STRAIGHT UP STRINGS

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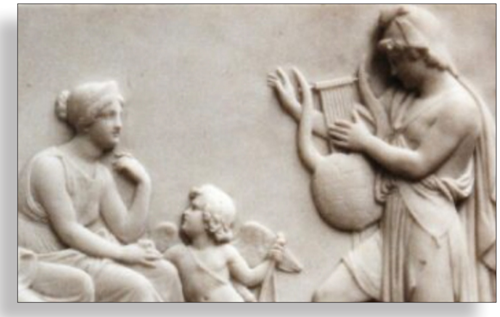
A BRIEF HISTORY OF MUSICAL STRINGS



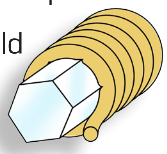
We're not really sure who discovered the musical magic of a vibrating string, but it may very well have been cave dwellers who were intrigued by the twang of the archer's bow. Primitive cultures recognized that a tightened vine or rope produced sounds, and early sailors must have marveled at the whistling in their rigging lines set alive by the wind. Early sculptures and stone carvings reveal that stringed musical instruments were a well-developed part of civilization in Ancient Mesopotamia as early as 3000 BC. The famous Greek philosopher, Pythagoras (570-c.495 BC), laid the foundation for modern acoustical physics, and his theories about string vibration have been relevant for more than 2,500 years.

The principles behind the musical string are not an invention but rather a study in physics. A tightened cord when struck or plucked, will continue to vibrate until its energy is exhausted. As it vibrates, it causes the air around it to move. If the string is attached to a membrane such as a soundboard, the string's energy excites the soundboard to cause even larger masses of air to move. The resulting air movement translates into waves of sound pressure called compression and rarefaction that carry to our ears and trigger our sense of hearing.

The earliest musical strings were made from animal gut, carefully dried and cured. The strings for lower notes were soaked in various types of varnish or tree pitch prior to drying to increase their mass so they could produce lower notes. The earliest wound strings date back at least to the 15th Century, and gut strings wound with metal wire first appeared in the 1660s. The windings added mass that allowed strings to be brought up to a workable tension while vibrating at a lower frequency.

Plain steel strings, and steel strings wound with silver, copper or brass followed shortly thereafter, but the inferior metal content and wire-drawing techniques of early strings caused them to be prone to breakage and poor tone.

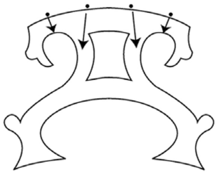
Drawing is the process of pulling large steel wire through sequential sizing dies to elongate the wire and reduce its diameter to the desired size. The drawing process exerts a great deal of tension on ths string that alters its linear structure and increases the wire's strength. As improvements were made in metallurgy and drawing techniques, the tonal properties and life of the strings likewise improved.



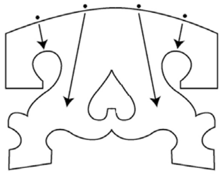
One of the problems associated with string winding was ensuring that the wrap wire would stay in place during the winding process and during hours of intense vibration when attacked by the musician's picks. Loose wrap wires on round core wire presented a dull sound, buzzes, and lack of tonal clarity. In the early 1970s, string makers started using core wires that were irregularly shaped to help ensure that the wrap wire was locked in place on the core. From this effort, the idea of hexagonal core wire was developed. The core wire was still drawn through sizing dies, but a hexagonal-shaped final die was added to draw the core wire to a semi-hexagonal shape. The hexagonal core wire improved how the wrap wire locked onto the core wire as the wrap wire was drawn onto the core during the string winding process. The result was longer string life and improved tone. But string design is only part of the story...

WHAT WE FOCUSED ON

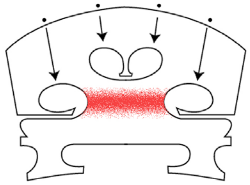
The early violin makers worked diligently to develop bridges that would efficiently transfer the strings' energy to the belly (soundboard) to provide equal timbre for each string. In Guarneri's design, which has stood the test of time for more than 270 years, none of the strings had a direct route to the belly; the energy from each string was attenuated through the waist of the bridge (red area) to provide equal timbre from each string. With it came the realization that the design of the bridge played a critical role in the tonal production of the instrument.



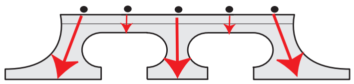
Nicolo Amati
1596-1684

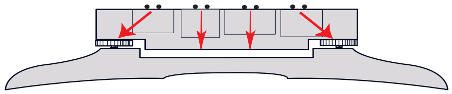


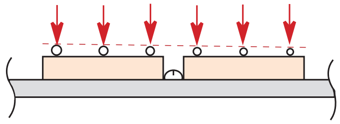
Antonio Stradivari
1664-1737



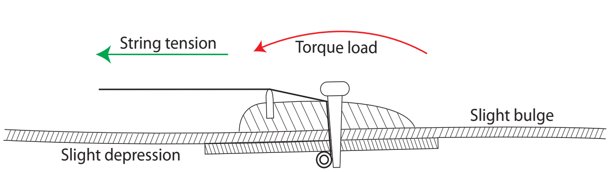
Bartolomeo Guarneri
1698-1774

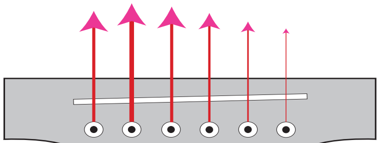






Contemporary acoustic stringed musical instruments with tailpieces present a wide range of bridge designs from the three footed banjo bridge, to the twin-post mandolin bridge, to the two-piece bridge saddles in resophonic guitars. The path of energy from strings to the soundboard is different in each case. These bridges are driven by the strings' lateral energy. In order to produce balanced tone, an adjustment must be made to the download pressure of each string based on where it sits on the bridge.





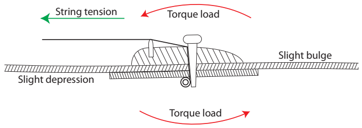
The soundboard on a fixed-bridge instrument, like the nylon-string classical guitar and the acoustic steel-string flattop guitar, is driven by the longitudinal energy of the strings. Here, changes in the strings' tension pull at, and release the saddle causing the bridge to rock on its center axis that in turn causes the soundoard to pump.

We recognized the need to compensate the lateral or downward pressures of the strings for movable-bridge (tailpiece) instruments and the longitudinal tensions of strings on fixed-bridge instruments. The three key elements were: a) where the strings sat on the bridge relative to the structure of the bridge (strings sitting over the feet of a bridge had a different energy path to the soundboard than strings sitting over arches in the bridge); b) the lateral pressure or longitudinal tensions of neighboring strings (a string's lateral or longitudinal energy production is relative to the neighboring strings' lateral or longitudinal energy production); c) the fact that there are inner strings or courses of strings that had neighboring strings, and outer strings or courses of strings with no neighbors.

With this criteria in hand, we took a straight up approach to musical string design in which the string gauges for each instrument family were considered based on bridge design. As a result, the strings' down pressures and longitudinal tensions were compensated for where the strings sit on the bridge, as welll as their tensions being relative to the tension of neighboring strings.

A paradigm shift in guitar string design that provides compensated torque for balanced tone and feel.

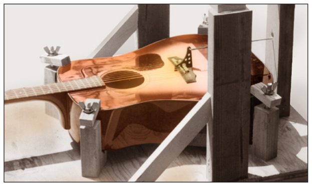
On an acoustic guitar, the soundboard is torqued forward by the tension of the strings pulling at the bridge, which causes the soundboard to twist.

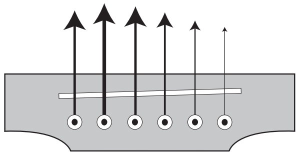


The strings' tension (green arrow) forces the bridge to twist on its axis, loading the soundboard and causing it to rock forward.

This twisting force creates a slight bulge in the soundboard behind the bridge and a slight hollow in front of the bridge; an indication that the soundboard is loaded and ready to respond to any change in the strings' tension. As the strings are played, the change in tensions forces the bridge to rock back and forth on its axis which, in turn, forces the soundboard to create a pumping action that produces sound.

In 1974, while working as a consultant to the Gibson Strings Division, Roger Siminoff proved the rocking theory with a guitar secured in a sturdy fixture to arrest the bridge's motion in either a lateral or longitudinal axis. The tests proved that the twisting moment of the bridge was paramount to how the soundboard functioned. It was evident from the tests that controlling the tension and torque load of each string was vital to producing balanced tone, sustain, and feel. Now, 50 years later, these, and similar tests have become the backbone of our effort to develop the ultimate musical strings. We learned that the tensional relationship of each string to its neighboring string is critically important. If, for example, a string that produces a tension of 15 pounds is neighbored by strings producing 20 pounds each, the 15 pound string will be unable to overcome its powerful neighbors to drive the bridge with equal energy and sustain. And, we learned that the tensions of the strings could not be the same.





The results of our exhaustive tests created a paradigm shift in guitar string design with carefully engineered core-to-wrap wire gauges derived from compensated torque and down-pressure loads plotted on a bell-shaped curve for optimum balance, tone, and feel.

...every note of every chord

Wound with **PHOSPHOR BRONZE** for optimum tone color

Unsure of what gauge is right for you and your guitar? Try our guitar sample paks, available in L/M/H and M/H/EB.

Specifications:

Guitar, light, #2700-L – ideal for finger picking and light fretting feel, light-bodied guitars
• Gauges: .011″ .015″ .0215″ .030″ .042″ .0525″ • Torque loads*: *E* 15.0 *B* 17.6 *G* 20.6 *D* 22.8 *A* 21.9 *E* 21.0 • Total torque*: 118.9 inch pounds
• Total longitudinal tension: 138.5 pounds • *E* and *B* plain, *G, D, A,* and *E* wound with phosphor bronze

Guitar, medium, #2700-M – for finger picking and flat picking, medium fretting feel, medium-bodied and dreadnaught guitars
• Gauges: .012″ .016″ .0215″ .030″ .044″ .0535″ • Torque loads*: *E* 17.2 *B* 19.3 *G* 20.6 *D* 22.8 *A* 24.9 *E* 21.9 • Total torque*: 126.79 inch pounds
• Total longitudinal tension: 146.5 pounds • *E* and *B* plain, *G, D, A,* and *E* wound with phosphor bronze

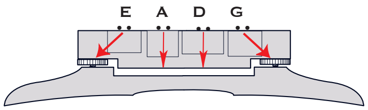
Guitar, heavy, #2700-H – perfect for a driving flat-picking style, ideal for dreadnaught-sized guitars
• Gauges: .013″ .0165″ .0235″ .034″ .045″ .0555″ • Torque loads*: *E* 19.3 *B* 22.8 *G* 24.5 *D* 25.8 *A* 27.9 *E* 23.6 • Total torque*: 143.9 inch pounds
• Total longitudinal tension: 167.5 pounds • *E* and *B* plain, *G, D, A,* and *E* wound with phosphor bronze

Guitar, enhanced bass, #2700-EB – a super partner for brand new guitars or guitars with rosewood sides and backboard
• Gauges: .013″ .0185″ .026″ .035″ .0465″ .0565″ • Torque loads*: *E* 19.3 *B* 24.6 *G* 30.5 *D* 29.8 *A* 28.7 *E* 24.8 • Total torque*: 157.7 inch pounds
• Total longitudinal tension: 182.5 pounds • *E* and *B* plain, *G, D, A,* and *E* wound with phosphor bronze

*Torque loads measured in inch-pounds at a 7/16″ saddle height, and compensated on a proprietary bell-shaped curve.

MANDOLIN

A giant step in the design of mandolin strings that delivers clarity, chop, and balance.



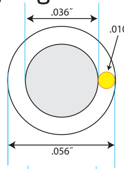
Strings positioned near the posts can't deliver the same energy to the soundboard as those strings positioned in the center of the saddle.

The heralded adjustable bridge patented by Gibson in 1921 solved the problem of action adjustability but gave us a bridge with the outer *E* and *G* string pairs positioned near the bridge's posts, and the inner *A* and *D* string pairs positioned in the center of the saddle. The result is an imperfect balance in tone, sustain, and clarity of the string pairs due to the positioning of the strings on the bridge's saddle.

Where strings are anchored to a bridge, such as on an acoustic steel-stringed guitar, compensating the longitudinal tension is critical for good string-to-string clarity, sustain, and tone. But where a movable bridge is concerned (such as on the mandolin), the soundboard is driven by the string's lateral energy that is transmitted down through the bridge posts, and this dictates the need for carefully compensated string gauges.

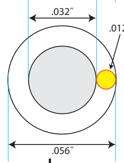
The solution for the mandolin: Since we knew we couldn't change every bridge, we took a straight up approach to this challenge and focused on how the strings' energy is driven through the bridge for centermost and outermost pairs of strings. As a result, we engineered a set of mandolin strings with a combination of plain and wound gauges whose relative down pressure loads and proximity to the bridge's posts are the primary focus. Our research brought about a paradigm shift in mandolin string design with carefully engineered core-to-wrap wire combinations that deliver compensated down pressure for improved balance, tone, and feel.

It's not just about gauges. There are several ways to manufacture a wound string for a given gauge. For example, to make a .056″ wound string, we could use a .036″ core wire and a .010″ wrap wire:



.010″ + .036″ + .010″ = .056″

or a .032″ core wire and a .012″ wrap wire:



.012″ + .032″ + .012″ = .056″

and so on. (Of course there are thresholds of optimum wire sizes for the wrap and the core wire to function efficiently.)

During the string winding proces the core and wrap wire tensions, and the feed-speed of the wrap wire are performed to our critical specifications to ensure that our compensated downloads are achieved. Of particular importance is the balanced timbre between the plain 1st and 2nd strings and the wound 4th and 5th strings.

...every note of every chord

Wound with **PHOSPHOR BRONZE** *for optimum tone color*

Straight Up Strings engineered with compensated downloads for optimum balance.

Specifications:

Mandolin, medium, #2500-M

- Gauges: *E* .0115″ *A* .016″ *D* .024″w *G* .039″w – Compensated downloads (pounds): *E* 5.5 *A* 4.0 *D* 4.0 *G* 7.0
- Total download at bridge base: 41 pounds • Total longitudinal tension: 179 pounds

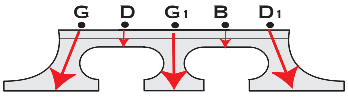
Mandolin, heavy, #2500-H

- Gauges: *E* .0115″ *A* .017″ *D* .026″w *G* .041″w – Compensated downloads (pounds): *E* 5.5 *A* 5.0 *D* 5.2 *G* 7.4
- Total download at bridge base: 46.2 pounds • Total longitudinal tension: 193.6 pounds

*Downloads measured: At 16° string-break angle (the angle the strings make as they pass over the bridge). A 16° string-break angle is typical for mandolins with a 5.5° to 6° neck pitch.

Managing the un-manageable with compensated down pressures for improved balance, clarity, and tone.

The 5-string banjo presents one of the most complicated energy transfer scenarios with its flexible soundboard (head) and 3-footed bridge. We found that the traditional 3-footed bridge used on most 5-string banjos provides the optimum weight and mass but doesn't compensate for the imperfect design of a bridge system with three of its strings positioned directly over feet and two strings positioned directly over arches.

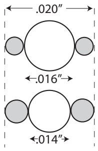


Strings positioned over the arches on a banjo bridge can't deliver the same energy to the banjo's head as those strings positioned directly over the bridge's feet.

Compounding the energy transfer problem, the down pressure of a three-footed bridge on a flexible soundboard is unevenly distributed such that the outer two feet present more down pressure than the center foot to the banjo's flexible and resilient head.

To drive the head with string-to-string consistency, the download of the strings must be compensated to correct for both the bridge's and the soundboard's (head's) unusual features.

Making the necessary gauge changes to arrive at the correct compensated downloads was further complicated by the fact that the 5-string banjo has only one wound string whose mass and resultant gauge could be achieved by various combinations of core and wrap wire sizes.



In order to arrive at the necessary mass for each of the plain strings, we had to find a source for fractional wire sizes measured to five decimal places.

We took a straight up approach to this challenge and focused on how the energy from each individual string is driven through the bridge's structure in order to determine the precise gauges for the ultimate banjo string sets with balanced tone, string to string. As a result, we engineered a set of banjo strings with a combination of plain and wound strings whose relative down-pressure loads coupled with their proximity to the bridge's feet deliver a carefully compensated load to the banjo's head. It's about down pressures, not gauges!

The last piece was finding a stainless wrap wire that didn't generate a rough surface when being wound; our chromium stainless did the trick!

...every note of every chord

D string wound with CHROMIUM STAINLESS for a silky smooth feel

Specifications:

Straight Up Strings engineered with compensated downloads for optimum balance.

Banjo, light, #2600-L

- Gauges: .009″ .0105″ .013″ .020″w .009″ • Compensated downloads (pounds): *D* 3.4 *B* 3.2 *G* 2.9 *D* 3.4 *G* 3.4
- Total download* at bridge feet: 16.2 lbs • Total longitudinal tension: 55.6 lbs

Banjo, medium, #2600-M

- Gauges: .010″ .0115″ .013″ .020″w .010″ • Compensated downloads (pounds): *D* 4.0 *B* 3.5 *G* 2.9 *D* 3.4 *G* 4.0
- Total download* at bridge feet: 17.8 lbs • Total longitudinal tension: 60.9 lbs

Banjo, heavy, #2600-H

- Gauges: .011″ .012″ .014″ .022″w .0105″ • Compensated downloads (pounds): *D* 4.5 *B* 3.7 *G* 3.2 *D* 3.7 *G* 4.3
- Total download* at bridge feet: 19.4 lbs • Total longitudinal tension: 70 lbs

* Downloads measured at a 15° string-break angle (the angle the strings make as they pass over the bridge). 13° to 16° is ideal for most bluegrass banjos.

• Semi-elastic high-carbon plain steel *D1*, *B*, *G1*, *G*, with a chromium stainless-wound *D*

Our guitar, mandolin, banjo, and resophonic string sets are available in single sets or in a 6-Pak cloth bag with a free Straight Up Strings wipe.

The challenge of a thin aluminum soundboard and a cast aluminum spider-bridge.

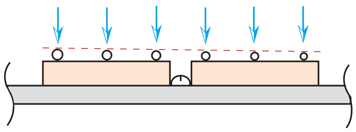
RESOPHONIC GUITAR

The bridge saddle of a resophonic guitar is comprised of two pieces of wood that fit securely in a lattice-like metallic frame referred to as a spider. In addition to supporting the load of the strings and transferring the energy to the cone (the round metallic soundboard), the spider presses down on the outer edge of the cone to securely anchor the cone around its perimeter. The spider features a central adjustable screw that tensions and drives the cone and draws it to the spider.

The transmission of energy from the strings to the soundoard (cone) of the resophonic guitar is very different from the bridge systems on other acoustic stringed musical instruments.

On the resophonic guitar, the strings pass from the tailpiece to the peghead and go over the bridge at a +/- 3° angle. When the strings are brought up to pitch, the spider and cone are loaded and ready to respond to the changes in the upward and downward energy presented by the strings.

Unlike the torque load of the strings at the bridge of an acoustic guitar that twists the bridge and soundboard back and forth, the bridge on the spider of a resophonic guitar moves up and down as it responds to changes in the strings' lateral energy. This up-and-down movement on the cone creates a pumping action in the body of the resophonic guitar resulting in the compression and rarefaction that our ears perceive as sound. Driving the mechanism of the spider and cone is tricky and requires a unique set of strings that compensate for the download of each string (see blue arrows) on the bridge based on where the strings sit on the bridge and spider, as well as the relative download pressure of the neighboring strings.



In addition to developing a set of strings with compensated downloads, we focused on thickness of the string gauges to place the strings in an even plane (see dotted red line) for the bar to rest on so the bar applies equal contact pressure for each string.

Next, we chose a smooth and slick phosphor bronze wrap wire that didn't abrade when it was wound, to provide noise-free slides up and down the neck, along with the heralded growl of the resophonic guitar.

The result of our tests brought us to create a seachange in resophonic guitar string design with carefully engineered core-to-wrap wire gauges derived from compensated down pressures plotted on a proprietary curve for optimum string-to-string balance, tone, and feel.

Straight Up Strings for the resophonic guitar are only available in medium gauge, optimum for every make and model.

...every note of every chord

Wound with
SLICK PHOSPHOR BRONZE
for ultimate barring

Specifications:

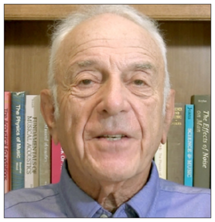
Straight Up Strings
engineered with compensated downloads for optimum balance.

Resophonic guitar, medium, #2800-M

- Gauges: .016.5″ .019″ .0265″ .035″ .047″ .057″
- Downloads*: *D* 8.3 *B* 8.4 *G* 8.4 *D* 8.3 *B* 8.2 *G* 8.3 • Total compensated download on spider: 49.9 ounces (3.12 pounds)
- Total longitudinal tension: 187 pounds
- Lower *G, B, D,* and *G* strings wound with a slick-surfaced phosphor bronze

* Down pressure loads measured at a 3° string-break angle over the bridge. Downloads and tensions for open *G* tuning.

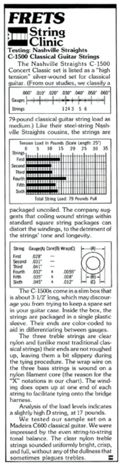
ABOUT US



Roger H. Siminoff is considered one of the foremost authorities on luthierie and musical acoustics, having designed, built, researched, played, and written about acoustic stringed instruments and their makers for more than six decades

Born in Newark, New Jersey in 1940, Siminoff's music appreciation developed at age 10 when he began to play the piano, and he soon became more intrigued with what was happening inside the piano than outside. Siminoff first built a pedal steel guitar with string benders when he was 18. That was soon followed by the construction of a 5-string banjo and an F-5-style mandolin, planting the seed for his life-long dedication to musical acoustics and the art of luthierie.

In 1974, Siminoff founded *Pickin' Magazine* and that publication was followed by the launch of *FRETS Magazine* in 1978. For these publications, Siminoff did extensive research on strings and musical acoustics, studied the early makers and manufacturers, conducted numerous interviews with prominent luthiers and musicians, and wrote countless articles on acoustics and the art of luthierie. Roger's introduction of the "String Clinic" column in *FRETS* magazine brought about many changes in the string industry including motivating manufacturers to report the tensons of their string sets.



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.

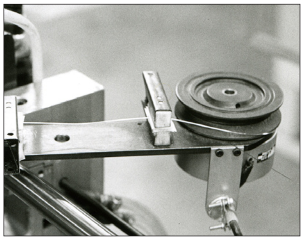
The three treble strings are clear nylon and (unlike most traditional classical strings) their ends are not roughed up, leaving them a bit slippery during the tying procedure. The wrap wire on the three bass strings is wound on a nylon filament core (the reason for the "X" notations in our chart). The 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.

Roger began working as a consultant to Gibson in 1972 when he licensed a patent for a vertebra truss rod system. In the following years Roger brought several other patents to Gibson including the "Crank" tuning knob, an adjustable nut, modular tuning machines, and a component guitar project that was halted during the move to Nashville in 1985. In 1978, Roger was responsible for launching the new Gibson F-5L mandolin.

As a consultant to the Gibson String Division in Elgin, Illinois, Roger developed a unique wire tensioning system for Gibson's wrap-wire winding machines. He then spearheaded a program to calculate the specific wire tension for each gauge of core wire during the winding process. His studies on balancing guitar string tensions led to the development of Gibson's "Equa" strings, followed by Gibson's "Grabber" strings featuring a quick and easy way to attach strings. Roger worked as artist relations manager in the development of Gibson's "Earl Scruggs" banjo strings.



In the early 1980s, he worked as a consultant to the Fender String Division in Chula Vista, California where he pioneered advancements in string winding techniques for Fender's "Squire" strings. Roger developed The Santa Cruz Guitar "Parabolic Strings" and consulted with several other private label string brands for the development and marketing of their string gauges.

Building on his past experience in string technology and his work as a luthier, Roger realized that more could be done to achieve the ultimate strings, and he focused on developing unique mandolin string sets whose gauges depend on where the strings sit on the bridge's saddle and how the energy from each string drives the soundboard. This led to the launch of Straight Up Strings in 2015 featuring string sets with uniquely compensated tensions for mandolin, followed a year later by compensated string sets for guitar, banjo, and resophonic guitar.

Siminoff has authored 12 books and several hundred articles on instrument construction and repair, musical acoustics, and the craftsmanship of stringed musical instruments. His research and writings on the life and work of both Orville Gibson and Lloyd Loar have made him a highly respected expert on these renowned artisans. (For more information on Lloyd Loar, Orville Gibson, and Gibson company history, please visit www.siminoff.net.)

Siminoff holds nine U.S. and three foreign patents for musical instrument designs, all of which have been licensed to various manufacturers.

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