straight Up Strings for the resophonic guitar in 2020.

Supporting documents

[redacted]

RECEIVED
JUL - 7 1982
FRETS MAGAZINE

June 28, 1982

Mr. Roger Siminoff
Frets Magazine
GPI Publications
20605 Lazaneo,
Cupertino, CA 95014

Dear Roger:

[redacted] would like to express and explain our concerns over the ideas recently presented by Frets Magazine relating to a uniform labeling system for total string load on every set of strings. While giving consumers as much information as possible about the product they are buying will always be a necessary ingredient in any successful marketing program, we at [redacted] disagree that a uniform string load labeling system contributes to this goal. Our reasons for resisting the adoption of a musical string load labeling system are two fold

(1) We disagree with your comparison of the total load of a set of strings to the octane rating of gasoline. The octane rating system truly defines a parameter that measures the PERFORMANCE of the product a consumer is buying - i.e. higher octane ratings allow an engine to make more efficient use of the power available from gasoline. However, while total load of a set of strings does provide one necessary piece of information that a consumer may be interested in, string load, taken alone, is one of the least important overall manufacturing parameters that controls the SOUND of a string. To illustrate this point, we have enclosed two acoustic .044 A-5 strings that tune up to the same tension ± 3%, and sound and feel very different due to the selection of core and wrap sizes). And if, as we at [redacted] believe, consumers gravitate towards products that SOUND the best, a uniform string load labeling system does nothing to help a consumer select the best sounding product. It only adds another confusing element that will, in all probability, be misunderstood, misinterpreted, and result in a more confused "average" consumer.

An example of the communications from strings manufacturers indicating their opposition to our findings on string tensions, and our recommendation to provide musicians with data.

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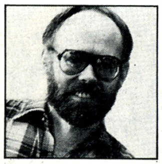
FRETS



FROM THE PUBLISHER

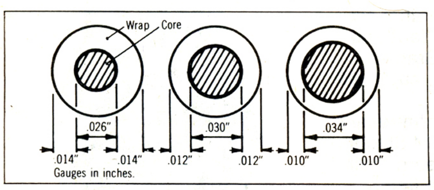
Straight Talk About Strings

EVERYONE KNOWS WHAT "Extra Strength" means, right? No? Well, how about "Giant Size"? And when is gasoline really "premium"?

So many terms that we all live with daily seem to have *implied* meanings rather than clearly agreed-upon definitions. Years ago the U. S. Food and Drug Administration had to jump into the ad field to set up some guidelines for such terms as "lemonade flavor," "sugar free," and "guaranteed."

What, you may wonder, does all this have to do with acoustic string instruments? Simple. Do you know what "light-gauge" strings are? Are you sure? The *Light* Touch AC-L set from Ends Strings has a total tension load of 133 pounds; Gibson's *light* G-130L set measures 154.5 pounds. That's a pretty significant difference in playability and response. Or how about the GHS *medium* set BB40? Its load tests at 176.5 pounds of tension. Fred's Warehouse *mediums*, on the other hand, measure a full 210.5 pounds — a 20% difference!

Often string manufacturers rate their products as light, medium, or whatever, based on gauge alone. But that can be unintentionally misleading to the musician, because an .054", for instance, can be made a number of ways. And each way affects the playability of the string, as well as its sound and projection. Here's an idea of some variations:



Each of those .054"s will feel, play, and sound different, even though when packaged they will all sport the designation ".054"."

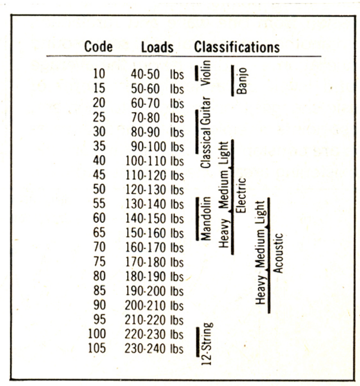
Sometimes there can be other, more serious considerations. For years, Martin has stamped the inside of their scalloped-braced guitar bodies "Use Medium-Gauge Or Lighter Strings Only." But, as we've seen, the "load" (the total tension or pull of the strings when all of them are brought up to pitch) of "light" and "medium" sets may vary widely. In our opinion, a total load of 150 pounds is reasonable for a "medium" set; but what will happen to that Martin guitar with a "medium" set that pulls at 215 pounds or more?

We asked Martin customer service representative Mike Longworth that very question. He responded: "Each of our guitars goes out with a 'Care And Feeding' booklet that indicates the style of guitar, its serial number, and the type of strings the instrument was adjusted for. We feel we are justified in expecting the owner to use strings that are equivalent to or are lighter than those indicated in that booklet. If the guitar is damaged because the wrong kind of strings are put on it, we might have to disclaim responsibility."

At *Frets*, we feel strongly that it is time for the string industry to add another dimension to its labeling practices. Sure, let the marketing people use "heavy,""light," "medium," and all the rest; and definitely list all the gauges. However, let's simply add "Total Load" up in a corner of the package somewhere. And all of a sudden, buying strings will take on a new, even more valuable cast where the player is concerned.

"Load" will tell the musicians most of what they want to know, and gauge listings will fine-tune the information. Comparing two sets of "light" strings today is a pretty heady chore — when you're trying to remember and compare the differences between .012"-.016"-.024"-.032"-.042"-.054" and .011"-.014"-.022"-.029"-.038"-.050". It's a lot easier to contrast "Load: 133" with "Load: 154.5," isn't it?

Below is a String Load Chart that *Frets* has prepared, showing our recommendations for reclassifying today's string package sets. Now, we're not suggesting that every string company rush right out to the printer this afternoon to remake all their packaging, nor are we even expecting all the manufacturers to agree with us. What we are planning, though, is to present our rating table and concept to the string industry leaders in the very near future. And we'd like your input before we do.



Is this idea meaningful to you? Is the system easy to follow? We'll consider and compile all your comments for our presentation to the manufacturers. And in one of our spring issues, we'll let you know the results.

— JC

Jim Crockett's column in the January 1982 issue of *FRETS* was published in advance of our NAMM Show meeting with the string manufacturers.