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Lyles

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(54) **LOW-FRICTION BRIDGE FOR STRINGED INSTRUMENT**

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G10D 3/04 (2006.01)

(52) **U.S. Cl.**
CPC ***G10D 3/04*** (2013.01)

(58) **Field of Classification Search**
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USPC 84/307
See application file for complete search history.

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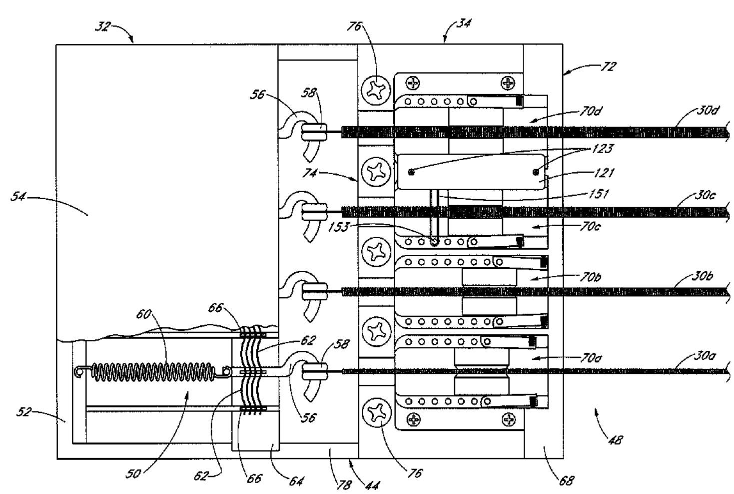
(57) **ABSTRACT**

A low-friction bridge for a stringed musical instrument employs a roller saddle that is adapted and positioned to roll upon a race. The race includes structure to guide the roller saddle as it rolls. A musical string is seated in a circumferential groove/saddle formed in the roller saddle. As the musical string stretches or contracts the saddle rolls, and thus the musical string does not slide in the saddle. As such sliding friction is avoided in favor of rolling friction of the roller saddle rolling upon the race. One or more contact members can be biased into contact with side faces of the roller saddle.

8 Claims, 11 Drawing Sheets



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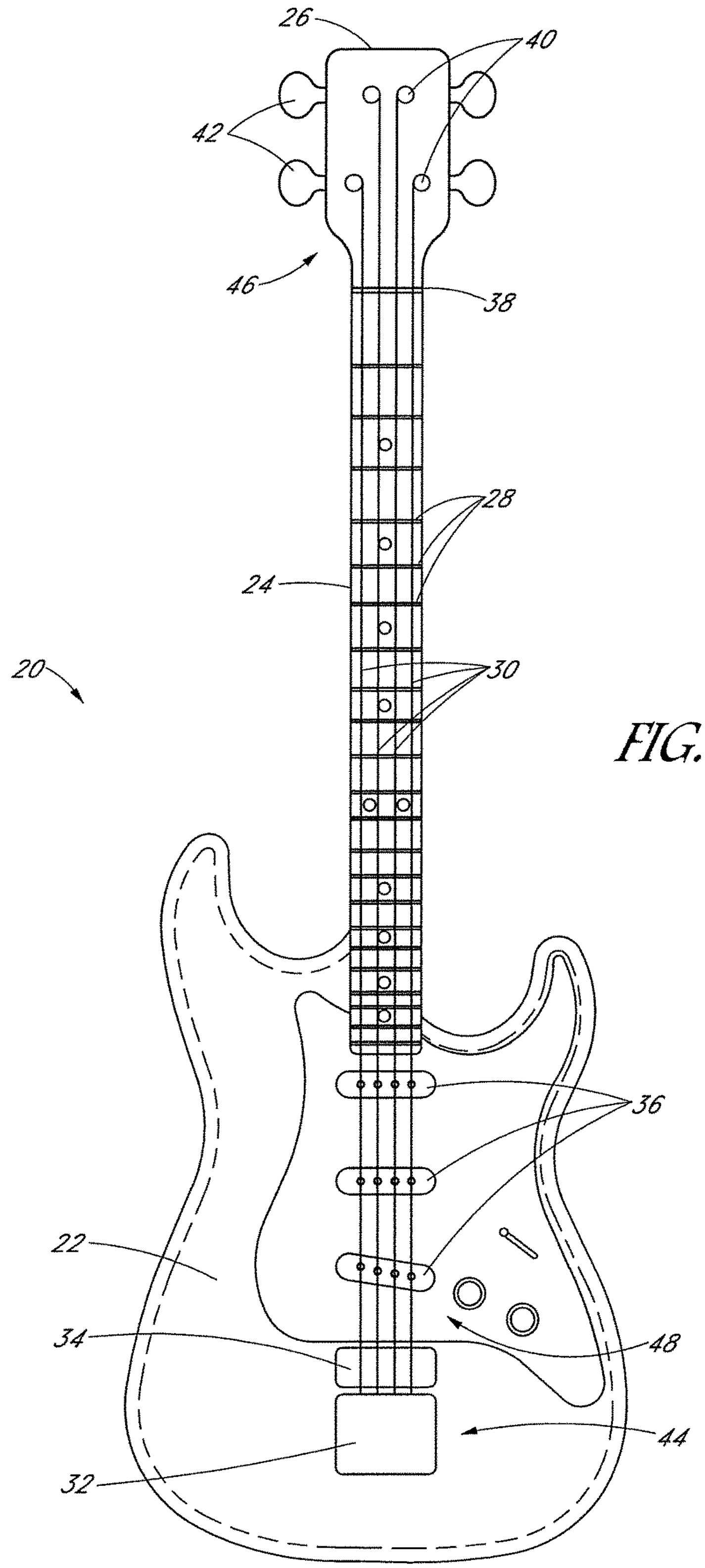

FIG. 1

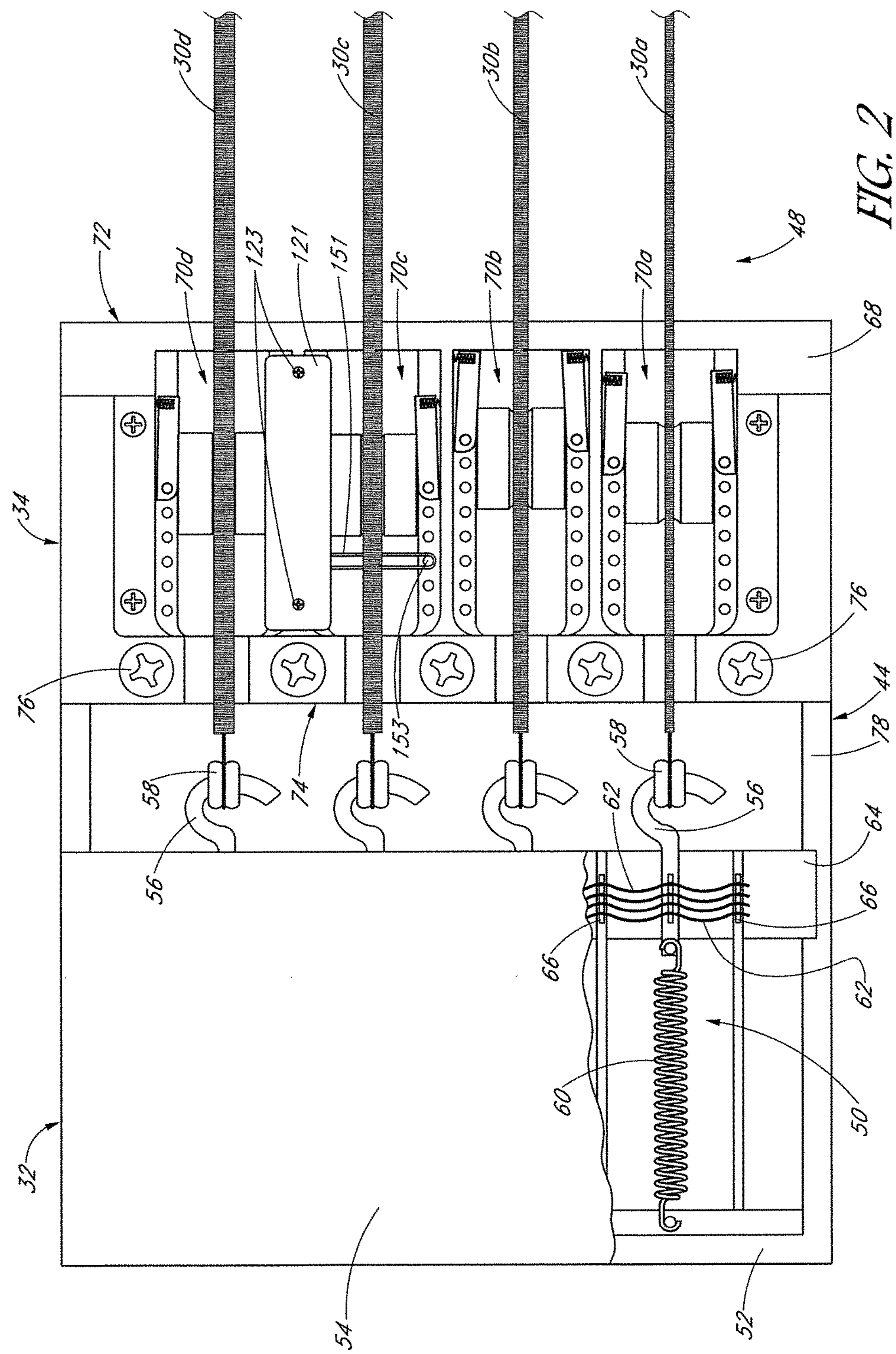
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FIG. 2

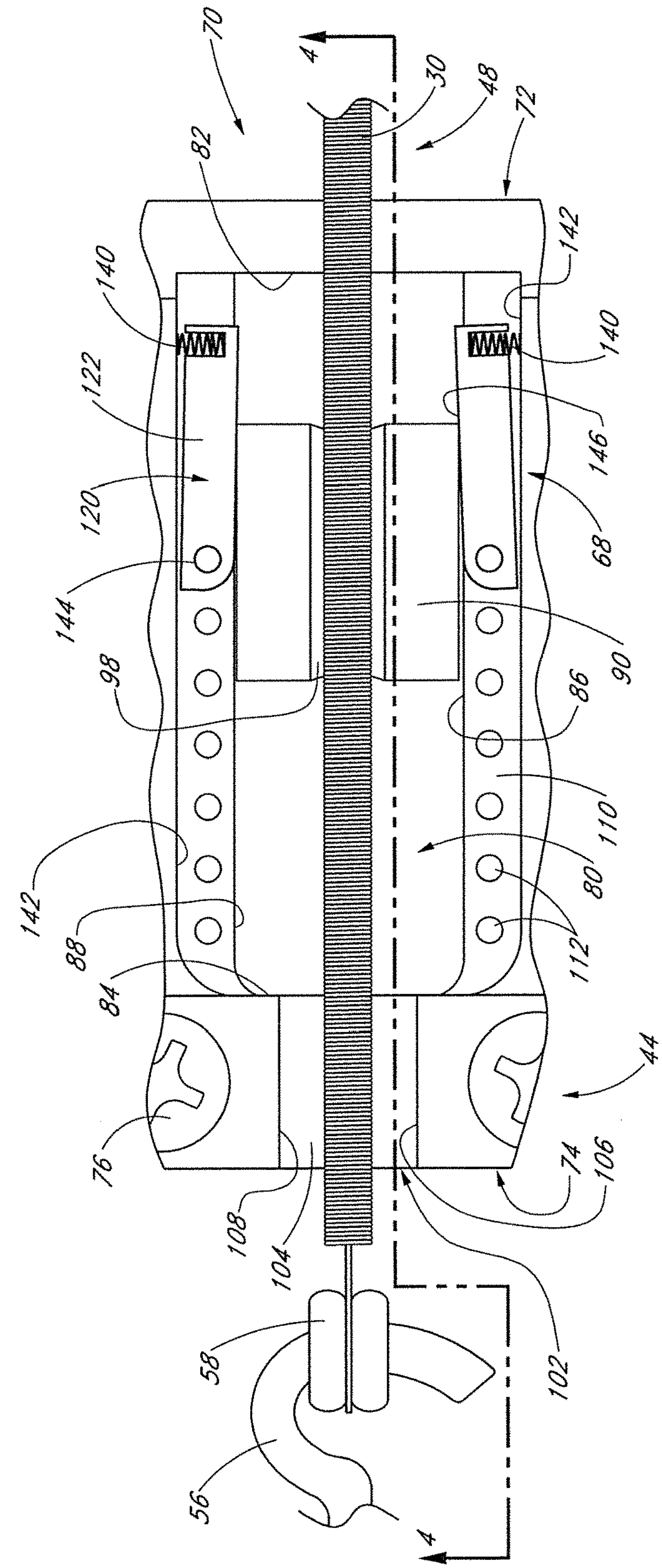
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FIG. 3

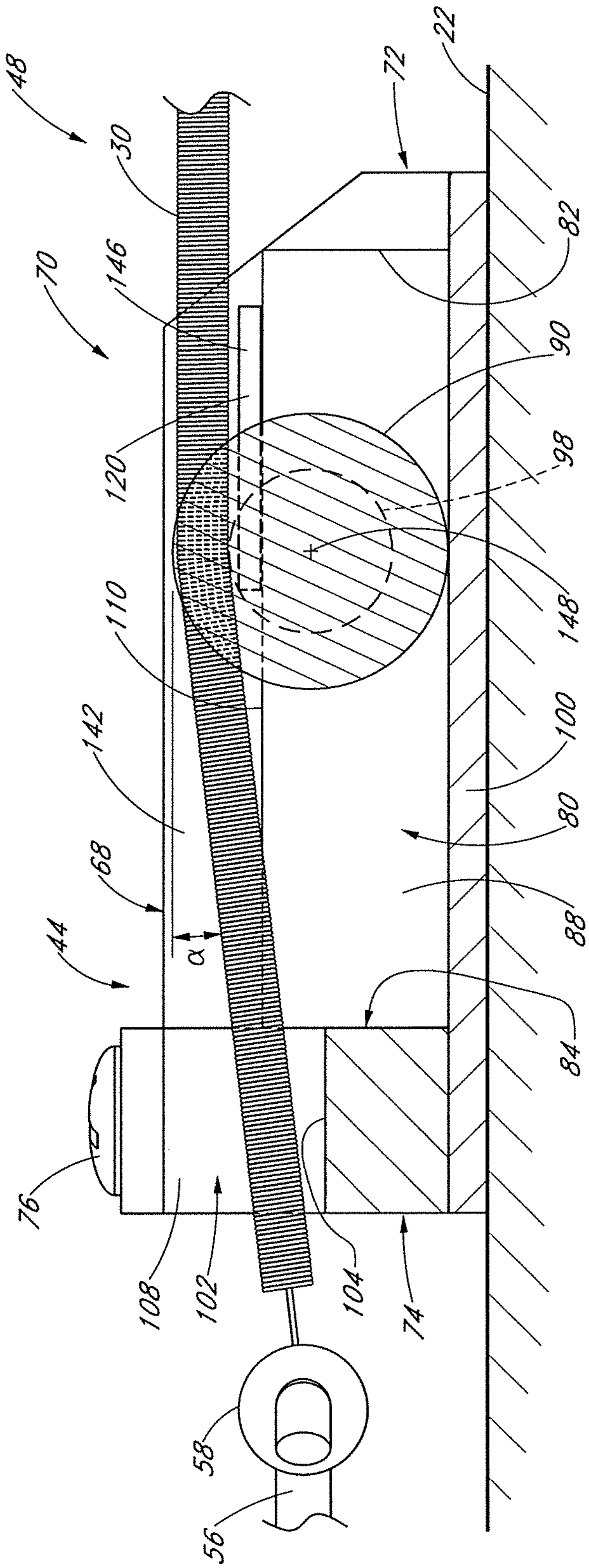
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FIG. 4

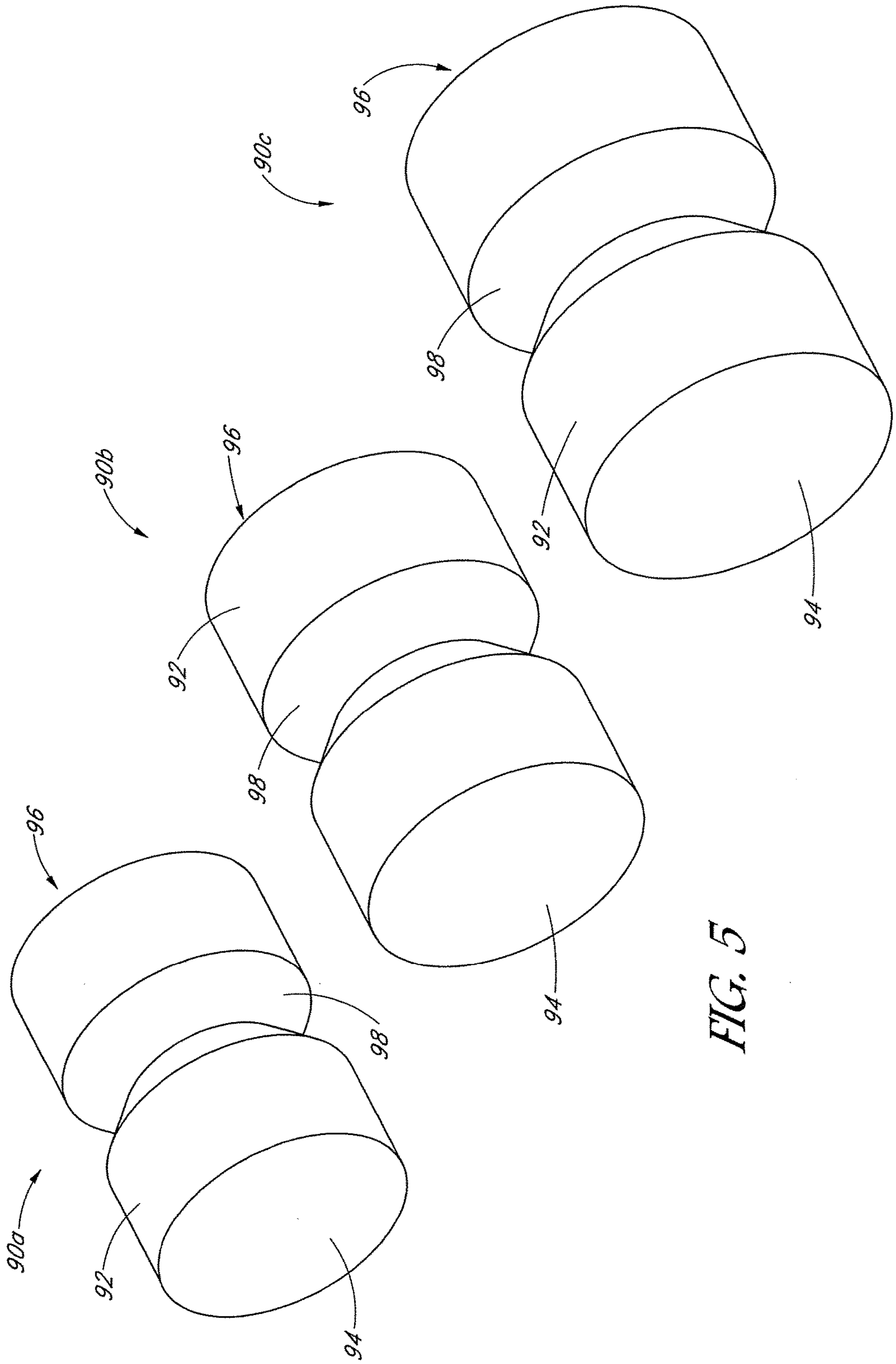

FIG. 5

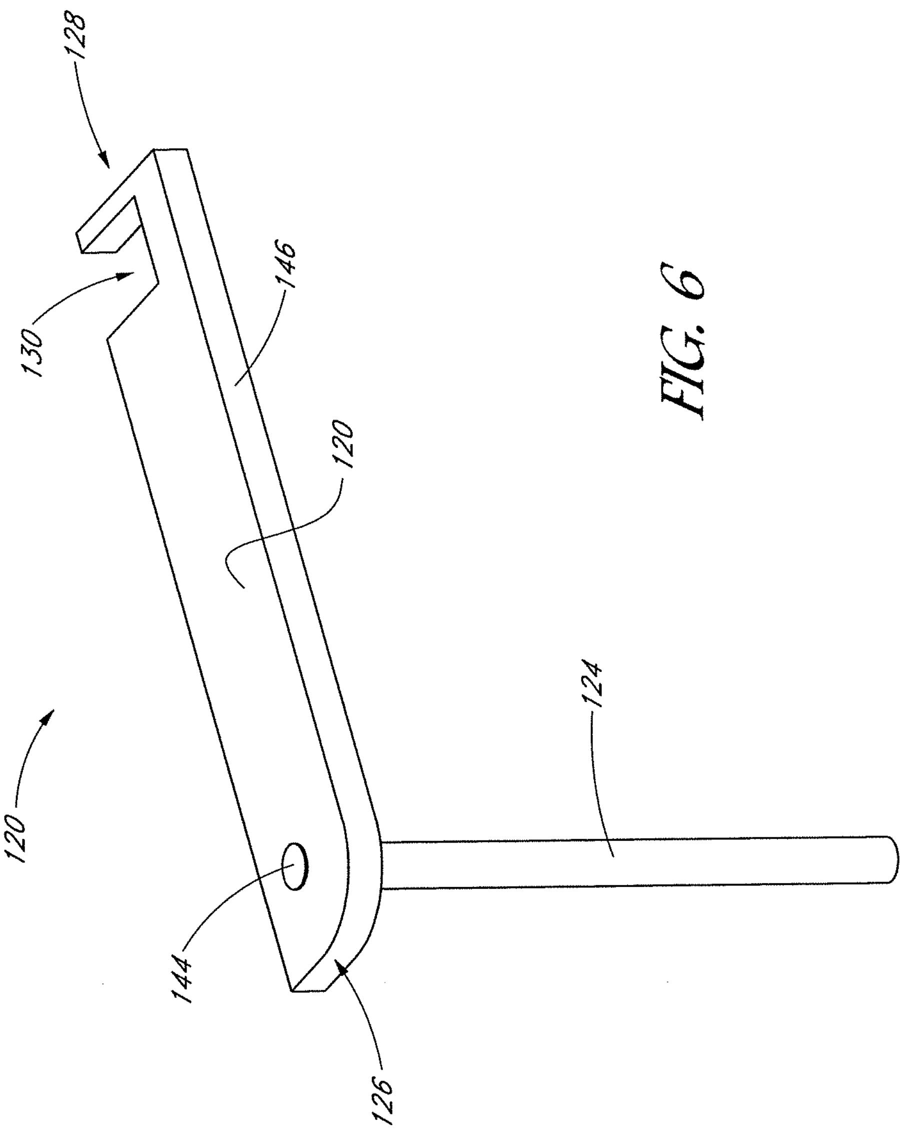

FIG. 6

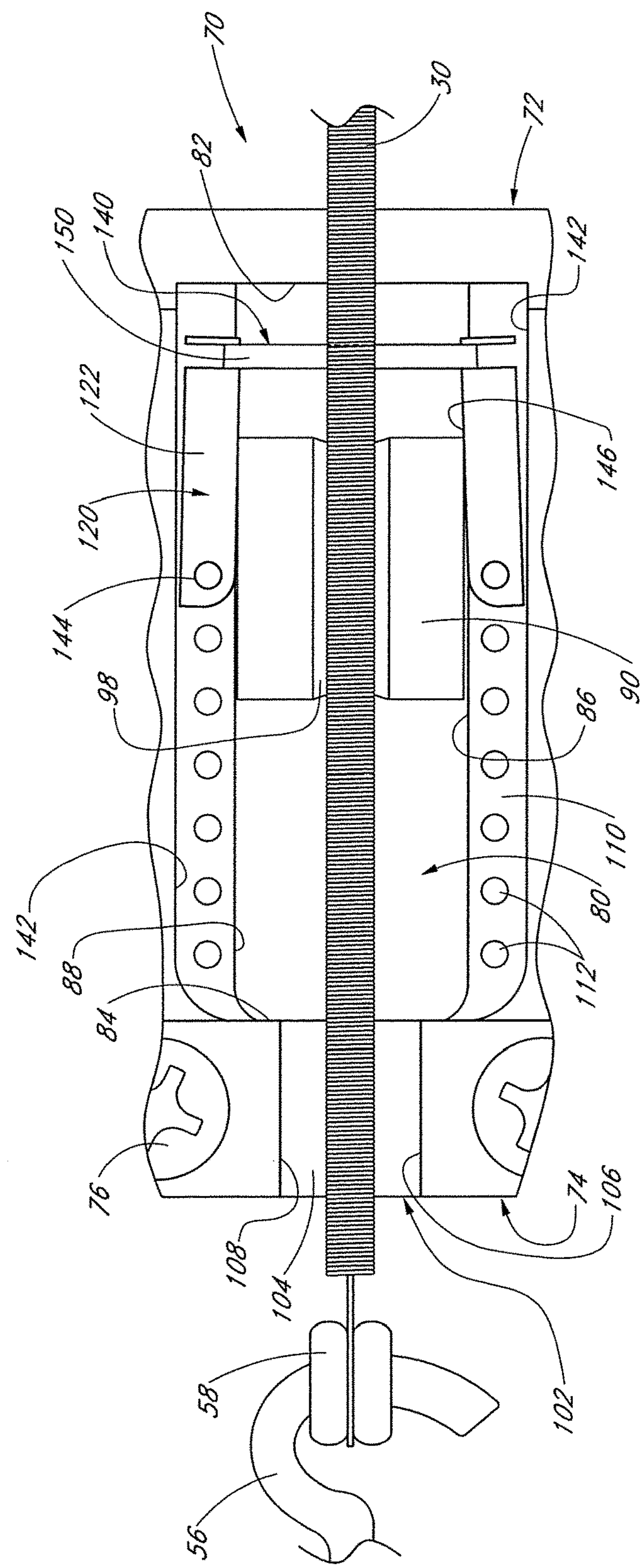
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FIG. 7

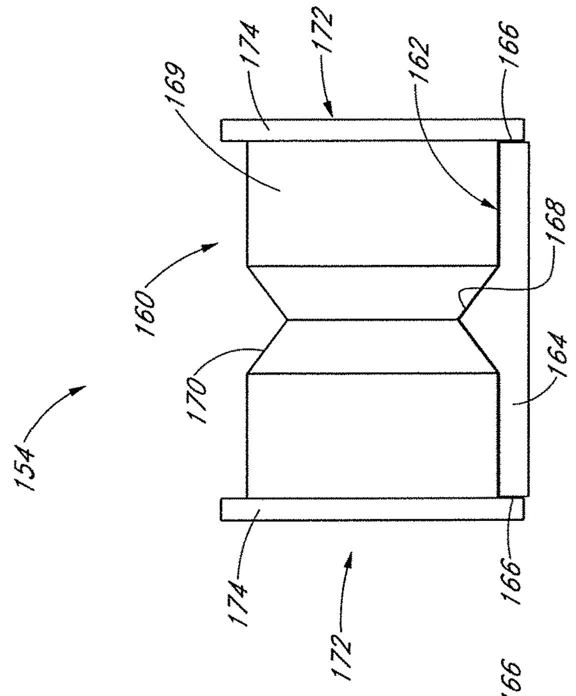
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FIG. 8B

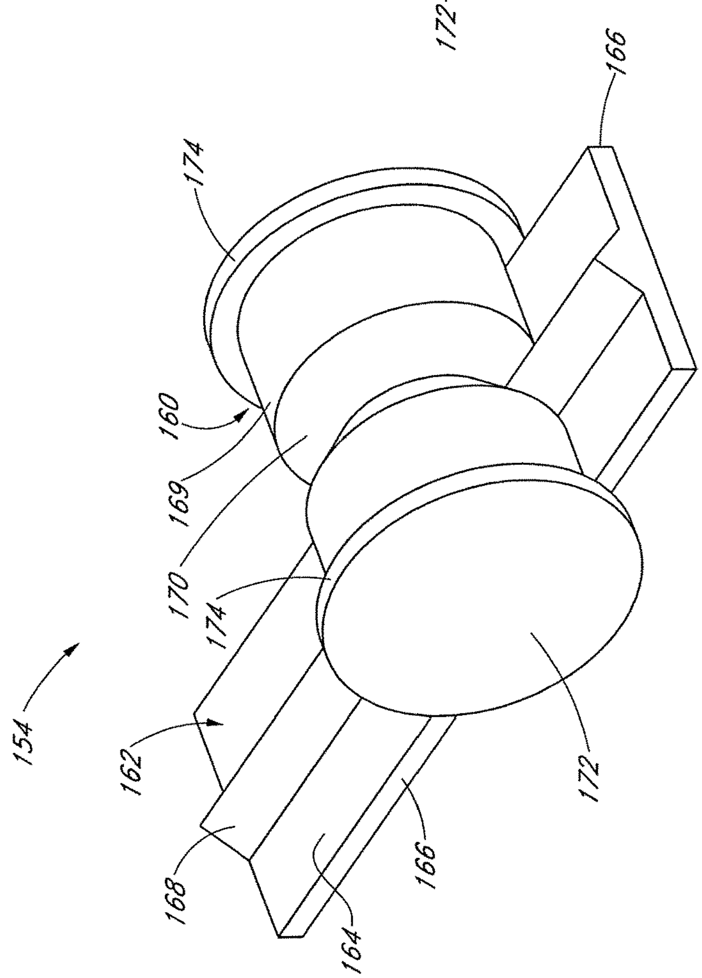
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FIG. 8A

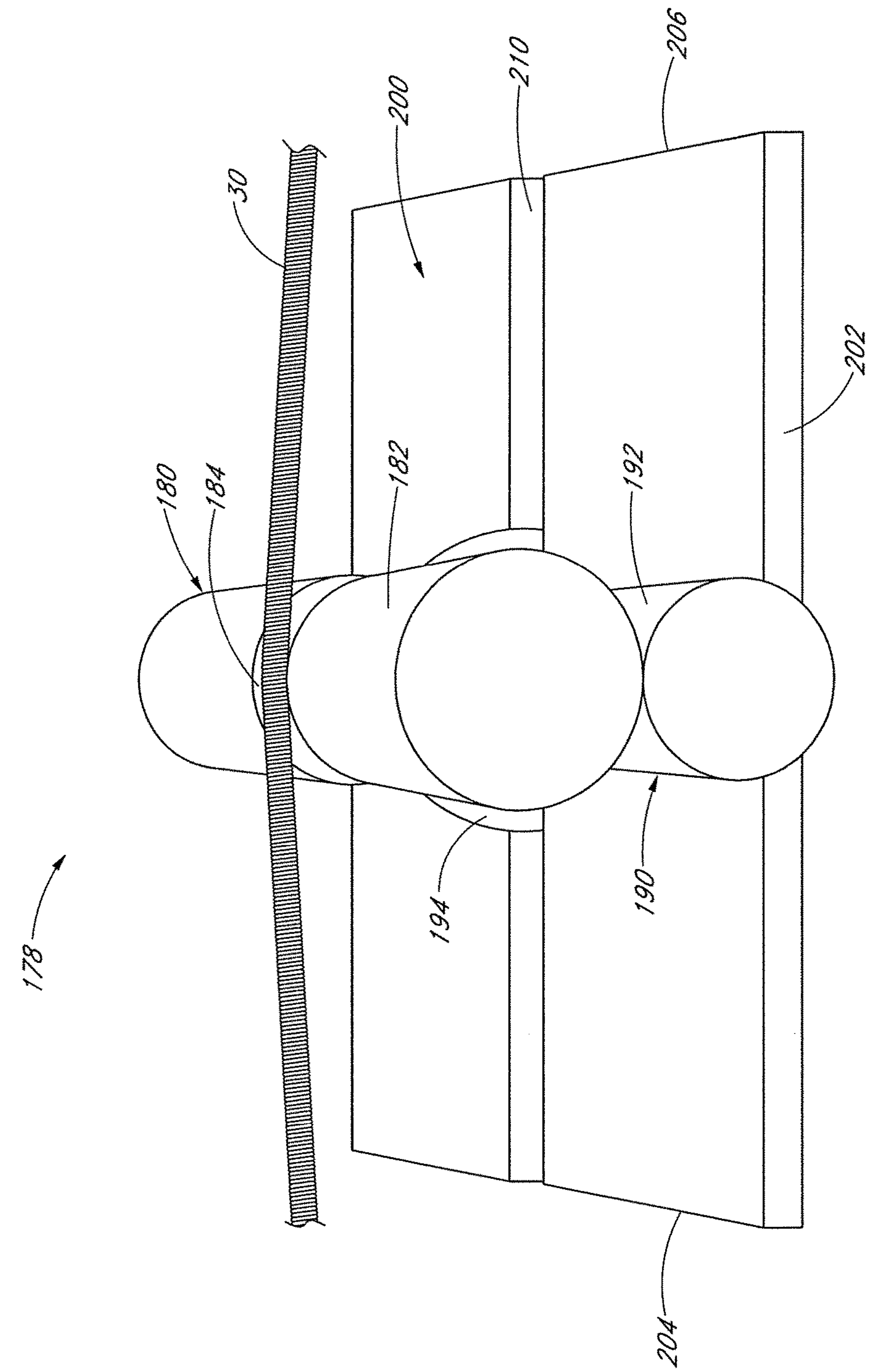

FIG. 9

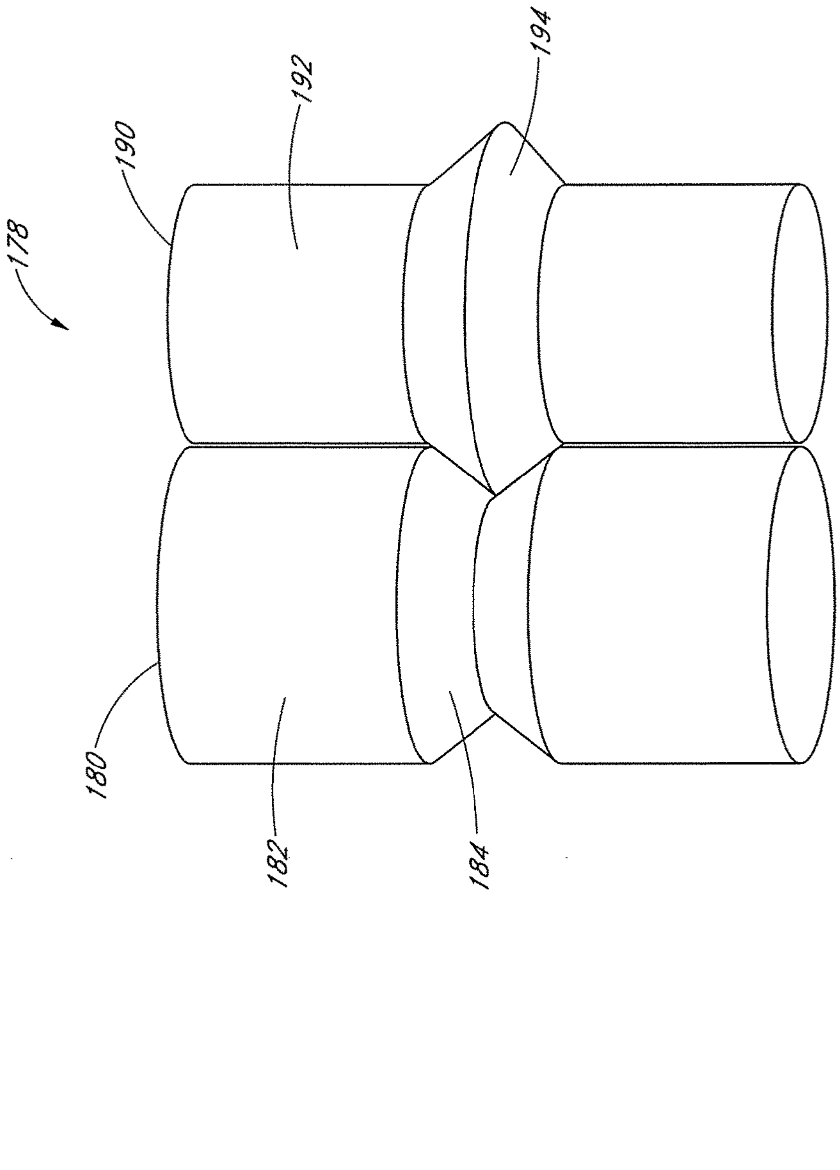

FIG. 10

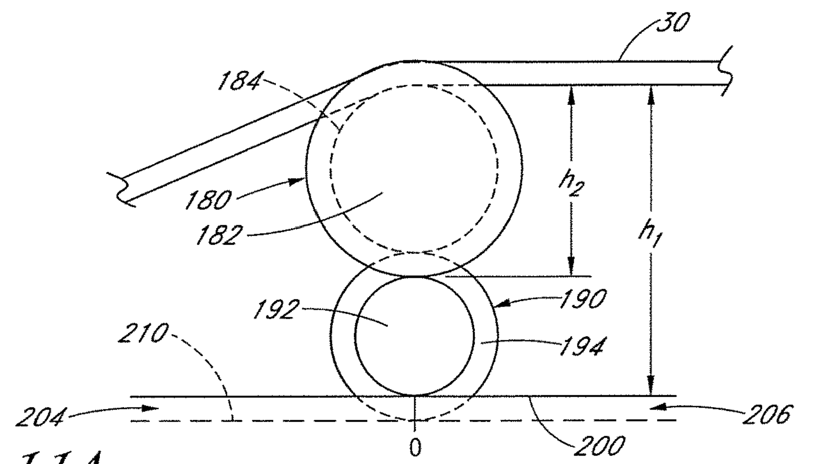

FIG. 11A

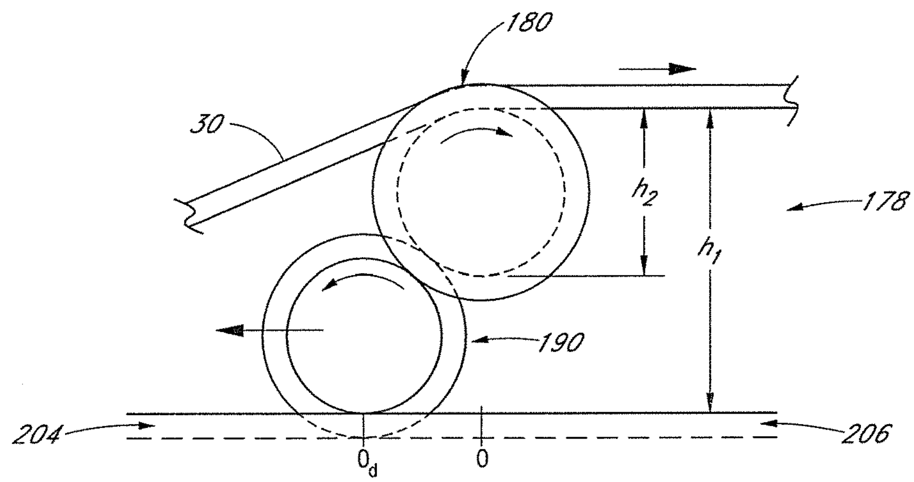

FIG. 11B

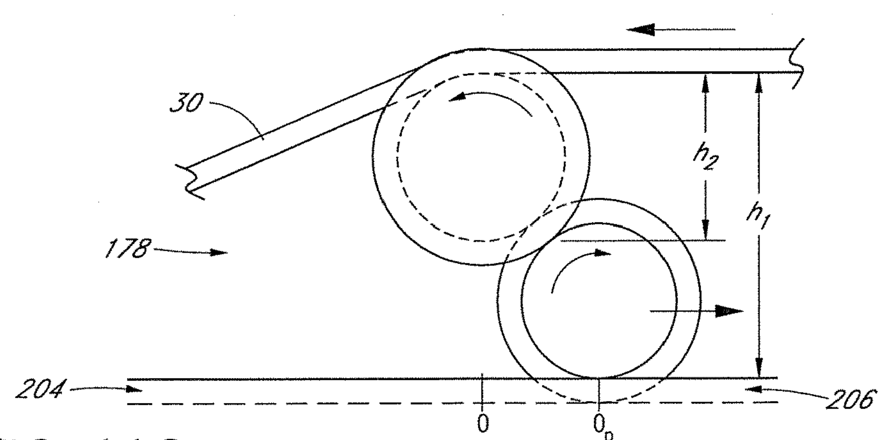

FIG. 11C

LOW-FRICTION BRIDGE FOR STRINGED INSTRUMENT

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. application Ser. No. 14/882,407 , filed Oct. 13, 2015, which claims priority to U.S. Provisional Application Ser. No. 62/063,329 , which was filed Oct. 13, 2014 , the entirety of both of which are hereby incorporated by reference.

This application relates to some of the subject matter concerning methods and apparatus for holding wires or strings as disclosed in Applicant's U.S. Pat. No. 7,855,440, which issued Dec. 21, 2010, and Applicant's copending U.S. application Ser. No. 14/476,619, which was filed Sep. 3, 2014, the entirety of both of which are hereby incorporated by reference.

BACKGROUND

The present disclosure relates to the field of stringed musical instruments, and more particularly to bridges for stringed musical instruments.

It is common for a stringed musical instrument such as a guitar to have a bridge separating a playing zone of the musical strings from a connection zone of the strings. The ends of the strings are held securely in the connection zone, while the playing zone is the portion of the instrument in which vibration of the strings makes music. In conventional guitars, a base or ball of a musical string is immovably secured at a flange or other connector, and the string is pulled over a bridge member, which separates the string into the playing zone and a connection zone. Over time, the musical string will stretch or contract, leading to the string possibly sliding over the bridge member. Friction forces may resist such sliding, resulting in string wear and/or inconsistent tuning.

Some guitars may secure the ball of the musical string to a string holder employing a constant tension device. Such constant tension devices may act to maintain a constant or near-constant tension in a musical string as it stretches or contracts. In such cases, the string moves as it stretches or contracts, and friction forces of the string sliding over the bridge can lessen the effectiveness of such constant tension devices, as well as causing excessive wear to the string.

Various approaches have been attempted to reduce friction in bridges. For example, some bridges may include low-friction coatings such as graphite. Another bridge design uses a rolling member as a string saddle, which rolling member rotates about an axle. Such designs can still suffer from excessive friction, and rolling saddles tend to suffer from decreased resonance and/or buzzing due to lateral movement of the rolling saddle when the string is plucked.

Additionally, in state-of-the-art electric guitars, bridge members are adjustable in a longitudinal direction in order to adjust the length of the string (known as intonation) and up and down to accommodate a user's preferred string height. Such adjustments are usually accomplished by screw-based systems. However, such systems also tend to decrease resonance.

SUMMARY

There is a need in the art for low-friction bridge having improved resonance and reduced, minimal or nonexistent

buzzing. There is a further need for such a bridge that enables intonation adjustment, and which can be configured to hold the strings at various heights above the associated instrument body.

In accordance with one embodiment, the present specification provides a low-friction musical string support, comprising a roller, a first contact member and a biasing member. The roller is configured to roll within a race defined by opposing first and second race side walls, and has opposing first and second side faces that face the opposing first and second race side walls, respectively. The roller further has a circumferential groove configured to accommodate a musical string seated therein. The first contact member is interposed between the first race side wall and the first side face of the roller. The biasing member is configured to urge the first contact member into contact with the first side face of the roller. When the string moves longitudinally, the roller rolls within the race.

In one such embodiment, the roller is formed of a resonant metal, and the contact member is formed of a polymer. Another embodiment additionally comprises a second contact member interposed between the second race side wall and the second side face of the roller.

Yet another embodiment additionally comprises a second biasing member configured to urge the second contact member into contact with the second side face of the roller. In some such embodiments, the biasing member also urges the second contact member into contact with the second side face of the roller.

In a still further embodiment, the biasing member spans across both the first and second contact member. In yet another embodiment, the biasing member comprises an elastomeric band.

In another embodiment, the first contact member is positioned to engage the first side face of the roller at a point above a center of the roller.

In accordance with another embodiment, the present specification provides a kit for a bridge of a stringed musical instrument. The kit includes first, second and third sets of roller saddles, each roller saddle comprising a cylindrical body having a circumferential saddle formed therein. The saddle is adapted to accommodate a musical string seated therein. Each of the first, second and third sets of roller saddles have a plurality of identical roller saddles. The cylindrical body of the roller saddles in the first set has a first radius, the cylindrical body of the roller saddles in the second set has a second radius greater than the first radius, and the cylindrical body of the roller saddles in the third set has a third radius greater than the second radius. A race defines a rolling path of each of the roller saddles.

Another embodiment additionally comprises first and second base plates, the second base plate having a greater thickness than the first base plate, the first and second base plates configured to be selectively secured to a body of a musical instrument. In a further embodiment, the first and second base plate each define the race thereon.

In accordance with still another embodiment, the present invention provides a low-friction musical string support. The support comprises a support bearing configured to roll over a race, and a roller saddle configured to roll upon the support bearing. The roller saddle comprises a string receiver configured to receive a musical string, which musical string is held at a tension. When the string elongates, the roller saddle rotates in a first rotational direction and the support bearing rotates in a second rotational direction.

In some such embodiments, the string receiver comprises a circumferential groove, and the support bearing comprises a circumferential ridge configured to fit complementarily within the circumferential groove of the roller saddle.

In accordance with still another embodiment, the present specification discloses a string system for a stringed musical instrument comprising a bridge module and a string holder module. The string holder module comprises a string tensioner configured to maintain tension in a corresponding string within a range about a perfect tune tension. The bridge module comprises a roller saddle having a circumferential groove and a string seated in the groove. The roller saddle can roll over a base plate.

In some such embodiments, when the string moves longitudinally the roller saddle rolls so that the string does not slide over the roller saddle surface.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a plan view of a four-string bass electric guitar schematically incorporating a bridge module and string holder module in accordance with one embodiment;

FIG. **2** is a close-up view of a bridge module and string holder module in accordance with an embodiment;

FIG. **3** is a top, plan view of a portion of the bridge module of FIG. **2**;

FIG. **4** is a side view taken along lines **4-4** of FIG. **3**;

FIG. **5** shows perspective views of roller saddles having features in accordance with some embodiments;

FIG. **6** is a perspective view of a contact member for use in the bridge module embodiment of FIGS. **2-4**;

FIG. **7** is a top, plan view of a portion of another embodiment of a bridge assembly;

FIG. **8**A is a perspective view of another embodiment of a bridge assembly;

FIG. **8**B is a front plan view of the embodiment of FIG. **8**A;

FIG. **9** is a perspective view of another embodiment of a bridge assembly;

FIG. **10** is a top, plan view of a roller saddle and support bearing of the embodiment of FIG. **9**;

FIG. **11**A is a schematic side view of the embodiment of FIG. **9**;

FIG. **11**B is a schematic side view of the embodiment of FIG. **9** in a first position; and

FIG. **11**C is a schematic side view of the embodiment of FIG. **9** in a second position.

DESCRIPTION

The following description presents embodiments illustrating aspects of the present invention. It is to be understood that various types of musical instruments can be constructed and/or retrofitted using aspects and principles as described herein, and embodiments are not to be limited to the illustrated and/or specifically-discussed examples. Rather, additional embodiments may selectively employ various aspects and/or principles disclosed in the specification. Also, for ease of reference, embodiments are disclosed and depicted herein in the context of a four-string bass electric guitar. However, principles as discussed herein can be applied to other acoustic and electric instruments such as, for example, violins, harps, and pianos.

With initial reference to FIG. **1**, a guitar **20** is illustrated. The illustrated guitar **20** comprises a body **22** from which an elongated neck **24** extends, which neck extends to a head **26**. As is typical with guitars, frets **28** can be provided along the neck **24**. Musical strings **30** traverse the body **22**, neck **24** and head **26** of the guitar **20**, and preferably are held in tension. More specifically, proximal ends of the strings **30** are held securely by a string holder module **32** and then pass over a bridge module **34**. Pickups **36** on the body **22** are configured to sense string vibrations above the guitar body **22**. The strings **30** traverse the neck **24**, extend over a head nut **38**, and are each wound about an axle **40**, which axle **40** preferably is controlled by turning a corresponding tuning peg **42**. As with conventional guitars, by turning the tuning pegs **42**, and thus also turning the axles **40**, each string **30** can be tightened to an appropriate tension corresponding to a desired string tune

A body string connection zone **44** is defined proximal of the bridge module **34** and a head string connection zone **46** is defined distal of the nut **38**. A playing zone **48** is defined between the bridge module **34** and nut **38**. String vibrations in the playing zone **48** are isolated from string vibrations in the body connection zone **44** and head connection zone **46** by the bridge module **34** and head nut **38**, respectively.

With reference next to FIG. **2**, an embodiment of a bridge module **34** and string holder module **36** is shown. The illustrated string holder module **36** includes a plurality of string tensioners **50**, one string tensioner **50** corresponding to each musical string **30**. The illustrated string tensioner **50** preferably comprises a constant tension device such as is originally disclosed in Applicant's co-pending U.S. application Ser. No. 14/476,619, which is incorporated herein by reference in its entirety. In this embodiment, multiple string tensioners are enclosed within and supported by a string holder module frame **52**. As shown in FIG. **2**, a plate **54** preferably covers the string tensioners. However, FIG. **2** has a portion of the plate **54** cut away to illustrate an exemplary string tensioner **50**.

In the illustrated embodiment, each string tensioner **50** comprises a connector **56** at its distal end to which a string ball **58** is attached. The string ball **58** is at the proximal end of each musical string **30**, and functions to connect the string **30** to the tensioner **50**. The string tensioner includes a primary spring **60** that is connected at its distal end to the connector **56** and at its proximal end to the frame **52**. Preferably, the primary spring **60** is held in tension and longitudinally aligned with the string **30**. As such, the primary spring **60** applies a longitudinal tension force to the attached musical string **30**. In the illustrated embodiment, a plurality of secondary springs **62** which, in the illustrated embodiment, comprise thin metal sheets, are attached to the connector **56** and to a secondary frame **64**. The secondary frame includes a plurality of stationary spring mounts **66** configured to hold the secondary springs **62**.

As discussed above, the primary spring **60** is held in tension and correspondingly applies tension to the attached string **30**. However, as the string **30** stretches and contracts over time, the primary spring **60** will correspondingly stretch or contract, thus changing the tension applied by the primary spring **60** to the string **30**. The secondary springs **62** are configured to apply a force to the connector. However, only a portion of this force is directed as a force vector in a longitudinal direction. Preferably, the longitudinally-directed vector force changes as the primary spring **60** elongates and contracts. Also, the secondary springs **62** are chosen so that the variation in the longitudinal force vector generated by the secondary springs generally corresponds to the change in longitudinal force applied by the primary spring **60** so that the secondary and primary springs, taken together, apply a constant or near-constant longitudinally-directed tension force to the corresponding string **30** over a range of operation.

In such embodiments, as the string **30** stretches and contracts, the string tensioner **50** will maintain a constant or near-constant tension in the string, however, the string **30** will move. For example the position of the string ball **58** may move proximally or distally, and correspondingly the string **30** will move over the bridge **34**. Excessive friction in the bridge could dilute the effectiveness of the string tensioner **50** in keeping tension in the string **30** at a constant or near-constant level.

In the illustrated embodiment, the string tensioner **50** has structure as illustrated. However, it is to be understood that other string tensioner configurations can be employed, including other embodiments of tensioners that apply a constant or near-constant force over an operational range. For example, Applicant's issued U.S. Pat. No. 7,855,330 discloses embodiments of constant tension devices that can maintain musical strings at a constant or near-constant tension in order to maintain string tune. Embodiments as disclosed in the '330 patent, closure of which is incorporated by reference in its entirety, can also be employed as a string tensioners. Still further, some string holder module embodiments may not adjust with the strings, but may more traditionally hold the string balls at a constant, fixed position. Such traditional embodiments may still benefit from the principles and aspects discussed herein.

With continued reference to FIG. **2**, a bridge module **34** comprises a plurality of races **70***a-d*, each race corresponding to a corresponding string **30***a-d*. As shown, the bridge module **34** comprises a distal end **72** and a proximal end **74**. A plurality of screws **76** attach the bridge module **34** to the guitar body **22**. In the illustrated embodiment, the bridge module **34** and string holder module **32** share a common frame **78**. In other embodiments, however, the bridge module **36** and string holder module **32** can be formed and attached to the guitar body independently of one another.

With reference next to FIGS. **2-4**, each race **70** comprises an elongated channel **80** defined by a distal channel wall **82**, proximal channel wall **84** and first and second channel side walls **86**, **88**. A roller saddle **90** is fit within the elongated channel **80** and is configured to roll therewithin.

With additional reference to FIG. **5**, each roller saddle **90** comprises a cylindrical body **92** and first and second side faces **94**, **96**. A circumferential groove or saddle **98** is formed in the cylindrical body **92**. In the illustrated embodiment, the groove is generally V-shaped. Other shapes, such as U-shaped or the like, can also be employed. Preferably, the saddle **98** is configured to receive a string **30** seated therein.

With particular reference again to FIGS. **3** and **4**, the bridge module **34** preferably includes a base plate **100**. The roller saddle **90** thus is configured to roll atop the base plate **100** and within the elongated channel **80**. A slot **102** is formed at a proximal end of the channel and is defined by a bottom surface **104** and opposing first and second side walls **106**, **108**. A string **30** extends from the playing zone **48** over the distal wall **82** and is supported in the saddle **98** of the roller saddle **90**. From the saddle **98**, the string **30** extends proximally through the slot **102** and proximal of the bridge module **34** until the string ball **58** is attached to the tensioner connector **56**. As such, in the illustrated embodiment the roller saddle **90** separates the body connection zone **44** from the playing zone **48**.

Preferably, a width of the elongated channel **80** between the first and second channel side walls **86**, **88** approximates a width of the roller saddle **90**, but enables the roller saddle **92** role within the channel **80** unobstructed by the channel side walls **86**, **88**. Preferably, the roller saddle **90** rolls on the base plate **100**. However, in other embodiments, the roller saddle may ride over and be supported upon the surface of the guitar body **22**.

As discussed above, the string **30** is seated in the groove/saddle **98**. Since the roller saddle **90** readily rolls on the base plate **100**, when the string **30** expands and contracts, the roller saddle **90** will roll to accommodate such movement and the string **30** will not slide relative to the surface of the saddle **98**. As such sliding friction of the string **30** over the saddle **98** is minimized or totally avoided in favor of rolling friction of the roller saddle **90** over the base plate **100**, which is much less than sliding friction.

Most preferably, the roller saddle **90** is formed of a solid block of a choice vibrational material such as bronze, brass or titanium. Preferably, the base plate **100** is also formed of a choice vibrational material. As such, resonance from the vibrating string **30** is easily transferred through the roller saddle **90** and base plate **100** to the guitar body **22**, and back to the string **30**.

As discussed above, accomplished guitarists wish to adjust the length of each guitar string **30** in order to attain proper tuning. Such length adjustment, known as intonation, typically involves independent positioning of each bridge member to set the desired length for the corresponding guitar string. In operation, a user may first select the desired intonation location of the roller saddle **90** by placing the roller saddle within the elongated channel **80** and rolling and/or pushing it to a desired position for intonation. Once intonation is completed, and the string has been put in place and is under tension, the roller saddle can operate normally, rolling with very low friction as the string stretches or contracts. Indeed, preferably, the roller saddle experiences no sliding-based friction, and only experiences the relatively-low rolling friction.

As discussed above, in the illustrated configuration, as the string **30** stretches or contracts a given length, the roller saddle will rotate. In fact, the rotating roller saddle will translate longitudinally to a lesser extent that the string translates longitudinally. As such, the roller saddle configuration dampens the effect string translation may have on intonation positions, and the saddle **98** translates less than does the string.

A user may also wish to adjust the height of the strings **30** relative to the guitar body **22**. To this end, preferably a base plate **100** is selected having a thickness that will place the strings **30** at or near a desired height above the guitar body **22**. With additional reference to FIG. **5**, a user can then select a desired roller saddle size. More specifically, a kit may be provided, which kit may include the bridge module **34** and multiple sets of roller saddles, each set of roller saddles having a different radius. For example, with particular reference to FIG. **5**, a first set of roller saddles **90***a* has a first radius R**1**, a second set of roller saddles **90***b* has a second radius R**2** that is nominally greater than the first radius R**1**, and a third set of roller saddles **90***c* have a third radius R**3** that is nominally greater than the second radius R**2**. The user can select the set of roller saddles having a radius corresponding to the desired height. The user can also select different sizes of rollers for particular strings so that each string can be at a desired height. In some embodiments, the kit may also or instead include multiple base plates, each having a different thickness. Thus by selecting a particular base plate and/or a particular set of roller saddles, a user may configure his bridge module **34** to have a desired height.

It is to be understood that, in other embodiments, height adjustment can be accomplished by other structures. For example, the bridge module may include screws that adjust the height of the entire module relative to the guitar body.

With particular reference again to FIGS. **2-4**, as discussed above, the roller saddle **90** fits complementarily within the elongated channel **80** so that it can roll therein. During use, vibration in a plucked string **30** is communicated to the corresponding roller saddle **90**. Such vibration includes a side-to-side component that carries the risk of generating a buzzing sound with the channel.

As shown, each race **70** additionally includes a pair of support surfaces **110** atop each channel side wall **86**, **88**. Spaced apart adjustment holes **112** preferably are formed through each support surface **110**.

With additional reference to FIG. **6**, a contact member **120** comprises an elongated bar **122** having a proximal end **126** and a distal end **128**. The elongated bar **122** is connected to an elongated pin **124** near a proximal end **126** of the bar **122**. A receiver **130** is formed as a cavity at or adjacent a distal end **128** of the bar.

With continued reference again to FIGS. **3** and **4**, the pin **124** of the contact member **120** fits into any of the adjustment holes **112**. Preferably, and as shown in FIG. **3**, the contact member **120** is placed so that the proximal end **126** of the contact member is at or adjacent a side surface **94**, **96** of the roller saddle **90**, and the distal end **128** of the elongated bar **122** is positioned distal of the roller saddle **90**.

In the illustrated embodiment, a biasing member **140**, such as a small coil spring, extends into each receiver **130** and engages a race side wall **142** so as to urge the elongated bar **122** to rotate about a pivot point **144**, and thus bias a contact surface **146** of the contact member **120** against the corresponding side face of the roller saddle **90**.

In the embodiment illustrated in FIG. **3**, each race **70** includes opposing first and second contact members **120** that are mirror images of one another and which engage opposing first and second side faces **94**, **96** of the roller saddle **90**.

With additional reference to FIG. **4**, preferably each elongated bar **122** of each contact member **120** is positioned above a rolling axis **148** of the roller saddle **90** and is at or near the level of the corresponding string **30**. In some embodiments, the contact member **120** is slightly below the corresponding string **30**; in other embodiments the contact member **120** is slightly above the corresponding string **30**; and in further embodiments the contact member **120** is at least partially aligned with or at the same height as the corresponding string **30**. Preferably, the corresponding roller saddle **90** is squeezed between the opposing contact members **120** with a biasing force in the range of up to about 4 pounds, more preferably between 0.5 and 3 pounds, and most preferably about 1 pound. As such, side-to-side vibrations that would tend to cause buzzing are dampened or prevented from causing buzzing as a string is plucked.

The user can change the position of the contact members **120** by pulling upward on the elongated bar **122** so that the pin **124** is removed from its associated hole **112**. The user can then insert the pin **124** into another one of the holes **112** as desired. Preferably, the contact members **120** on opposite sides of the channel **80** are inserted into symmetrically aligned holes **112** so as to exert a symmetrical biasing force on the associated roller saddle **90**. In additional embodiments, a detent structure can be provided on the pin **124** or holes **112** so that the pins **124** do not slide out of holes **112** unintentionally.

In some embodiments, a cover can be attached atop the support surface **110** to prevent the contact members **120** from falling out of the holes. With reference again to FIG. **2**, such a cover **121** is shown placed atop the frame **68** and secured with screws **123** after contact members **120** have been positioned as desired. The cover **121** prevents the contact members **120** from sliding out of the holes **112**.

In the illustrated embodiment, the elongated bars **122** rest upon support surface **110**. In additional embodiments, one or more of the contact members can include a pin that is longer than the corresponding holes **112** so that when the pin is inserted into the hole the elongated bar **122** will be spaced from the support surface **110**.

In the illustrated embodiment, the contact members **120** are positioned relative to the associated roller saddle **90** so that the pivot point **144** is near a center of the roller saddle and most preferably proximal of a center of the roller saddle **90**, while the distal end **128** of the elongated bar **122** is positioned distal of the roller saddle **90**. As such, the elongated bar **122** pivots inwardly a small amount to take up play that may exist between the side faces **94**, **96** of the roller saddle **90** and the channel side walls **86**, **88** in order to minimize or prevent buzzing.

In the illustrated embodiment, each of the elongated bar **122** on opposite sides of the channel pivot inwardly. In additional embodiments, the elongated bar **122** on only one of the sides may pivot, while the opposing elongated bar remains stationary. In still further embodiments, only a single contact member is employed, biasing the roller saddle from only one side of the channel. Preferably, the opposing channel wall can be lined with a low-friction material, such as Teflon-infused Delrin. The contact member thus biases the roller saddle into contact with the low-friction material lining the channel wall, thus minimizing or eliminating buzzing during operation.

With particular reference to FIG. **4**, the string ball **58** attaches to the connector **56** at a point lower than, or closer to the guitar body than, the position at which the string **30** is supported by the saddle **98**. In this arrangement the string **30** exerts a downwardly-directed force on the roller saddle **90**, which force helps keep the string **30** and roller saddle **90** in place and also keeps the string **30** firmly engaged with the saddle **98** so that any vibrations in the string **30** in the body connection zone **44** are kept separate from string vibrations in the playing **48**.

A break angle α is defined as the angle between the string **30** proximal of the saddle **98** and the string **30** distal of the saddle **98**. Notwithstanding the benefits of the force exerted by the string **30** onto the roller saddle **90** by virtue of the break angle α, because of the break angle α, a longitudinally-directed vector force exerted by the string **30** tends to urge the roller saddle **90** longitudinally in a distal direction. Of course, a friction force between the roller saddle **90** and the base plate **100** provides some resistance against the longitudinally-directed break angle vector force. However, there is a risk that, when the string **30** and roller saddle **90** are vibrating, the longitudinally-directed break angle vector force may cause the roller saddle **90** to slide distally over the base plate **100**, possibly moving the roller saddle **90** out of the selected intonation position. However, the biasing force exerted by the opposing contact members **120** also exerts a longitudinally-directed vector force component directed proximally in opposition to the break angle vector force, and thus resists the break angle vector force.

Additionally, if the string **30** is de-tensioned, such as by a string breaking, the biasing force exerted by the opposing contact members **120** will tend to hold the roller saddle **90** in its position. Thus, the user will not have to start from scratch in finding and setting the proper intonation upon restringing the guitar **20**. Also, the roller saddle **90** will tend not to fall out of the channel **80** upon de-tensioning of the corresponding string **30** because it is held in place by the contact members **120**.

With reference next to FIG. **7**, another embodiment is illustrated in which the biasing member **144** of the contact members **120** comprises an elastic band **150** that extends between the receivers **130** of the opposing contact members **120**. Preferably, the elastic band **150** is selected to have a relaxed state somewhat smaller than the distance between opposing contact members **120** so that it is stretched in order to be received in opposing receivers **130** so as to exert a proper biasing force when connected. In additional embodiments, a plurality of sets of elastic bands **150**, each set being configured to apply a different biasing force when attached to opposing receivers **130**, can be included in a kit to enable the user to select a preferred biasing force for the contact members **120**.

With reference again to FIG. **2**, in some embodiments a second elastic band **151** can be stretched across the channel **80** proximal of the roller saddle **90**. In such embodiments, secondary pins **153** can be placed in holes **112** on opposing sides of the channel, and the second elastic band **151** can be stretched across the secondary pins **153** to prevent the roller saddle **90** from rolling or sliding excessively proximally during use. In other embodiments, the second elastic band **151** can be placed so as to be in actual contact with the roller saddle.

In a preferred embodiment, the contact members **120** are constructed of a low friction material so that even though the contact members are exerting a biasing force on the side faces **94**, **96** of the roller saddle **90**, the roller saddle can still roll with minimal friction being exerted by the contact members **120**. In one preferred embodiment, the elongated bars **122** are formed of a Teflon-infused Delrin material having a very low coefficient of friction, such as within a range of less than about 0.2, and more preferably between about 0.07-0.14 so that, when combined with the biasing force, there will be less than 10 cents of change in aural tone when the string is loaded at about 30 pounds of tension. In another embodiment, the elongated bars **122** are formed of a choice vibrational material such as is used for the roller saddle.

In the embodiments illustrated herein and discussed above, the contact members **120** are configured to pivot while exerting a biasing force on the side faces of the roller saddle. Additional embodiments may employ different structure to exert a biasing force on one or more side faces of the roller saddle. For example, in another embodiment the contact member can comprise an elongate bar that traverses all or much of the length of the channel, and is biased inwardly so as to be biased inwardly against a side face of the roller saddle in any position of the roller saddle along the length of the channel. Such biasing can be provided by springs such as coil springs, torsion springs, flat springs, leaf springs or the like, or by other materials such as elastomers in compression or tension.

With reference next to FIGS. **8**A and B, another embodiment of a bridge assembly **154** comprises a roller saddle **160** to roll over a race **162**. The race **162** comprises an elongated base plate **164** having opposing side edges **166** and an elongated ridge **168** extending generally centrally along the race **162**. In the illustrated embodiment, the elongated ridge **168** has a generally upside-down V shape. The roller saddle **160** comprises a cylindrical body **169** and a circumferential groove/saddle **170** that is configured to receive a string seated **30** therewithin. Preferably, the groove/saddle **170** has a shape complementary to the elongated ridge **168** so that the roller saddle **160** receives the ridge **160** therein and is precisely guided as it rolls along the race **162**.

The illustrated roller saddle **160** also comprises side faces **172** and side ridges **174** adjacent the side faces **172**. The illustrated side ridges **174** have a diameter greater than the adjacent cylindrical body **169** and preferably are placed so as to hang over the side edges **166** of the race **162**, also to help align the roller saddle **160** as the cylindrical body **169** rolls over the race **162**.

It is to be understood that, in additional embodiments, the roller saddle **160** may not include the side ridges **174**, so that the cylindrical body **169** is guided only by the saddle **170** being engaged with the elongated ridge **168** or, alternatively, the race **162** may not include the ridge **168** so that the cylindrical body **169** is guided only by the side ridges **174** being aligned with the side edges **166** when rolling over the race **162**.

With reference next to FIGS. **9-11**, yet another embodiment of a bridge assembly **178** comprises a roller saddle **180** that comprises a cylindrical body **182** having a circumferential groove/saddle **184** formed therein. In the illustrated embodiment, the groove/saddle **184** is generally V-shaped, and is configured to receive a musical string **30** seated therewithin. A support bearing **190** also comprises a cylindrical body **192**, which has a circumferential ridge **194** extending therefrom. Preferably, the circumferential ridge **194** is shaped complementarily to the groove/saddle **184** so that the ridge **194** fits within the groove/saddle **184**.

A race **200** comprises an elongated base plate **202** having a proximal end **204** and a distal end **206**. An elongated groove **210** is formed along the length of the elongated base plate **202**. The groove **210** preferably is shaped generally the same as the groove/saddle **184** and complementary to the circumferential ridge **194** of the support bearing **190** so that the support bearing **190** rolls upon the base plate **202** with the ridge **194** received in the elongated groove **210**, which guides the support bearing **190**.

As shown in FIGS. **9-11** the support bearing **190** rests and rolls upon the base plate **202** with the ridge **194** received in the elongated groove **210**, and the roller saddle **180** rests and rolls upon the support bearing **190** with the ridge **194** received in the groove/saddle **184**. A musical string **30** is also seated in the saddle **184**. The string **30** is arranged to have a break angle proximal of the roller saddle **180**, and the string **30** thus exerts a force tending to keep the roller saddle **180**, support bearing **190** and base plate **202** engaged with one another.

As the string **30** stretches or contracts, portions of the string at the roller saddle **180** will translate distally or proximally. In the illustrated embodiment, the string **30** will not need to be slid over the saddle surface during such translation. Instead, the roller saddle will rotate to accommodate such translation.

As best shown in FIGS. **11**A-C, as the string translates distally (see FIG. **11**B), the roller saddle **180** will rotate clockwise. However, the support bearing **190** will in turn rotate counter-clockwise, and will translate proximally relative to the roller saddle **180** rolling over the race **200**. As such, the groove **184** of the roller saddle **180**, at which the string is seated, substantially does not translate, but instead simply rolls over the support bearing **190**, which support bearing **190** does in fact translate (proximally, in this example). Schematically, this operation is illustrated as moving from the arrangement in FIG. **11**A to the arrangement in FIG. **11**B. The benefit of this interaction is to reduce (or eliminate) any change in the playable length of the string as the roller saddle **180** rolls with the change of string length. As such, intonation position is preserved even as the string translates longitudinally

A similar, but oppositely directed, effect will occur when the string **30** translates proximally, which is represented schematically as moving from the arrangement in FIG. **11**A to the arrangement in FIG. **11**C.

Notably, in guitars, the total range of translation of the musical string **30** during operation and even during stretching and contracting of the string **30** can be relatively low, such as less than about 0.12 inches, more preferably less than about 0.08 inches, and most preferably about 0.06 inches. Thus, it is anticipated that embodiments applied to guitars have operational lengths of longitudinal string translation within or approximating these ranges.

As depicted in FIG. **11**A-C, the roller saddle **180** rotates over the support bearing **190**, while the support bearing **190** translates as it rotates upon the race **200**. As such, a distance h**2** between the saddle **184** and the point at which the roller saddle cylindrical body **182** contacts the support bearing cylindrical body **192** decreases moving from the arrangement in FIG. **11**A to the arrangement in FIG. **11**B, as does the total height h**1** of the saddle **184** relative to the race surface (or the surface of the associated instrument). In one embodiment, if the support bearing **190** has a diameter of about 0.25 inches, the saddle **184** of the roller saddle **180** (and thus the string **30**) will change in height h**1** by a maximum of about 0.007 inch. In some embodiments and applications, this change in height may be acceptable.

In additional embodiments, the roller saddle, the support bearing, and/or the race can be shaped to define one or more cams that can cancel out or reduce the change in height h**1**. For example, although in some embodiments the roller saddle and support bearing have been described as cylindrical, and the race as flat, in other embodiments one, the other, or both of the roller saddle and support bearing may not be cylindrical, and/or the race can be inclined or curved. As noted above, the range of translation of the string can be quite small, preferably spanning only a portion of the circumferential surface of either bearing.

In one embodiment, the groove/saddle of the roller saddle can be cammed so that a vertical distance h**2** between the point at which the string contacts the saddle surface and the point at which the roller saddle contacts the support bearing is smallest at a central portion of the range of motion, and increases on both sides, thus maintaining the string height h**1** at or near a constant value. Similarly, in other embodiments the upper and or lower surface of the support bearing can be configured so that the point at which the string contacts the saddle surface remains at a substantially constant height from one end of the operational range of rotation/translation to the other. The race can also be curved, for example having a concave curvature, to counteract height change during translation of the support bearing. In still other embodiments, combinations of such camming structures can be employed.

In still further embodiments, the race can be configured so that the position of the race can be manually translated proximally or distally by the user during tuning so that the string can be centered in the range of operation when at a desired perfect tune position or tension.

The embodiments discussed above have disclosed structures with substantial specificity. This has provided a good context for disclosing and discussing inventive subject matter. However, it is to be understood that other embodiments may employ different specific structural shapes and interactions.

Although inventive subject matter has been disclosed in the context of certain preferred or illustrated embodiments and examples, it will be understood by those skilled in the art that the inventive subject matter extends beyond the specifically disclosed embodiments to other alternative embodiments and/or uses of the invention and obvious modifications and equivalents thereof. In addition, while a number of variations of the disclosed embodiments have been shown and described in detail, other modifications, which are within the scope of the inventive subject matter, will be readily apparent to those of skill in the art based upon this disclosure. It is also contemplated that various combinations or subcombinations of the specific features and aspects of the disclosed embodiments may be made and still fall within the scope of the inventive subject matter. For example, the roller saddles and races described in connection with FIGS. **2-4** can also incorporate features of the roller saddles and races described in connection with FIGS. **8**A & B or **9-11**. Accordingly, it should be understood that various features and aspects of the disclosed embodiments can be combined with or substituted for one another in order to form varying modes of the disclosed inventive subject matter. Thus, it is intended that the scope of the inventive subject matter herein disclosed should not be limited by the particular disclosed embodiments described above, but should be determined only by a fair reading of the claims that follow.

What is claimed is:

1. A low-friction musical string support, comprising:

an elongated race defining a first race surface;

a roller saddle configured to roll about a rolling axis and upon the elongated race, the roller saddle having a first arcuate rolling surface and an arcuate saddle portion, the first arcuate rolling surface being oblique to the rolling axis;

the first race surface being complementary to the first arcuate rolling surface so that the first arcuate rolling surface engages and is supported by the first race surface;

the first arcuate rolling surface and first race surface adapted so that the first arcuate rolling surface rolls upon the first race surface, and as the first arcuate rolling surface rolls upon the first race surface, the rolling axis of the roller saddle translates longitudinally relative to the elongated race;

the arcuate saddle portion having an arcuate groove configured to accommodate a musical string seated therein upon a groove inner surface;

wherein when the musical string moves longitudinally, the first arcuate rolling surface rolls upon the first race surface and the roller saddle rotates about the rolling axis.

2. A low-friction musical string support as in claim **1**, wherein the first arcuate rolling surface extends about the entire circumference of the rolling axis.

3. A low-friction musical string support as in claim **1**, wherein the guide member of the elongated race remains adjacent the guide face of the roller saddle when the roller saddle translates longitudinally relative to the elongated race.

4. A low-friction musical string support as in claim **1**, wherein the roller saddle additionally comprises a second arcuate rolling surface, and the elongated race comprises a second race surface that is complementary to the second arcuate rolling surface so that the second arcuate rolling surfaces engages and is supported by the second race surface.

5. A low-friction musical string support as in claim **4**, wherein the second arcuate rolling surface is oblique relative to the rolling axis.

6. A low-friction musical string support as in claim **5**, wherein the first and second arcuate rolling surfaces are disposed at equal but opposite oblique angles relative to the rolling axis.

7. A low-friction musical string support as in claim **6**, wherein the first and second arcuate rolling surfaces are adapted to be simultaneously supported and roll upon the first and second race surfaces, respectively.

8. A low-friction musical string support as in claim **7**, wherein the first and second race surfaces are flat.

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