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**German**

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(54) **ADJUSTABLE NECK JOINT FOR STRINGED INSTRUMENTS**

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***G10D 3/095*** (2020.01)

(52) **U.S. Cl.**
CPC .................................... ***G10D 3/095*** (2020.02)

(58) **Field of Classification Search**
CPC ...................................................... G10D 3/095
See application file for complete search history.

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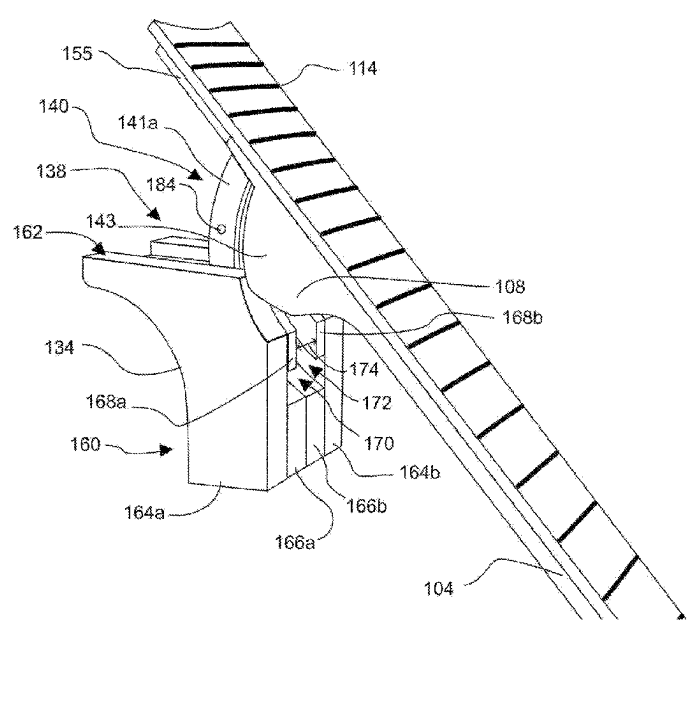
(57) **ABSTRACT**

An adjustable neck joint for a stringed instrument includes a neck with a heel portion formed as a first half of a rotating joint and a body with a neck block formed as a second half of the rotating joint. The first half of the rotating joint and the second half of the rotating joint may each be configured to connect with the other and movably interface with each other such that the neck is rotatable with respect to the body about an axis located immediately adjacent to and above a position along the neck.

**18 Claims, 10 Drawing Sheets**



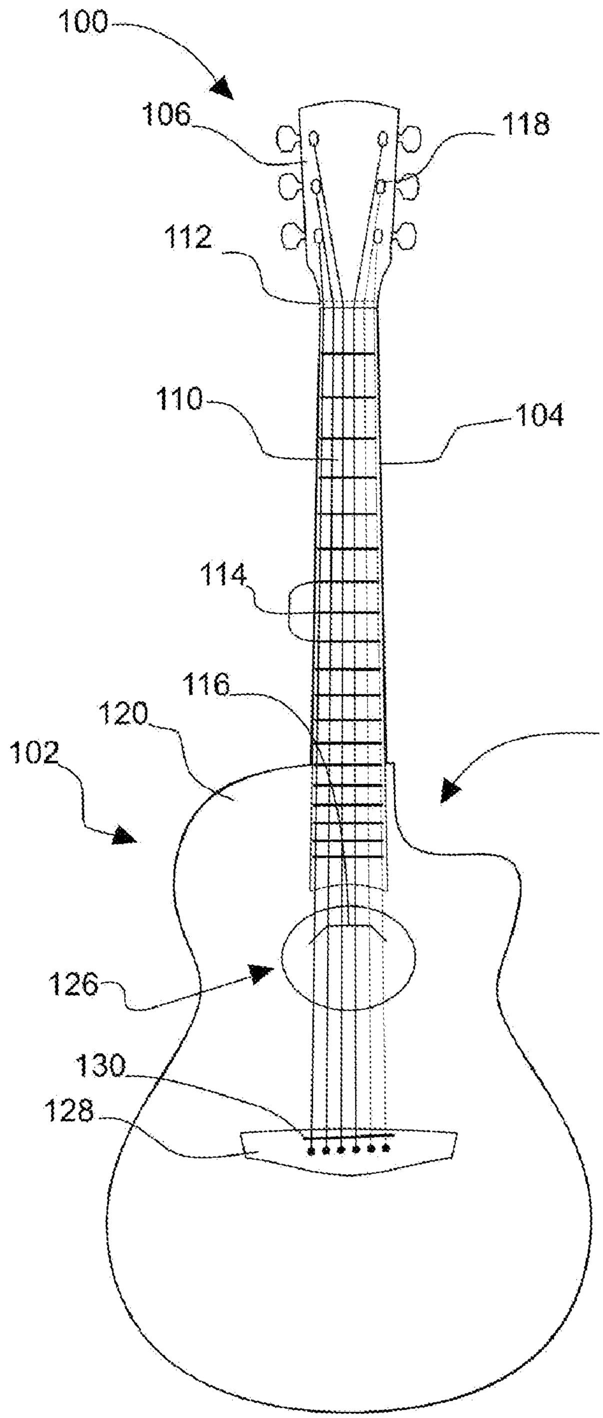

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Fig. 1A

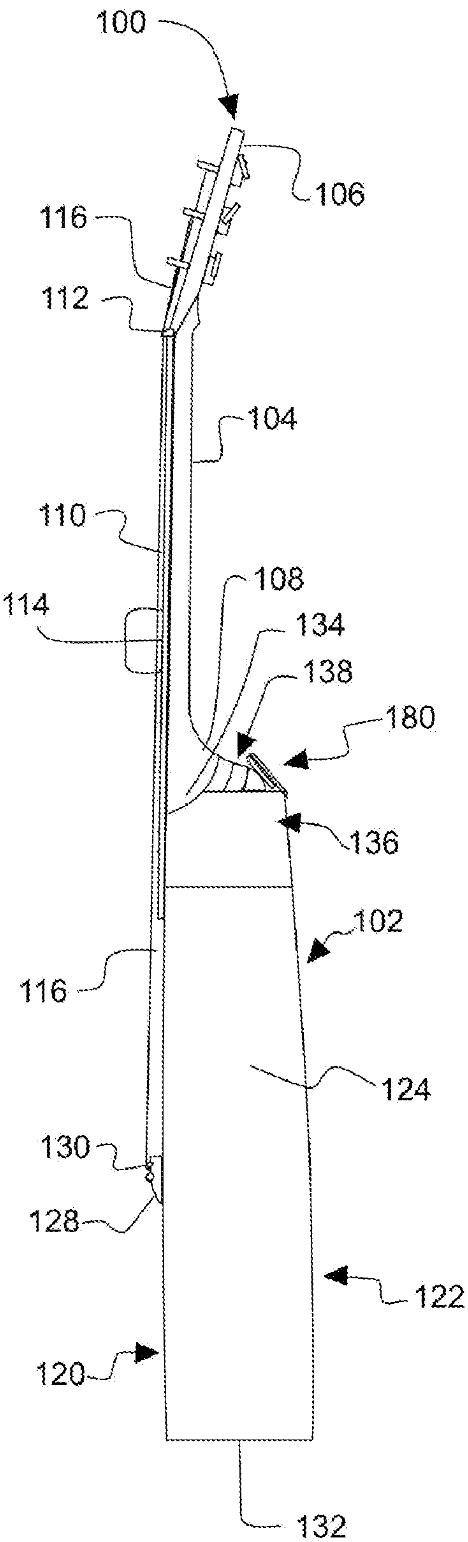
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Fig. 1B

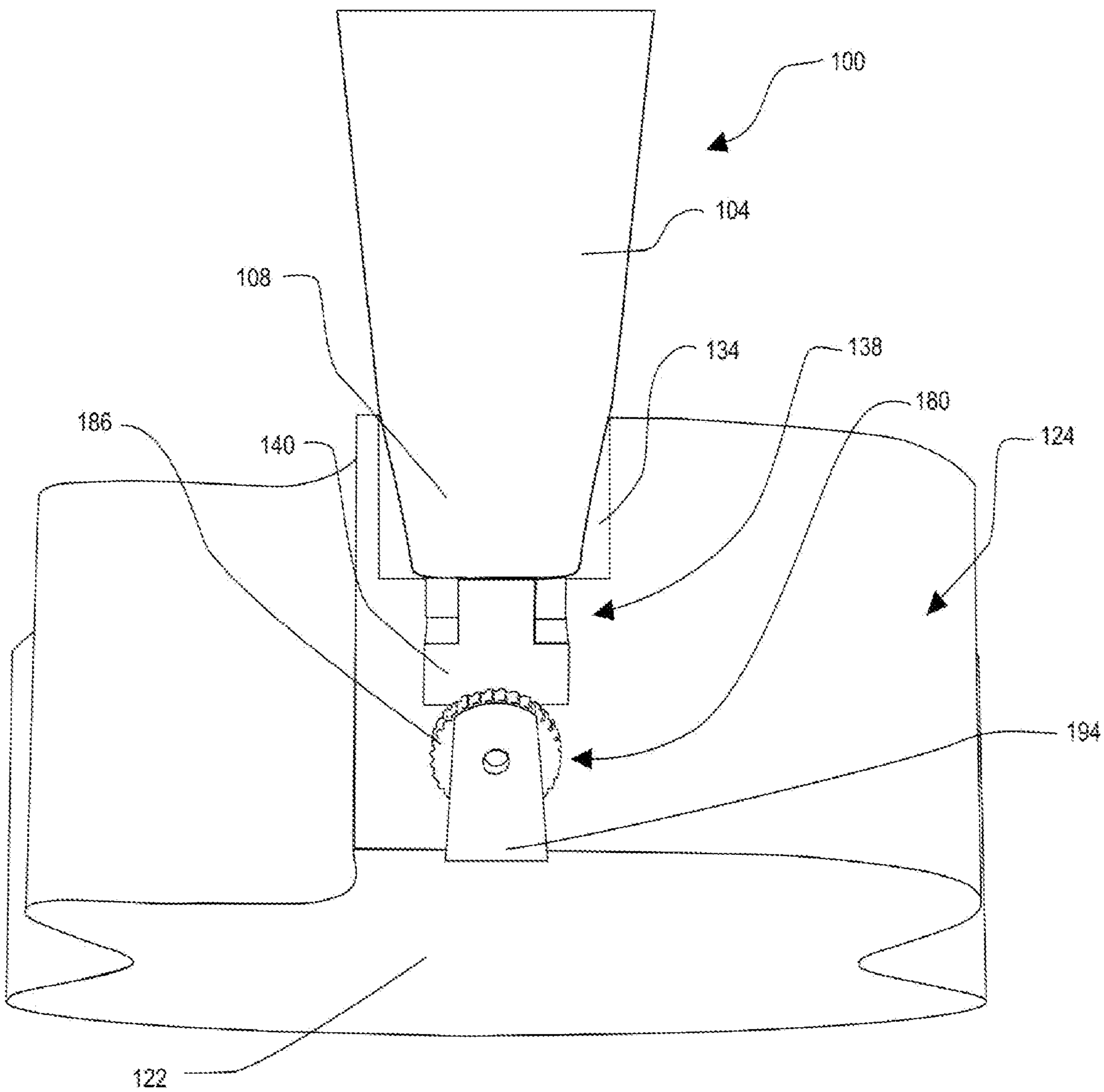
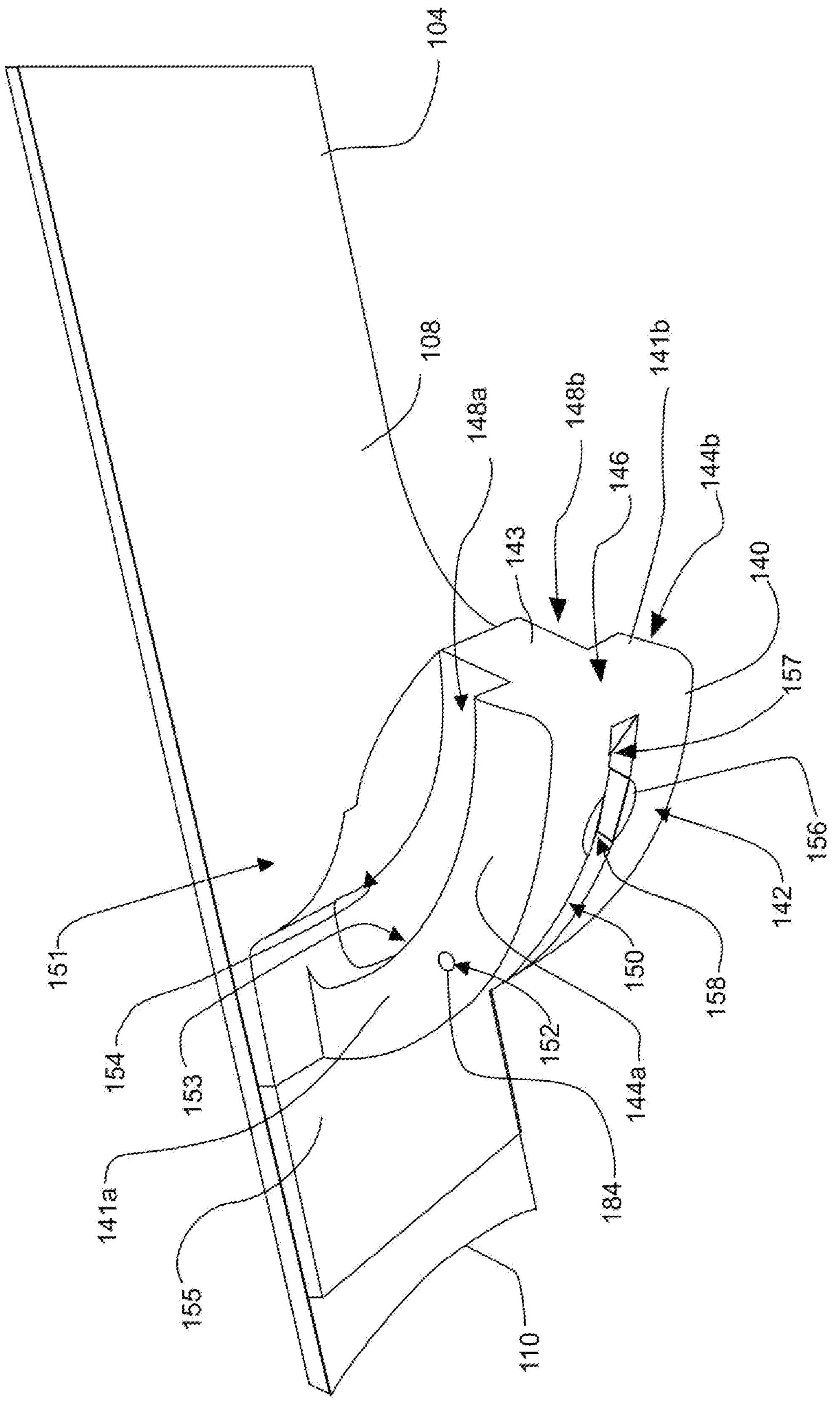



Fig. 1C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146
141b
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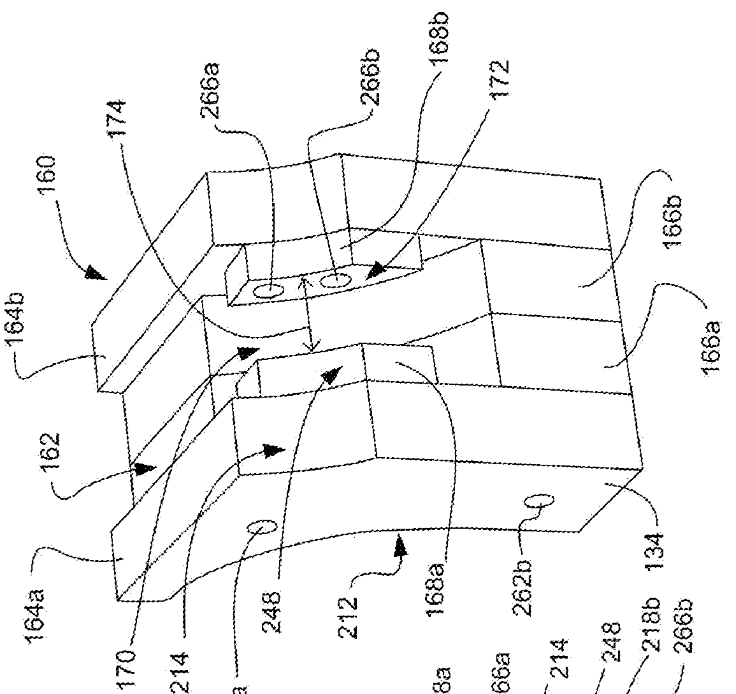
141a
155
110

Fig. 2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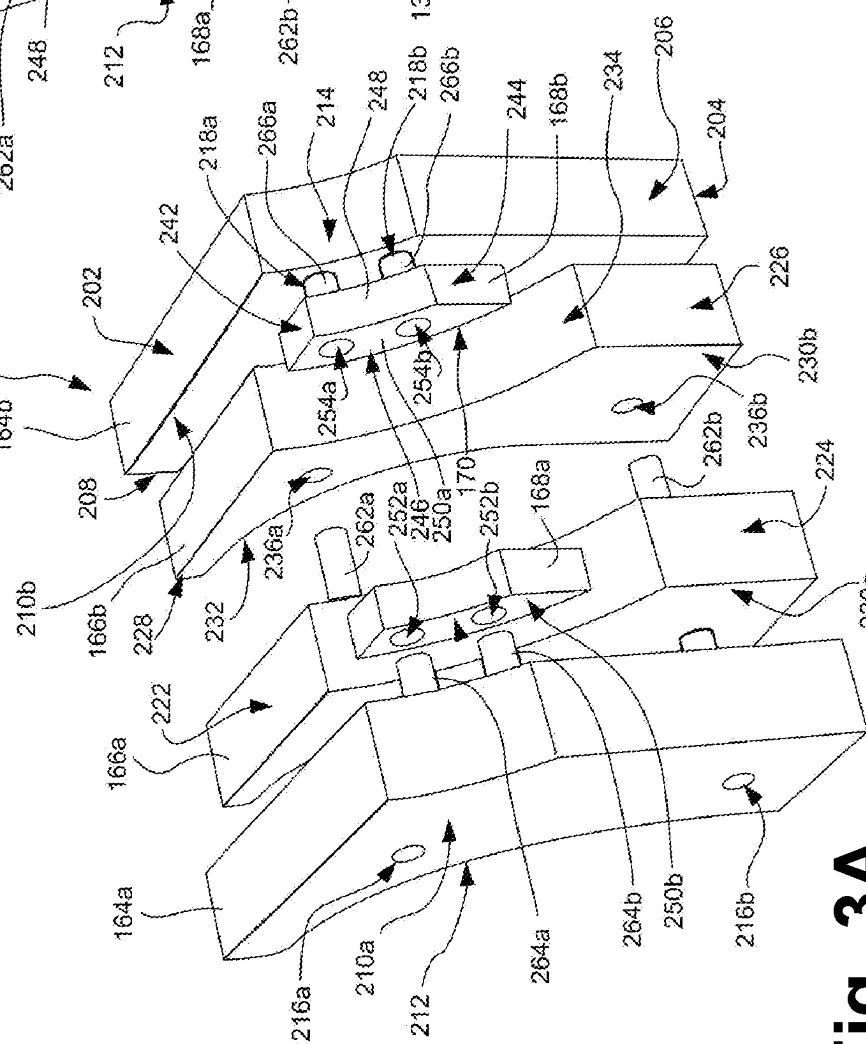
168a
262b
134

Fig. 3B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228
232
236a
254a
252a
246
250a
254b
170
262a
252b
168a
262b
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Fig. 3A

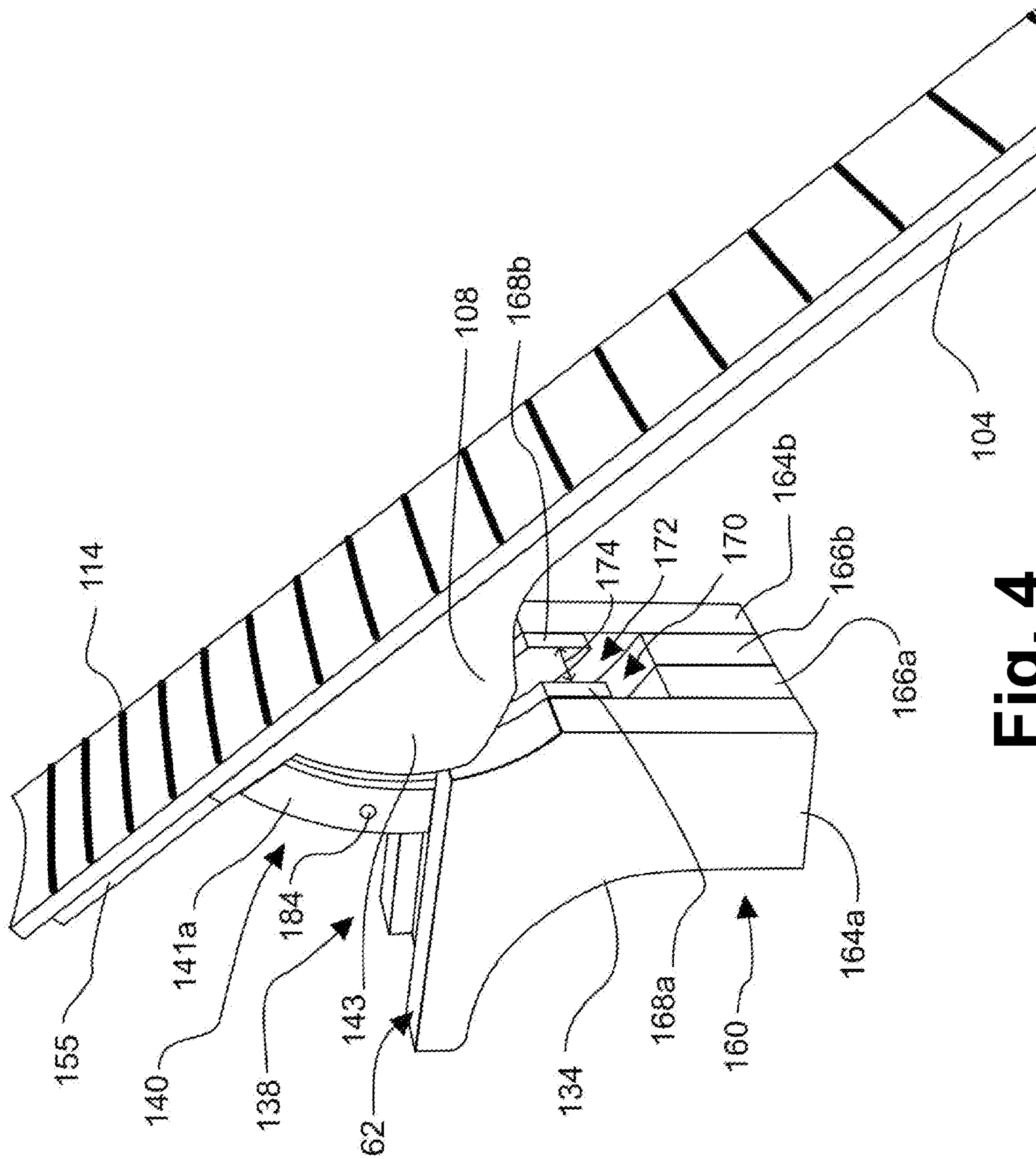
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Fig. 4

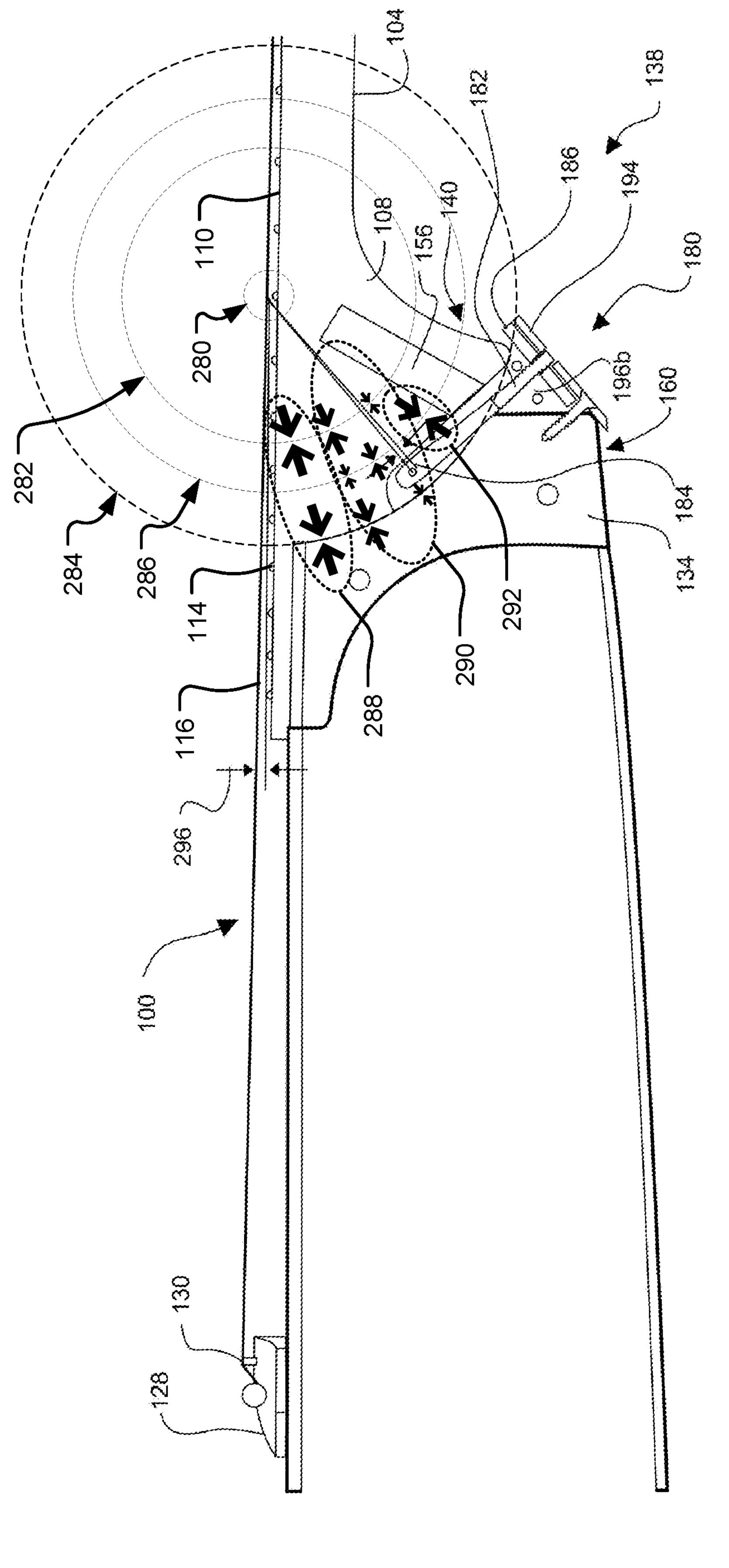
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Fig. 5

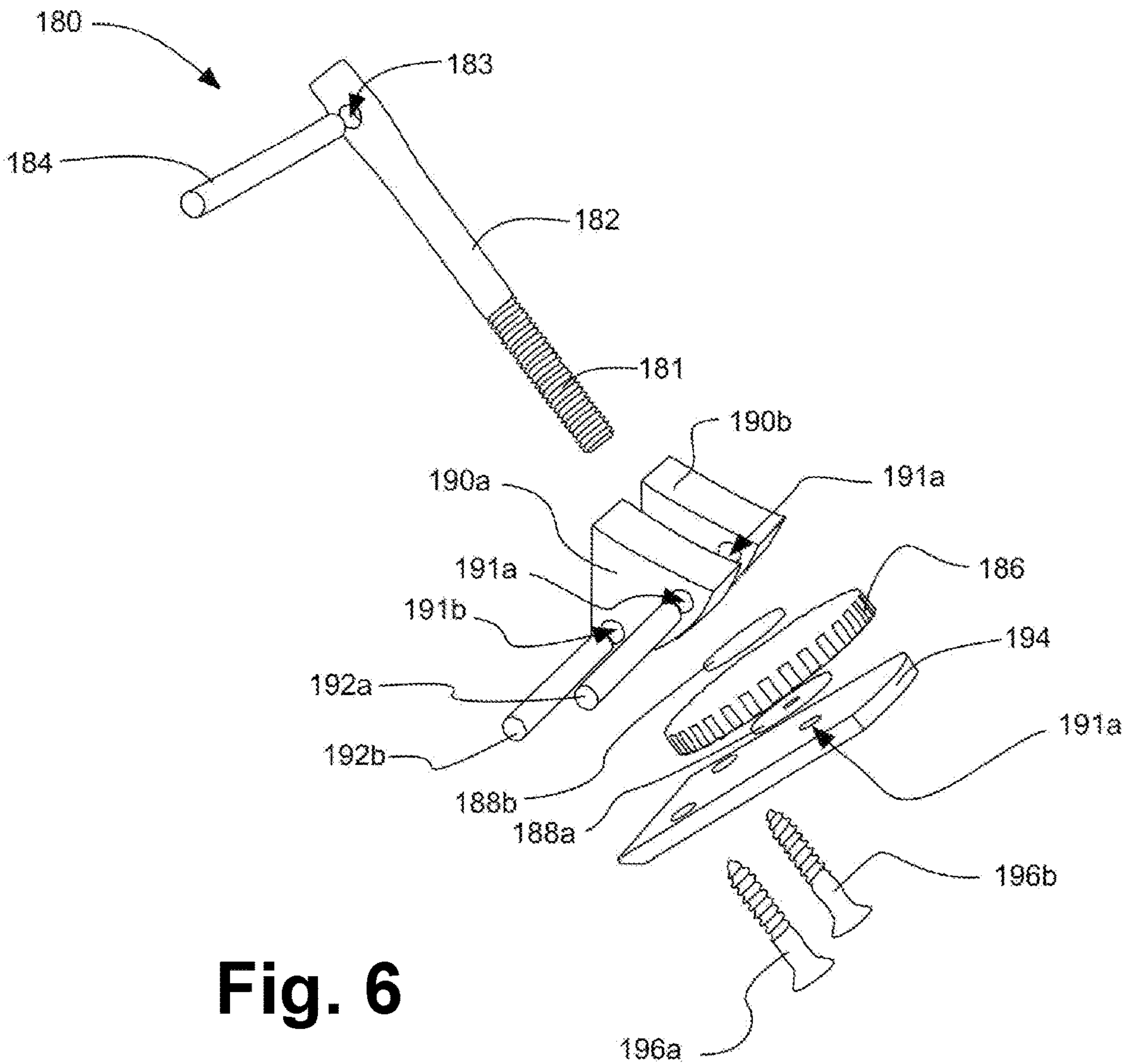
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Fig. 6

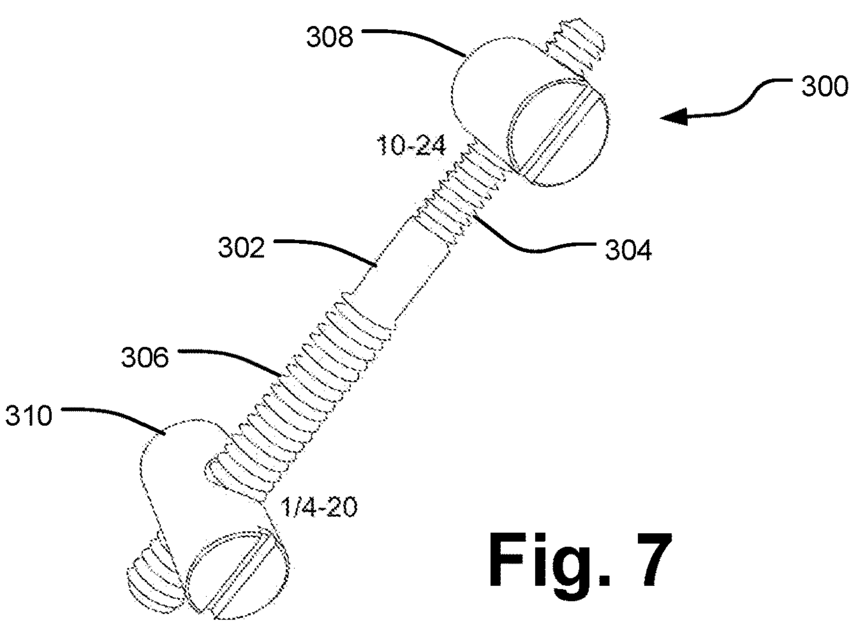
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Fig. 7

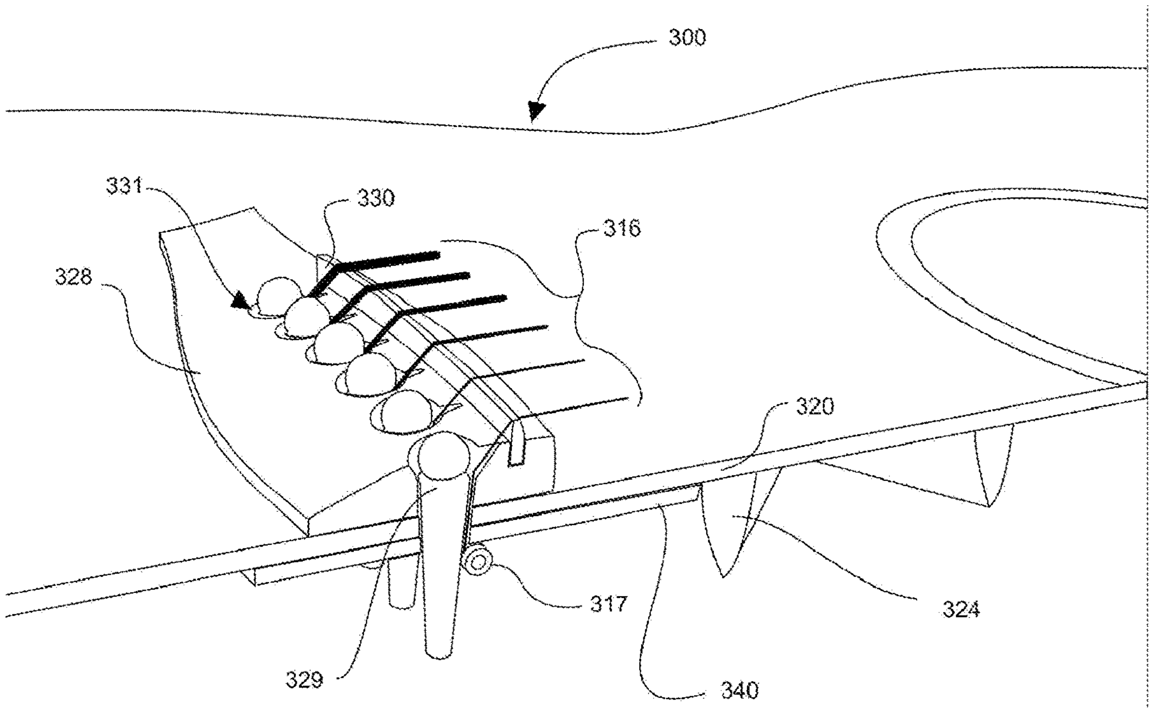


Fig. 8
(Prior Art)

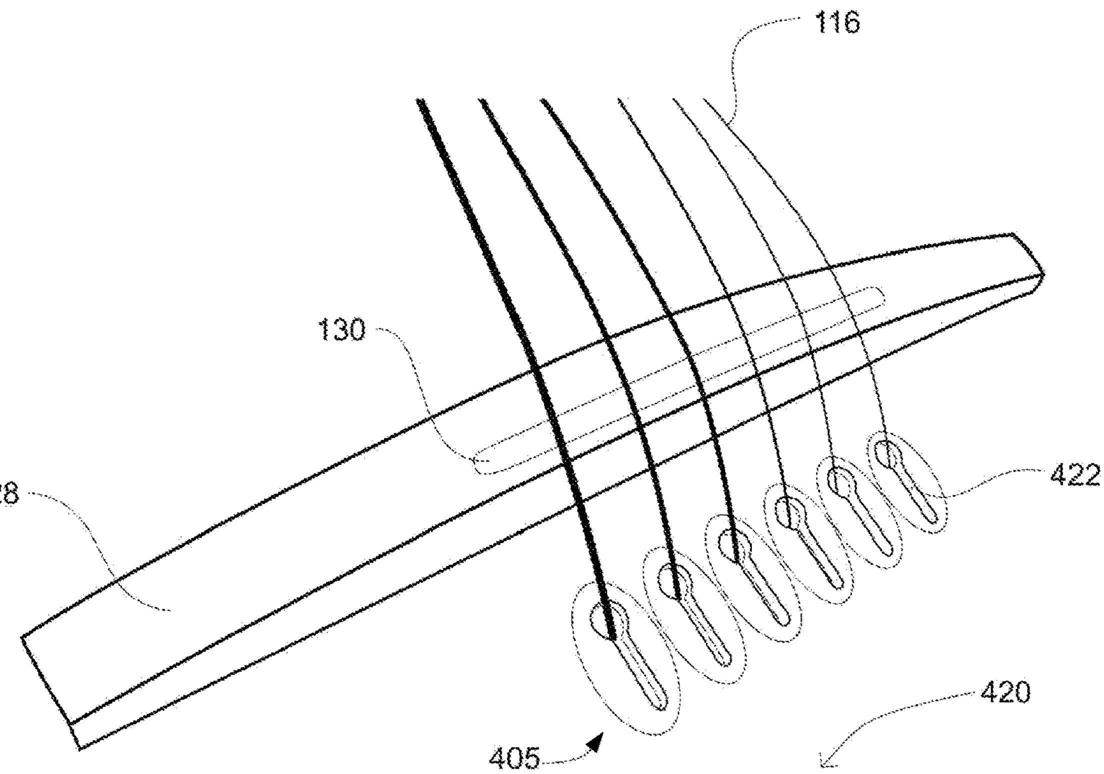


Fig. 9

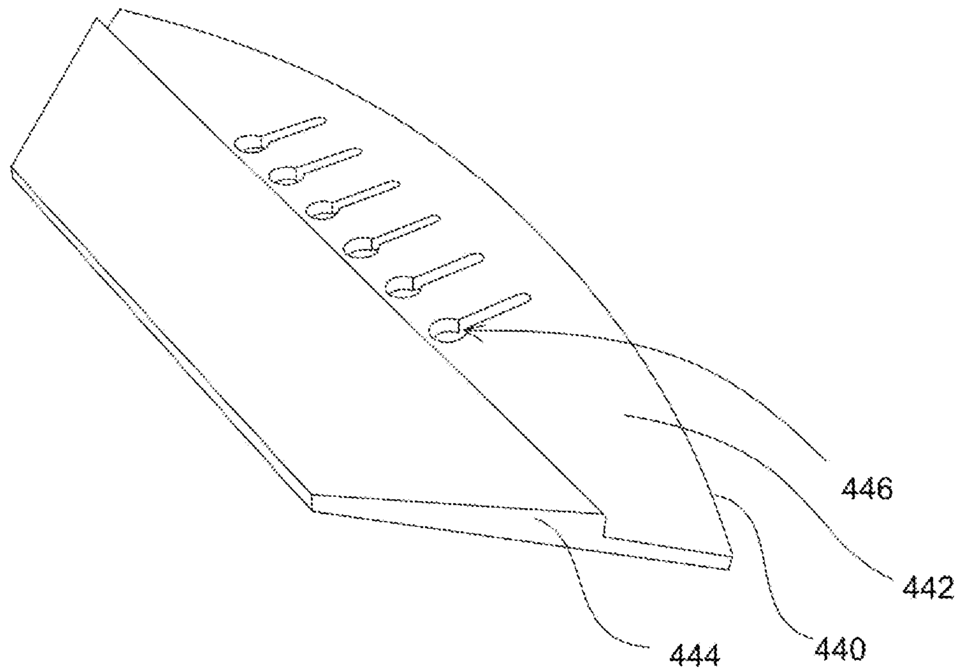
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Fig. 10

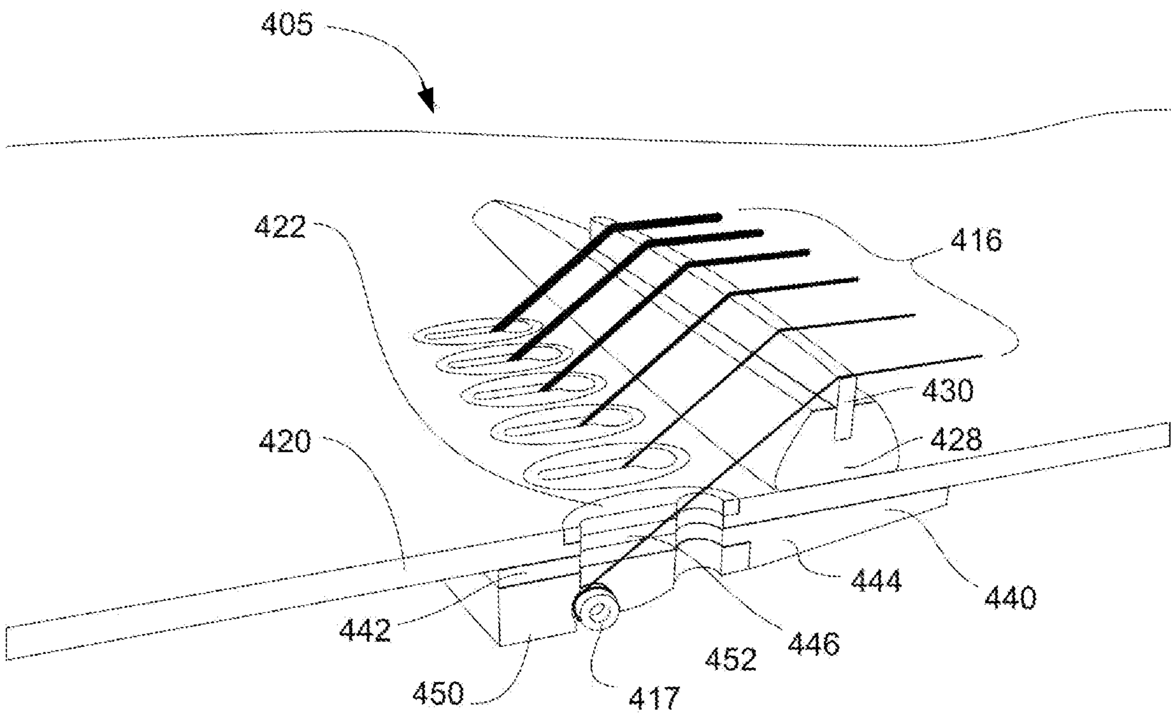
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Fig. 11

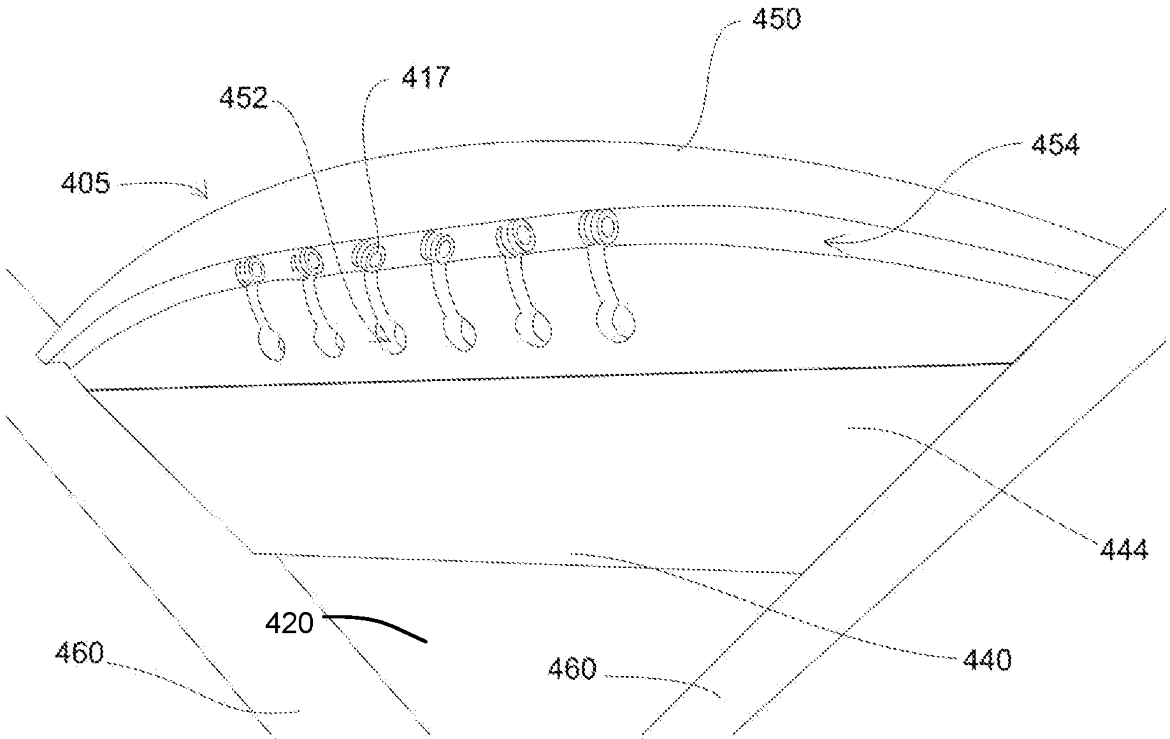


Fig. 12

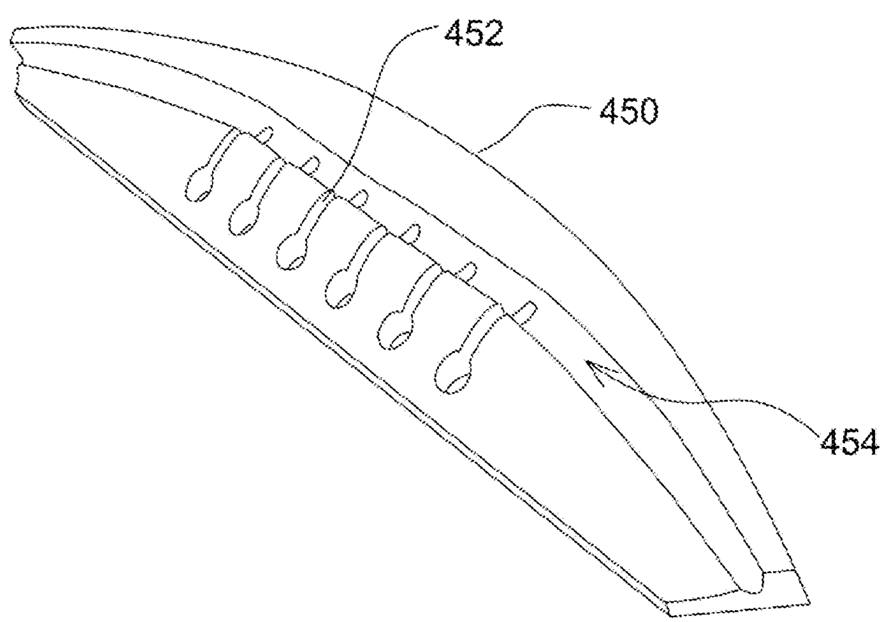


Fig. 13

# ADJUSTABLE NECK JOINT FOR STRINGED INSTRUMENTS

## CROSS REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of priority pursuant to 35 U.S.C. § 119(e) of U.S. provisional application No. 63/329,191 filed 8 Apr. 2022 entitled "Adjustable neck joint for stringed instruments" and further claims the benefit of priority pursuant to 35 U.S.C. § 119(e) of U.S. provisional application No. 63/375,184 filed 9 Sep. 2022 entitled "Adjustable neck joint for stringed instruments," each of which is hereby incorporated herein by reference in its entirety.

## TECHNICAL FIELD

The technology described herein relates to woodworking joinery for stringed musical instrument design and, more particularly, to a structure for changing the action of the strings above a fingerboard.

In a separate section of the disclosure, the technology described herein relates to a string anchor structure for a hollow body stringed instrument.

## BACKGROUND

With respect to a stringed instrument, the "action" is the distance of the strings from the fingerboard, also referred to as a fretboard, on the neck of the instrument. The distance between the strings and the fingerboard surface is often carefully adjusted for player comfort. The strings are typically closest to the fingerboard adjacent to the peghead and are typically furthest from the fingerboard adjacent to the body. Musicians may often select a stringed instrument based upon the type of action they prefer, or modify the action of a stringed instrument to provide a desired string height above the fingerboard.

In the example of an acoustic guitar (and similarly with most other stringed instruments), the strings are anchored at two points: at the headstock or peghead end of the neck, and at the bridge near the middle of the body. Different guitar and other stringed instrument manufacturers may provide different action heights by design of the angle of the neck with respect to the sound body or by selection of the height of the bridge above the soundboard, or through a combination of both. However, even when the action is specifically tuned to the desires of a musician, seasonal changes in humidity may cause the body, e.g., acoustic guitar tops, to swell or shrink which changes the action and affects the playability of the instrument.

The typical method for lowering a "high action" is to change the string height at the bridge. This is accomplished by grinding material off the saddle, the removable part of the bridge that marks one end of the vibrating portion of the string. To adjust and raise a "low action," the saddle is either replaced with a new, taller one or shims are placed beneath it to increase the height of the strings at the bridge. Alternatively, the bridge may be replaced by one with a taller base. These adjustments often require the skill and tools of a luthier. The appropriate action height is arrived at by trial-and-error and requires de-tuning and re-tuning the instrument with each adjustment to the saddle.

The information included in this Background section of the specification, including any references cited herein and any description or discussion thereof, is included for technical reference purposes only and is not to be regarded subject matter by which the scope of the invention as defined in the claims is to be bound.



## SUMMARY

In one implementation, a design for attachment of the neck to the body of a stringed musical instrument using an adjustable joint is disclosed. The design of the joint allows the player to change the neck angle for the purpose of making the instrument optimally playable. In another implementation, a distributed bridge structure for a stringed instrument is disclosed with a separate string anchor piece that is positioned underneath the soundboard.

In one implementation, an adjustable neck joint for a stringed instrument includes a neck with a heel portion formed as a first half of a rotating joint and a body with a neck block formed as a second half of the rotating joint. The first half of the rotating joint and the second half of the rotating joint may each be configured to connect with the other and movably interface with each other such that the neck is rotatable with respect to the body about an axis located immediately adjacent to and above a position along the neck.

In another implementation, a stringed instrument includes a neck with a heel portion formed as a first half of a rotating joint and a body with a neck block formed as a second half of the rotating joint. The first half of the rotating joint and the second half of the rotating joint are each configured to connect with each other and movably interface with each other such that the neck is rotatable with respect to the body about an axis perpendicular to a longitudinal axis of the neck. In further implementations, the neck may further include a peghead on an opposite end of the neck from the heel and a fingerboard extending along a top surface of the neck from the peghead to beyond the heel. In further implementations the body may further include a top surface, a bridge mounted on the top surface, and a string termination structure connected to the body.

The stringed instrument may further include a plurality of strings, each connected at a first end to the peghead and at a second end to the string termination structure, extending above and along the fingerboard, and supported above the top surface of the body by the bridge at an intermediate location along a length of each string. The stringed instrument is thereby configured such that upon rotation of the first half of the rotating joint with respect to the second half of the rotating joint, the fingerboard moves toward or away from the strings, thereby adjusting an action of the strings and, upon such adjustment of the action, the strings remain in tune.

This Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used to limit the scope of the claimed subject matter. A more extensive presentation of features, details, utilities, and advantages of the present invention as defined in the claims is provided in the following written description of various embodiments and implementations and illustrated in the accompanying drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

The disclosure will be readily understood by the following detailed description in conjunction with the accompanying drawings, wherein like reference numerals designate like structural elements.

The use of cross-hatching or shading in the accompanying figures is generally provided to clarify the boundaries between adjacent elements, e.g., when shown in cross section, and also to facilitate legibility of the figures. Accordingly, neither the presence nor the absence of cross-hatching or shading conveys or indicates any preference or requirement for particular materials, material properties, element proportions, element dimensions, commonalities of similarly illustrated elements, or any other characteristic, attribute, or property for any element illustrated in the accompanying figures.

Additionally, it should be understood that the proportions and dimensions (either relative or absolute) of the various features and elements (and collections and groupings thereof) and the boundaries, separations, and positional relationships presented therebetween, are provided in the accompanying figures merely to facilitate an understanding of the various embodiments described herein and, accordingly, may not necessarily be presented or illustrated to scale, and are not intended to indicate any preference or requirement for an illustrated embodiment to the exclusion of embodiments described with reference thereto.

FIG. **1**A is a top plan view of an exemplary embodiment of a guitar with an adjustable neck joint as described in the present disclosure.

FIG. **1**B is a right side elevation view of the guitar of FIG. **1**A.

FIG. **1**C is a rear perspective view of the guitar of FIG. **1**A showing the adjustable neck joint and an exemplary embodiment of a related adjustment mechanism.

FIG. **2** is a right side, perspective view of the neck of the guitar of FIG. **1**A with the tenon portion of the heel partially inserted into the mortise portion of the neck block during assembly of the guitar.

FIG. **3**A is an exploded rear perspective view of components of a neck block of the guitar of FIG. **1**A that together form a mortise portion of the adjustable neck joint.

FIG. **3**B is a rear perspective view of the neck block of FIG. **4**A in an assembled configuration.

FIG. **4** is a right-side perspective view of the heel of the neck of the guitar of FIG. **1**A forming a tenon portion of the adjustable neck joint partially inserted within the mortice portion of FIG. **3**B.

FIG. **5** is a right side, elevation view of the neck of the guitar in cross section joined to the neck block with indications of the range of adjustment of the action provided by the adjustable neck joint and further indications of the relative forces on the tenon portion and the mortise portion across the adjustable neck joint.

FIG. **6** is an exploded, right side, perspective view of the adjustment mechanism for the adjustable neck joint of the guitar of FIG. **1**A.

FIG. **7** is a perspective view of an alternate embodiment of a tie rod of an adjustment mechanism for use with the adjustable neck joint of the guitar.

FIG. **8** is a cross section view of a prior art guitar bridge showing the ball ends of the guitar strings secured with bridge pins beneath the soundboard and bridge plate.

FIG. **9** is a perspective view of an example implementation of a floating bridge and eyelets through the top soundboard through which the ends of the guitar strings pass.

FIG. **10** is a bottom perspective view of an example implementation of a bridge plate.

FIG. **11** is a bottom perspective view of a removable string anchor.

FIG. **12** is a cross section view of the soundboard and bridge of FIG. **9** depicting a removable string anchor of FIG. **11** retained against the bridge plate of FIG. **10** and securing the ball ends of the guitar strings.

FIG. **13** is bottom, perspective view of the removable string anchor of FIG. **11** retained against the bridge plate of FIG. **10**, mounted against bracing strips on an inner surface of the soundboard, and securing the ball ends of the guitar strings.

## DETAILED DESCRIPTION

In a first implementation, a stringed instrument with an adjustable neck joint is disclosed. In this document, a guitar has been chosen as the exemplary string instrument to demonstrate the neck joint. However, the adjustable neck joint as disclosed herein is equally adaptable for use an implementation with any stringed instrument, acoustic or electric, having a fingerboard or fretboard connected to a body, for example, violins, violas, cellos, basses, banjos, mandolins, lutes, sitars, and others. The adjustable neck joint disclosed herein allows a player to make precise adjustments to the action height without modifying the saddle or detuning the strings. An adjustment mechanism may be incorporated to push or pulls on the base of the neck within the joint, which causes the neck to rotate along an arc about an axis transverse a longitudinal axis of the neck. In an example implementation, the axis of rotation is transverse to the length of the strings and positioned on the strings at a chosen location along the neck.

In order to better understand the present disclosure, an acoustic guitar **100** with an embodiment of an adjustable neck joint **138** is depicted in FIGS. **1**A-**1**C. As with most acoustic guitars, the guitar **100** has a body **102** connected to a neck **104**, which extends from the rear of the body **102**. The neck **102** is typically made from a solid piece of wood and may be formed with a hollow shaft to receive a reinforcing truss rod. However, such is not required. The neck **104** is generally smooth and curved on the back side and flat on the front side. A headstock **106** or peghead is formed at the distal end of the neck **104** and is unitary, i.e., is formed within the same piece of wood as the neck **104** for strength. A heel portion **108** of the neck **104** is formed on the opposite end of the neck **104** from the headstock **106** and is configured for attachment of the neck **104** to the body **102**.

A fingerboard **110** lays on top of the flat side of the neck **104**. A nut **112**, which is actually a block arranged transverse to the longitude of the neck **104**, caps the distal end of the fingerboard **110** at the transition from the neck **104** to the headstock **106**. The nut **112** may have six grooves that are spaced laterally apart from each other such that the centers of each groove are equidistant from adjacent grooves. Some of the grooves may be wider than other grooves in a descending order to accommodate the heavier (thicker) strings that provide lower pitches. The grooves in the nut **112** keep the strings separated from each other across the length of the guitar **100**. The fingerboard **110** on the guitar **100** is inlaid with frets **114**, which are typically metal bars that are arranged transverse to the length of the neck and demark positions at which the effective length of the string can be shortened to change the note played. However, many stringed instruments, for example, violins, violas, cellos, and basses, do not use frets and the musician merely presses a string against the fingerboard to change the note. The guitar **100** is typical with six strings **116** of varying diameter to provide a wide range of notes of various pitch. At a first end, the strings **116** are connected to the headstock **106** with tuning pegs **118**.

At a second end, the strings **116** are connected to the body **102** of the guitar **100**. The body **102** is composed of a top soundboard **120** and a bottom backboard **122**, which are connected by a sidewall **124** to form a hollow enclosure. The soundboard **120** defines a sound hole **126**, typically within the center of the body **102** and directly beneath the strings **116** as they stretch across the body **102**. A bridge **128** sits on top of the soundboard **120** beyond the sound hole **126** and provides the termination location (e.g., a pin hole section) for the second end of the strings **116**. A saddle **130** seats within the bridge **128** and the strings **116** held against the saddle **130**. The saddle **130** is similar to the nut **112** in that it is a hard block that is oriented transverse to the length of the strings **116**. The saddle **130** may or may not have grooves like the nut **112** for separation of the strings **116**. If the bridge **128** provides fixed termination locations for the strings **116** that are spaced laterally apart and equidistant from each other (e.g., as with a pin hole section in the bridge), the saddle **130** may not be provided with grooves as the pins in the bridge **128** will keep the strings **116** separated from each other across the length of the guitar **100**.

The strings **116** are placed under tension between the nut **112** at the first end and the saddle **130** at the second end by winding the first ends around the tuning pegs **118**. The length of the strings **116** between the nut **112** and the saddle **130** is predetermined to result in appropriate standard harmonics for each string when played openly as well as when pressed against a fret **114**. The frets **114** are appropriately spaced apart to change the length of each string **116** at locations that result in different harmonic notes. The tuning pegs **118** rotate to tighten or loosen the strings to manipulate the pitch of each of the strings **116** and ultimately create appropriate tension such that each string **116** is "in tune."

The sidewalls **124** of the body **102** are typically affixed to a tail block **132** within the hollow of the body at the tail end to hold them together at a first end, and are affixed to a neck block **134** at an opposite end of the body **102** where the neck **104** attaches. In typical guitars, the neck is rigidly and fixedly attached to the neck block to prevent collapse of the joint between the neck and body when the strings are placed under tension. Tensions across the strings placed on an acoustic guitar can range from a low as 60 lbs (267 N) (e.g., for a guitar with nylon strings or with light gauge strings attached to a tailpiece) to up to 170 lbs (756 N) or more for a guitar with steel wire strings and a pin hole attachment within a pin bridge. However, in embodiments of the guitar **100** as disclosed herein, the neck **104** is movably attached to the neck block **134** using an adjustable neck joint structure **138** as further described herein. Additionally, and adjustment mechanism **180** may be provided in conjunction with the adjustable neck joint **138** to both resist movement of the neck joint **138** once a desired position is selected and to further make fine adjustments to the "action" of the strings **116**.

With most acoustic guitars (as well as other stringed instruments), the primary method for changing the action, i.e., the height of the strings above the fingerboard (particularly near the base of the neck adjacent to the body), is to change the height of the saddle. While the ridge could also be removed and replaced with a different saddle seat, this is much more difficult in the case of a pin bridge (i.e., a bridge that provides a termination structure for the strings), which is typically glued to the soundboard and requires the skills of a luthier. The height of the saddle above the wood of the bridge typically has a finite range of adjustment (from 0 mm to ~6-8 mm), either lowering by trimming the saddle or raising by shimming under the saddle in the channel in the bridge where the saddle is seated.

The force vector exerted by the string tension mostly compresses the saddle into its slot in the bridge when the saddle is short, but as the height of a saddle increases, the force vector points more towards the bridge pins. When the strings are under tension, a tall saddle acts as a lever arm, which twists the bridge and the top of the soundboard to which the bridge is adhered along that force vector. A maximum height for a saddle above the soundboard is limited by the strength of the materials of the guitar since either the bridge or saddle will crack under the torque if the saddle is adjusted too high. The wood of the bridge is the obvious lower boundary for reducing the string height. Over time, the strings under tension may cut into the saddle and undesirably lower the action. This may be addressed relatively easily by shimming or replacing the saddle. Addressing an undesirably high action is more difficult.

Most guitars are constructed with a neck that is either glued or bolted to the body at a fixed angle which in turn determines how tall the bridge and saddle must be for a comfortable action. Over several decades under tension, the guitar body and neck commonly flex and warp to the extent that the lowest adjustment of the saddle still leaves too high an action above the fingerboard to reasonably play the guitar. Resetting the neck angle solves the issue, but that is accomplished by removing the neck from the body and carefully chiseling and sanding wood off the mating surface at the heel of the neck where it mates with the neck block. This is an expensive and technical job requiring the skills of a luthier.

The violin family of instruments usually have a neck connected to the body by way of a V-shaped sliding dovetail joint. The mating surface between the side (ribs) of the instrument body and the heel of the neck determines the neck angle, and the dovetail is carved for a snug fit which presses the mating surfaces together. The mating surfaces are further fixed together with glue. This type of neck joint is not adjustable per se and more difficult to remove than a bolted-on neck, but it can be dismantled and re-set by a skilled woodworker by adding veneers and chiseling and sanding the mating surfaces in order to change the angle where the neck meets the body and maintaining a tight joint.

In contrast to these methods for joining a neck to a body of a stringed instrument, the present disclosure details an adjustable neck joint **138** formed as a curved, mortise and tenon sliding dovetail as shown in greater detail in FIG. **2**. The tenon portion **140** of the adjustable neck joint **138** is formed on the heel **108** of the neck **104** as depicted in FIG. **3**, shown in isolation, separated from the body **102**. The mortise portion **160** is formed within the tail block **132** of the body **102** as depicted in FIGS. **4**A and **4**B. As noted, the tenon portion **140** is formed as a curved, T-shaped rail within the heel **108** unitary with the neck **104** (i.e., the tenon portion **140** is formed within the same piece of wood stock as the neck **104**. The tenon portion **104** is defined by an arcuate bottom surface **142** bounded by two arcuate, lateral sidewalls **144***a*, **144***b* that are perpendicular to the arcuate bottom surface **142**. A butt surface **146** forms the free end of the tenon portion **140** and may be formed as a curved surface following the curve of the outer surface of the heel **108** to provide a smooth transition from the heel **108** to the tenon portion **140**. Lateral arcuate channels **148***a*, **148***b* are formed within each of the arcuate sidewalls **144***a*, **144***b* and each is bounded by a lower arcuate wall **153** and an upper arcuate wall **154**. Lateral arcuate rails **141***a*, **141***b* and a center arcuate post **143** are thus formed by the arcuate channels **148***a*, **148***b*. The lower arcuate wall **153** is narrower than the upper arcuate wall **154**, which extends transversely outward to meet the widest portion of the heel **108** of the neck **104** at a block surface **151**. The depth of the arcuate channels **148***a*, **148***b* terminates at a bed plate **155**, which extends beyond the heel **108** and beyond the arcuate bottom surface **142** of the tenon portion **140** to support the portion of the fingerboard **110** that extends over the soundboard **120** on the body **102**.

In order to strengthen the tenon portion **140**, a reinforcement dowel **156** may be fixed (e.g., glued) within a receiving shaft **157** bored through the arcuate bottom surface **142** and extending as a blind hole into the heel **108**. The angle of the axis of the receiving shaft **157** is normal to the arcuate bottom surface **142** and is positioned in the longitudinal center of the arcuate bottom surface **142** between the tenon sidewalls **144***a*, **144***b*. The receiving shaft **147** is offset from the butt wall **146** sufficiently that the reinforcement dowel **156** extends into the center mass of the heel **108**. As described later herein, the forces on the adjustable neck joint **138** may cause significant stress forces across the tenon portion **140**. In this location, the forces may be across the grain of the wood in this region of the tenon portion **140** as compared with the rest of the neck **104**, wherein the forces are primarily in compression along the grain of the wood. The reinforcement dowel **156** may thus provide additional strength to the tenon portion **140**.

A channel **150** for receiving a tie rod component of the adjustment mechanism **180** may be formed within the bottom arcuate surface **142**. As the reinforcement dowel **156** also extends to the bottom arcuate surface **142**, the channel **150** may also be formed within the base portion of the reinforcement dowel **156** as a notch **157**. A hinge pin hole **152** is also bored laterally trough the tenon portion **140** between the tenon sidewalls **144***a*, **144***b*. A hinge pin **184** for pivotably connecting the tie rod component to the tenon portion **140** resides in the hinge pin hole **152**. (The components of the adjustment mechanism **180** are described in greater detail herein in FIG. **6**.)

The mortise portion **160** of the adjustable neck joint **138** is depicted in FIGS. **4**A and **4**B. The components of the mortise portion **160** are shown in an exploded view in FIG. **4**A and the assembled mortise portion **160** is depicted in FIG. **4**B. The assembled mortise portion **160** also functions as the neck block **134** for joining the sidewalls **126** of the body **102** adjacent to the neck. The mortise portion **160** is formed primarily of a pair of outer mortise blocks **164***a*, **164***b*, a pair of inner mortise blocks **166***a*, **166***b*, and a pair of mortise retainer blocks **168***a*, **168***b* held together by a number of dowels as described below.

Each outer mortise block **164***a*, **164***b* is slightly taller than the corresponding inner mortise blocks **166***a*, **164***b*, and is bounded by a rectangular box form defined by a flat top surface **202**, a flat bottom surface **204**, a flat front surface **206**, a flat rear surface **208**, and flat, lateral outer and inner surfaces **210***a*, **210***b*. A rear wall of each outer mortise block **164***a*, **164***b* is formed as a large diameter arcuate brace **212** curving concavely between the rear surface **208** at an upper edge and the bottom surface **204** at a lower edge. A top portion of the front face of the outer mortise blocks **164***a*, **164***b* forms an arcuate bevel **214** curving concavely between the front edge of the top surface **202** and the front edge of the bottom surface **204**, but has a much shorter arc length than the arcuate brace **212**. Each of the outer mortise blocks **164***a*, **164***b* also defines a first set of upper and lower blind holes **216***a*, **216***b* for ultimate receipt of corresponding dowels for connection to the inner mortise blocks **166***a*, **166***b*. The openings to the first set of blind holes **216***a*, **216***b* are formed within the inner surfaces **210***b* of each of the outer mortise blocks **164***a*, **164***b*. Each of the outer mortise blocks **164***a*, **164***b* further defines a second set of upper and lower blind holes **218***a*, **218***b* for ultimate receipt of corresponding dowels for connection to the mortise retainer locks **168***a*, **168***b*. The openings to the second set of blind holes **218***a*, **218***b* are formed within the inner surfaces **210***b* of each of the outer mortise blocks **164***a*, **164***b*.

The inner mortise blocks **166***a*, **166***b* are slightly shorter than the corresponding outer mortise blocks **164***a*, **164***b*, and each is bounded by a rectangular box form defined by a flat top surface **222**, a flat bottom surface **224**, a flat front surface **226**, a flat rear surface **228**, and flat, lateral outer and inner surfaces **230***a*, **230***b*. A rear wall of each inner mortise block **166***a*, **166***b* is formed as a large diameter arcuate brace **232** curving concavely between the rear surface **228** at an upper edge and the bottom surface **224** at a lower edge. The arcuate brace **232** of each inner mortise block **166***a*, **166***b* is congruent in radius and arc length with the large diameter arcuate brace **212** of the outer mortise blocks **164***a*, **164***b*. A top portion of the front face of the inner mortise blocks **166***a*, **166***b* forms a channel surface **234** curving concavely between the front edge of the top surface **222** and the front edge of the bottom surface **224**, but has a shorter arc length than the arcuate brace **232** and a longer arc length than the arcuate bevels **214** of the outer mortise blocks **164***a*, **164***b*. Each of the inner mortise blocks **166***a*, **166***b* also defines a pair of upper and lower through holes **236***a*, **236***b* for ultimate receipt of corresponding dowels. The openings to the through holes **236***a*, **236***b* extend between the outer surfaces **230***a* and the inner surfaces **230***b* of each of the inner mortise blocks **166***a*, **166***b*. In some implementations, the pieces of wood used for the outer mortise blocks **164***a*, **164***b* and the inner mortise blocks **166***a*, **166***b* may be selected and oriented such that the grain in each of the block is oriented diagonally upwards, but at slightly different angles to increase the strength of the mortise portion **160** and avoid introducing complementary weaknesses.

Each of the mortise retainer blocks **168***a*, **168***b* is formed as an arcuate solid segment (like a comma or quotation mark in form) bounded by a flat top surface **242**, a flat front surface **244**, an arcuate rear retainer surface **246**, a flat rear surface **228**, and flat, lateral outer and inner surfaces **230***a*, **230***b*. The arcuate rear surface **246** curves convexly between the top surface **242** at an upper edge and the front surface **244** at a lower edge. The arcuate bevel surface **248** curves concavely between the top surface **242** at an upper edge and the front surface **244** at a lower edge. A first of the mortise retainer blocks **168***a* also defines a pair of upper and lower through holes **252***a*, **252***b* extending between the outer surface **250***a* and the inner surface **250***b* for ultimate receipt of corresponding dowels. A second of the mortise retainer blocks **168***b* further defines a pair of upper and lower through holes **254***a*, **254***b* extending between the outer surface **250***a* and the inner surface **250***b* for ultimate receipt of corresponding dowels.

A first pair of upper and lower dowel rods **262***a*, **262***b* are provided to connect all of the outer mortise blocks **164***a*, **164***b* and the inner mortise blocks **166***a*, **166***b* together. The inner surfaces **210***b* of each of the outer mortise blocks **164***a*, **164***b* are positioned adjacent to the outer surfaces **230***b* of each of the inner mortise blocks **166***a*, **166***b*. The inner surfaces **230***a* of each of the inner mortise blocks **166***a*, **166***b* are also positioned adjacent to and directly opposite each other. The upper dowel **262***a* extends through the upper through holes **236***a* of each of the inner mortise blocks **166***a*, **166***b* and is long enough to further extend into the upper blind holes **216***a* of each of the outer mortise blocks **164***a*, **164***b*. The lower dowel **262***a* extends through the lower through holes **236***b* of each of the inner mortise blocks **166***a*, **166***b* and is long enough to further extend into the lower blind holes **216***b* of each of the outer mortise blocks **164***a*, **164***b*.

When assembled, the outer mortise blocks **164***a*, **164***b* and the inner mortise blocks **166***a*, **166***b* are sandwiched firmly together in the order described and are held together by the upper and lower dowel rods **262***a*, **262***b*, which are glued within the respective holes. As shown in FIG. **4**B, once assembled, a recessed fretboard bed **162** is formed by the top surfaces **222** of the inner mortise blocks **166***a*, **166***b* between the taller outer mortise blocks **164***a*, **164***b*. A recessed arcuate mortise channel **170** is also formed by the channel surfaces **234** of the inner mortise blocks **166***a*, **166***b* between the outer mortise blocks **164***a*, **164***b* due to the larger arc length of the channel surfaces **234** as compared to the shorter arc length of the arcuate bevels **214** of the outer mortise blocks **164***a*, **164***b*.

The mortise retainer blocks **168***a*, **168***b* are also connected to the outer mortise blocks **164***a*, **164***b* in the final assembly of the mortise portion **140**. The mortise retainer blocks **168***a*, **168***b* is respectively attached to the inner surfaces **201***b* of corresponding outer mortise retainer blocks **164***a*, **164***b* by separate sets of dowel rods, i.e., left upper and lower dowels **262***a*, **262***b* and right upper and lower dowels **264***a*, **264***b* which extend through respective upper and lower through holes **252***a*, **252***b* of the mortise retainer blocks **168***a*, **168***b* and continue into the upper and lower blind holes **218***a*, **218***b* within the inner surfaces **210***b* adjacent to the arcuate bevel **214** on each of the outer mortise blocks **164***a*, **164***b*. The inner surface **250***b* of each of the mortise retainer blocks **168***a*, **168***b* is secured against the respective inner surfaces **210***b* of each of the outer mortise blocks **164***a*, **164***b*.

The mortise retainer blocks **168***a*, **168***b* are formed such that, when attached to the outer mortise blocks **164***a*, **164***b*, the arcuate bevels **248** of the mortise retainer blocks **168***a*, **168***b* have the same radius of curvatures as the arcuate bevels **214** of the outer mortise blocks **164***a*, **164***b* and together create a smooth, arcuate surface on the mortise portion **140**. Similarly, the flat front surfaces **244** of the mortise retainer blocks **168***a*, **168***b* are in alignment with the flat front surfaces **206** of the outer mortise blocks **164***a*, **164***b* and together create a smooth, flat surface. The flat top surfaces **242** of the mortise retainer blocks **168***a*, **168***b* are recessed from the top surfaces **202** of the outer mortise blocks **164***a*, **164***b* but are in planar alignment with the top surfaces **222** of the of the inner mortise blocks **166***a*, **166***b* and are thus in the same plane as the fretboard bed **162**. The radius of curvature of the arcuate rear retainer surface **246** of each of the mortise retainer blocks **168***a*, **168***b* is smaller than a radius of curvature of the channel surfaces **234** of each of the inner mortise blocks **166***a*, **166***b*, thus creating a separation distance or gap between the inner mortise blocks **166***a*, **166***b* and the mortise retainer blocks **168***a*, **168***b* to form the rail retention slots **172**. The widths of the mortise retainer blocks **168***a*, **168***b* are also narrower than the widths of the inner mortise blocks **166***a*, **166***b* such that there is a separation distance **174** between the inner surfaces **250** of each of the mortise retainer blocks **168***a*, **168***b* when the mortise portion **140** is assembled.

Returning to FIG. **2**, an initial step in assembly of the adjustable neck joint **138** is depicted. The tenon portion **140** of the heel **108** of the neck **104** is inserted into the mortise channel **170** of the mortise portion **160** such that the arcuate rails **141***a*, **141***b* slide along the mortise channel **170** within the rail retention slots **172**. The arcuate tenon post **143** fits snugly between the mortise retainers **168***a*, **168***b* within the separation distance **174**, which is chosen to be substantially congruent with the width of the tenon post **143**. The neck **104** may then be rotated to slide the tenon portion **140** within the mortise portion **160** until the bed plate **155** seats in the fretboard bed **162**. At this point, the neck **104** is fully attached to the neck block **134** in the body **102** and the fingerboard **110** is at its lowest position, meaning that when the strings **116**, they will be at their highest action.

FIG. **5** depicts the forces acting on the adjustable neck joint **138** when the strings **116** are tuned and under typical tension. With the arcuate mortise and tenon construction of the adjustable neck joint **138**, there are three surfaces that interface with each other in the adjustable neck joint **138**: a heel-mortise interface **282** (between the upper arcuate wall **154** on the heel **108** and the arcuate bevels **214** on the outer mortise blocks **164***a*, **164***b* and the arcuate bevels **248** on the mortise retainer blocks **168***a*, **168***b*); a tenon-retainer interface **286** (between the lower arcuate walls **153** of the tenon rails **141***a*, **141***b* and the rear retainer surfaces **246** of the mortise retainer blocks **168***a*, **168***b*); and a tenon-mortise interface **286** (between the arcuate bottom surface **142** of the tenon rails **141***a*, **141***b* and the surface of the mortise channel **170**). As shown in FIG. **5**, when the joint is under compression, there are generally three regions of differing forces: an upper joint stress region **288** with generally higher compressive forces across the heel-mortise interface **282** and the tenon-mortise interface **286** (generally parallel to the string tension); a middle joint stress region with generally lower forces across all three interfaces (as this is the region including the mortise retention blocks **168***a*, **168***b*); and a lower joint stress region **292** with generally higher forces concentrated on the tenon-retainer interface **284**, as this is the region on which the string tension exerts the most tension forces across an interface (rather than compressive forces found in the upper joint stress region **288**) due to the force vector components at this angle. The incorporation of the reinforcement dowel **156** helps counter this strain of this force placed on the tenon portion **140** in a direction that is more transverse to the grain of the wood in the neck **104**, which is thus weaker.

Components of an exemplary adjustment mechanism **180** are shown in FIG. **6** and include a tie rod **182**, a pair of compression backstop rails **190***a*, **190***b*, a thumbwheel **186**, and a backstop plate **194**. The tie rod **182** has a first, threaded end **181** and defines a transvers clevis hole **183** at an opposite end. The clevis hole **183** is configured to receive a hinge pin **184**. Each of the compression backstop rails **190***a*, **190***b* is formed as a pie-shaped block and defines a pair of through holes **191***a*, **191***b* transverse through a thickness of the compression backstop rails **190***a*, **190***b*. The through holes **191***a*, **191** are configured to receive assembly pins **192***a*, **192***b* that are long enough to provide a separation distance between the two compression backstop rails **190***a*, **190***b* such that the threaded end **181** of the tie rod **182** will fit between them. The threaded end **181** of the tie rod **182** also fits between the assembly pins **192***a*, **192***b*, such that it is "boxed" between the compression backstop rails **190***a*, **190***b* and the assembly pins **192***a*, **192***b*.

The thumbwheel **186** defines a threaded aperture configured to receive the threaded end **181** of the tie rod **182**. The thumbwheel **186** seats between the outer arc surfaces of the compression backstop rails **190***a*, **190***b* and the backstop plate **194**. A first bushing **188***a* may be provided to seat around the threaded end of the tie rod **182** between the thumbwheel **186** and the backstop plate **194**. A second bushing **188***b* may be provided to seat around the threaded end **181** of the tie rod **182** between the thumbwheel **186** and the compression backstop rails **190***a*, **190***b*. The backstop plate **194** may define an aperture **195** configured to align with the threaded aperture in the thumbwheel **186** to allow the threaded end **181** of the tie rod **182** to extend there-through depending upon the level of adjustment of the action. The backstop plate **194** may further define several through holes for passage of mounting screws **196***a*, **196***b* used to affix the backstop plate to the neck block **134**.

FIG. **5** also depicts the completed adjustable neck joint **138** including the adjustment mechanism **180**. For inclusion of the adjustment mechanism **180**, before the tenon portion **140** of the neck **10** is inserted into the mortise portion **160**, the tie rod **182** is attached to the tenon rails **141** by placing the end of the tie rod **182** with the clevis hole **183** within the tie rod channel **150** and connecting the tie rod **182** to the tenon portion **140** with the hinge pin **184** inserted through the hinge in holes **152**. The tie rod **182** may then lie recessed in the tie rod channel **150** while the tenon portion **140** is rotated into place within the mortise portion **160** as described above. The compression backstop rails **190***a*, **190***b*, assembled with the pins **192***a*, **192***b*, are then placed about the threaded end **181** of the tie rod **182**. The wedge portions of the compression backstop rails **190***a*, **190***b* seat between the front surfaces **226** of the inner mortise blocks **166***a*, **166***b* of the mortise portion **160** and the arcuate bottom surface **142** of the tenon rails **141***a*, **141***b*.

The tie rod **182** is of a length such that the threaded portion **181** extends beyond the compression backstop rails **190***a*, **190***b* far enough to engage with the thumbwheel **186**. The first bushing **188***a* may be placed about the tie rod **182** before screwing the thumbwheel **186** onto the threaded end **181**. The second bushing **188***b* may be placed about the threaded end **181** once the thumbwheel **186** is screwed far enough onto the threads such that the threaded end **181** extends beyond the thumbwheel **186**. The backstop plate **194** may be placed against the thumbwheel **186** such that the threaded end **181** of the tie rod **182** aligns with and extends into the aperture **195**. The backstop plate **194** may then be affixed to the neck block **134** with a set of mounting screws **196***a*, **196***b*. The backstop plate **196** need not be removed to remove the neck **104** if desired, e.g., for breakdown to transport or for maintenance of the guitar **100**. The thumb-screw **186** may merely be turned to force the tie rod **182** forward, and thereby rotate the tenon portion **140** within the mortise portion **160** until the threaded portion **181** releases from the thumbscrew **186**. The neck **104** may then be removed from the neck block **134** by rotating in the opposite directions from assembly.

FIG. **5** depicts the guitar **100** in a strung state and indicates how the action can be easily adjusted using the adjustment mechanism **180** in combination with the adjustable neck joint **138**. Note first that the tenon portion **140** rotates within the mortise portion **160** about a radius origin **280**. All the radii of the arcuate surfaces of the tenon portion **140** and the mortise portion **160** are measured from this radius origin **280** and therefore align concentrically. By sharing a common radius origin **280**, all the surfaces easily slide against each other as the neck **104** is rotated during assembly or disas-sembly. For a guitar **100**, the natural location for the radius origin **280** is at a point above the 12$^{th}$ fret, which is the physical and harmonic center of the strings **116**. In this exemplary implementation, the radius origin **280** is set at about 2 mm above the fingerboard **110** above the 12th fret. However, other locations for the radius origin may be selected along the length of the fingerboard and other location may be desirable depending upon the design of the particular stringed instrument. The 2 mm height is generally the middle of the angular range **296** of the action for a guitar at this location. At locations closer to the sound hole **126** at the tail end of the fingerboard **100**, the travel distance between the strings **116** and the fingerboard **110** through the action angle **296** may be greater, e.g., about 3 mm. In other stringed instruments, the height of the action and desirable ranges may be different than for a guitar.

As indicated in FIG. **5**, the adjustment mechanism **180** may be used to move the tenon portion **140** of the neck **104** within the mortise portion **160** of the neck block **134**. By turning the thumbwheel **186**, the tie rod **182** is pulled or pushed with an extremely fine adjustment, thus also pulling or pushing the tenon portion **140** through a very small arc. In practice, the tenon portion **140** may arcuately translate through an angle of about 1 degree as indicated by the arcuate translation **294** measured at the hinge pin **184**. The arcuate translation **184** of the tenon portion **140** causes the fingerboard **110** to translate through an identical angle with respect to the strings **166** across the angular range **296**, thereby providing an adjustment to the action. Further adjustment than about 0.5 degrees in a low action direction will result in the strings **116** positioned too close to the frets **114**, which causes buzzing. Further adjustment than about 0.5 degrees in a high action direction is difficult to play and also introduces more significant torque on the saddle **130** and bridge **128**. Therefore, the depth of the fretboard bed **162** and thickness of the bed plate **155** may be chosen to create a stop interface that prevents excess rotation in the high action direction.

In another example implementation shown in FIG. **7**, a differential screw **300** may be used as the tie rod adjustment arm. A differential screw **300** uses two slightly different thread pitches in two sections **304**, **306** along the same shaft **302**, which results in movements of the two sections **304**, **306** at different rates through respective barrel nuts that act as hinge pins within the heel **108** and neck block **134**, respectively. The difference between travel rates is the effective travel rate of the mated parts, e.g., the heel **108** fixed to a first nut **308** engaging the first differential screw section **304** and the neck block **134** fixed to a second nut **310** engaging the second differential screw section **306**. The travel distances of each of the differential screw sections **304**, **306** are much farther that the relative travel distance of the heel **108** with respect to the neck block **134**, for example. The relative travel distance is actually the difference in travel distances of each of the differential screw sections **304**, **306** with respect to their nuts **308**, **310**. (This is similar to how a microscope lens adjuster works.)

In one example embodiment, the first screw section **304** may have a 10-24 thread, which translates to a travel distance of 0.0416" per turn, and the second screw section **306** may have a ¼-20 thread, which translates to a travel distance of 0.050" per turn. When the screw sections **304**, **306** are attached to opposing structures (e.g., the heel **134** and the neck block of a stringed instrument), the effective travel distance between the opposing structures is 0.008" per turn. In the context of the stringed instrument, 7.8 turns results in a 1/16" adjustment—a ratio that allows for very fine adjustment with very low force application.

In one example embodiment, one of the nuts, typically the barrel nut **308** in the heel, may be formed of a softer material than a metal, for example, nylon or Delrin® to act as a "weak link." In the event the threads of the barrel nut **308** most internal to the joint, i.e., in the heel **108**, become stripped, the outer barrel nut **310** will still work to allow the differential screw **300** to unscrew the far end from the barrel nut **308** in the heel **108**, thus releasing the heel **108** from attachment to the differential screw **300** (corresponding to the tie rod adjustment arm) and allow the neck **104** to pivot out of the neck joint **138** and separate from the body **102**. In this manner, the neck **108** will not be trapped in the neck joint **138** by the adjustment mechanism **180** using the differential screw **300**. Further, if the internal barrel nut **308** is made of a softer material, the threads will more likely shear under excessive force, releasing the internal end of the differential screw **300** and allowing the neck **108** to rotate with respect to the neck block **134**. In this manner, the softer barrel nut **308** can act as a "circuit breaker" and potentially prevent damage to or breakage of the neck **108** if the stringed instrument is dropped or otherwise subjected to bending or other torque forces between the neck **108** and the body **102**.

It should be appreciated that by using the adjustment mechanism **180**, the action can be adjusted off initial center through a full 1 degree of motion without the guitar **100** going out of tune. The axial center of rotation **280** is located along the line of the taut string when the neck **104** is in the middle of the adjustment range. Rotating the neck **104** on this axis **280** within the useful range for a guitar player essentially maintains the distance between the endpoints of the strings **116**. Thus, the tension remains unchanged and the strings **116** stays in tune regardless of the angle. Over a 1 degree range (e.g., about 3 mm from a low string position to a high string position at the last fret adjacent to the sound hole **126**), there may only be about a 2/1000 in. (0.051 mm) to 4/1000 in. (0.12 mm) change in the length of the strings **116**, which translates into a de minimis change in string tension, which further reflects in an almost imperceptible effect on tuning. In fact, a tuning device will still register the guitar **100** in tune as the action is changed from a low position to a high position using the adjustment mechanism **180** in combination with the adjustable neck joint **138**.

It may be appreciated that compression backstop rails **190*a***, **190*b*** interface with both the tenon portion **140** and the mortise portion **160** of the adjustable neck joint **138** as a form of wedge between the two surfaces. This wedge action helps prevent accidental movement of the neck **104** about the adjustable neck joint **138** by "locking" against the surfaces when the thumbscrew **186** is tightened snug against the compression backstop rails **190*a***, **190*b***. It should be understood that the wedge force of the compression backstop rails **190*a***, **190*b*** on the adjustable neck joint **138** does not prevent the fine adjustment movement of the tie rod **182** to change the action height of the strings. Such adjustment may be aided by coating the moving surfaces of the adjustable neck joint **138** with paste wax, which serves as a lubricant and also as a vapor barrier. When the guitar **100** is strung with the strings **116**, the tension on the strings **116** locks the tenon portion **140** and the mortise portion **160** rigidly together in the adjustable neck joint **138**, creating a strong joint that fully counters and withstands the string tension.

The curved, sliding, adjustable neck joint **138** is unique in form and function. There are many variations on mortise-and-tenon joints and sliding dovetails in woodworking. However, curved dovetails are extremely rare. The adjustable neck joint **138** functions partly like a mortise-and-tenon and partly like a dovetail. It is a cantilevered hinge that requires no hardware to function. A neck joint that doesn't rely on glue or fasteners is new to the art of stringed instruments. Further, all other adjustable neck joints rely on metal fasteners or brackets.

Stringed instrument necks are cantilevered by necessity for ergonomics. Most necks either use glued joints or fasteners that directly oppose the cantilever load caused by the string tension that would otherwise threaten to fold up the neck and body like a hinge. The adjustable neck joint **138** resolves the tension within the joint without requiring a fixed angle between the body **102** and neck **104** like traditional stringed instrument construction, which results in a fixed action height. Equilibrium across the adjustable neck joint **138** is achieved by spreading the compressive and the twisting loads over the semi-cylindrical faces of the tenon portion **140** and the mortise portion **160** across multiple interfaces **282**, **284**, **286**. The neck **104** and body **102** remain free to rotate around the eccentric axis, either circular or elliptical by design choice, while under load from the string tension and thereby allow for adjustment of action height.

A number of benefits are achieved by the adjustable neck joint **138** as disclosed herein. Foremost, the action is easy to adjust by changing the angle of the neck **104** with respect to the body **102**. Changing the action on most acoustic guitars necessitates de-tuning the strings and modifying the saddle with tools. This design allows for changing the action with the turn of a thumb wheel **186**. The range of adjustment is also likely sufficient to overcome warping of the body **102** over time, so a neck reset should not be necessary.

The ideal height of the bridge **128** and saddle **130** can be selected and the neck angle can match it for whatever action the player chooses. Instruments sound different depending on the amount of twisting force on the bracing caused by the lever arm of a higher or lower saddle. Typical instruments have neck angles set with a particular saddle height target for ideal tone, but if the player wants an action that is higher or lower than the builder anticipated (or if the guitar warps over time) the saddle will be higher or lower than the target. The ability to adjust the action with the thumb wheel **186** obviates this problem.

The tuning remains unaffected by the change in angle, so changing the action during a performance is possible. The center of rotation is located along the line of the taut strings **116** when the neck **104** is in the middle of the adjustment range. Rotating the neck **104** on this axis within the useful range for a guitar player essentially maintains the distance between the endpoints of the strings **116**—thus, the tension remains unchanged and the strings **116** stay in tune regardless of the angle.

In the example implementation disclosed, the curved mortise portion **160** of the neck block **134** is machined as multiple blocks that are then glued together with dowels. This ensures that the neck **104** is in alignment with the long axis of the guitar **100** and cannot rotate in any unintended way. Several redundant load bearing surfaces are machined in the heel **108** perpendicular to the long axis of the neck **104** to form the tenon portion **140** and constrain side-to-side movement. The string tension between the neck **104** and body **102** is spread over a broad wooden surface area in the joint. In comparison to typical dovetail joints in the violin family of stringed instruments, the adjustable neck joint **138** has more than twice the wood-on-wood surface area contact providing significantly greater distribution of the load across the joint.

The connection between body **102** and neck **104** is a wooden joint, which is an attribute valued by many players for the tone. The adjustable neck joint **138** requires no metal hardware to maintain the neck angle under string tension. The adjustment mechanism **180** is also not loaded by string tension. Metal hardware often buzzes and rattles, particularly when under tension, and that likelihood is reduced with this design. Because the adjustable neck joint **138** allow the neck **104** to be easily removed from the body **102**, the design makes it possible to have different necks for a single body. Musicians who sometimes play fretless or with additional strings may find it advantageous to swap necks on and off the same body if they like the tone generated by the body.

Notwithstanding the benefits of avoiding metal hardware, there are embodiments in which the use of metal structures can provide greater strength while being mounted in such a way that possible noise is entirely dampened and avoided. In one such implementation, the mortise portion in the neck block of the body may define two opposing arcuate grooves of constant radius (i.e., the arcs are circular sections), depth (e.g., ½" deep), and width (e.g., ⅛" wide). An arcuate piece of metal may be fixed within each groove and extend laterally into the mortice area (e.g., about ¼" protrusion) when fully seated in the grooves to form respective trunnions. In one embodiment, the metal trunnion pieces may be cut from a section of metal pipe of a radius congruent with the radius origin for the arc of the tenon on the heel moving within the mortice of the neck block (e.g., the $12^{th}$ fret on the neck of a guitar). In one embodiment, the radius of the arc of the grooves matches the dimensions of a 6" diameter metal pipe. In some implementations, the metal may be aluminum to offer a lightweight, smooth surface for joint movement, while providing significant strength to the joint without degradation, e.g., rust. The tenon on the heel of the neck is similar to the all-wood version of the joint described above. The difference is that instead of a forming a wooden I-beam shape, corresponding grooves are cut into lateral sides of the tenon on the heel to mate with the metal trunnions. The metal trunnions create a durable and precise trunnion for the neck to slide along.

In this embodiment, the tie rod adjustment arm may be a differential screw as described above interfacing with two barrel nuts, one in each of the neck block in the body and the heel of the neck to act as connectors and hinge pins. The first tie rod hinge pin is a barrel nut in the tenon of the heel, which is positioned in a similar location as in prior embodiments. The second tie rod hinge pin may be in the form of a barrel nut fixed within the neck block under the backboard instead of floating on the heel. A hole in the backboard may allow for access by an adjustment wrench to the end of the differential screw for adjustment or removal.

The neck **104** is also easy to remove for shipping. When acoustic guitars are shipped, there is a high risk of damage if the case is dropped. The design requirements for a slim guitar neck conspire to make the area near the nut the likeliest point of breakage when the inertia of the relatively massive body pushes the headstock against the case in a fall. With the adjustable neck joint **138** disclosed herein, the player can easily remove the neck **104** for shipping and thereby avoid a common cause of damage.

String Anchor for Use with Floating Bridge

In another implementation, an alternative bridge design is disclosed. In order to contrast the features of the alternative bridge, an initial discussion of a typical prior art pin bridge **328** depicted in the portion of a prior art guitar **300** of FIG. **8**. The pin bridge **328** supports a saddle **330** and also includes a pin hole section **331** for termination of the strings **316**. The pin hole section **331** defines six holes, one for each string, in a row behind the saddle **330** that extend through the pin bridge **328**. In the prior art, a pin bridge **328** is typically glued to the top of the soundboard **320** beyond the sound hole. The soundboard **320** defines holes aligned with and position beneath the holes in the pin hole section **331**. A bridge plate **340**, e.g., a flat piece of wood used as a supporting structure may further be glued to the bottom side of the soundboard **320** beneath the bridge **328** within the resonant enclosure of the body. Additional holes corresponding to and aligning with the holes in the pin hole section **331** and the soundboard **320** may also be provided in the bridge plate **340**. The ends of the strings **316** extend over the saddle **330** and pass through the holes in the pin hole section **331** of the pin bridge **328**, the corresponding holes in the soundboard **320**, and the corresponding holes in the bridge plate **340**. The strings **316** are retained in the pin hole section **331** by bridge pins **329**.

Wire strings **316** typically terminate with ball ends **317** as a structural aid to retain the strings **316** with the pin hole section **331** in the pin bridge **328**. The ball ends **317** are typically small metal rings that the string wires wrap around. The ends of string wires then are twisted back on their length to form a tight eye around the ball ends **317**, which form the terminal ends of the strings **316**. The aligned holes through the pin hole section **331**, the soundboard **320**, and the bridge plate **340** are large enough for the ball ends **317** to pass through. The bridge pins **329** are formed with a head on top and then taper conically along their length to a bottom end. The bridge pins **329** are inserted into respective holes in the pin hole section **331** of the pin bridge **328** and fit tightly therein as a wedge and compress the strings **316** against the rear sides of the holes. The ball ends **317** are restrained against the bottom surface of the bridge plate **340** and the side wall of the tapered section of the bridge pins **329**, thereby securing the ends of the strings **316** to the pin bridge **328**. The strings **316** typically form a "break angle" of about 25-30 degrees from the top of the saddle **330** to the holes in the pin hole section **331**. This angle provides a good balance between maintaining the longitudinal tension along the strings **316** and resisting the rotational torque on the saddle **330** and pin bridge **328** caused by the downward force component of the strings **316** behind the saddle **330**.

A typical fixed pin bridge **328** such as shown in FIG. **8** relies on a glue seam between the pin bridge **328** and the soundboard **320** to hold up to 170 lbs (756 N) or more of tension on the strings **316**. Changes in humidity often break this seam loose or crack the soundboard top **320** of the guitar **300** due to the mismatch in rates or amounts of seasonal shrinkage between the harder wood species used for the bridge **328** and the softer wood species used for the soundboard **320**. Additionally, over time, as a saddle is lowered to maintain an appropriate action height, the break angle may decrease to as little as 10 degrees. When the break angle is this shallow, there may not be enough downward tension on the strings **316** across the saddle **330**, resulting poor tone. One solution when the saddle **330** gets to low (e.g., about ¹⁄₁₆" from the wood of the pin bridge **328**) is to cut channels between the saddle slot and the bridge pin holes so that the strings **316** can take a more direct path downward to the bridge plate **340**.

FIGS. **9-13** disclose a new implementation of a bridge system **405** for an acoustic guitar **400** or similar stringed instrument. The bridge system **405** is provided by a combination of a bridge **428** and saddle **430**, a bridge plate **440**, and a string anchor **450** as shown and further described below. As depicted, the bridge **428** sits on top of the soundboard **402** beyond the sound hole and supports a saddle **430**. In this implementation, the bridge **428** may "float," i.e., it may not be glued to the soundboard **420** of the guitar **400**. This allows the player some flexibility in placement of the bridge for tone and allows the player to swap out different bridges and saddles as desired. In addition, because the bridge **428** is not glued to the soundboard **420**, differences in seasonal shrinkage and expansion of different species of wood as between the bridge **428** and the soundboard **420** due to humidity and temperature will not negatively affect the interface between either structure.

A series of six eyeholes **422** are formed within and through the soundboard **420** behind and parallel to the bridge **429**. The eyeholes **422** may be keyhole-shaped with a larger circular opening on one side closest to the bridge and a rectangular €slot of narrower width that the diameter of the circular portion extending away from the circular portion toward the tail of the guitar **400**. The circular portions of the eyeholes **422** are of a diameter large enough for a ball end **417** of a wire guitar string **416** to pass through.

The bridge plate **440** is affixed to the underside of the soundboard **420** and seats beneath the bridge **428** and extends toward the tail of the guitar **400** underneath the eyeholes **422** and beyond. As depicted in isolation in FIG. **10**, the bridge plate **440** may be formed with two different sections: a flat, uniformly thinner shelf section **442** that extends under the soundboard eyeholes **422** and a thicker cleat section **444** that generally seats underneath the bridge **428**. The shelf section **442** defines a series of six bridge plate eyeholes **446** that are formed as keyhole-shapes of the same size and form as the soundboard eyeholes **422** and are positioned underneath and directly aligned with the soundboard eyeholes **422**. As shown in FIGS. **12** and **13**, in some implementations, the bridge plate **440** may be formed to fit within and butt against bracing strips **460** adhered to the underside of the soundboard **420**. Bracing strips **460** are provided in various design patterns to reinforce the soundboard **420** and also affect the resonance generated by the soundboard **420** and the body cavity depending on number, size, location, and stiffness of the wood species.

The string anchor **450**, depicted in isolation in FIG. **11**, is a counterpart functionally to the bridge pins **329** and bridge plate **340** in the prior art only in that it secures the ends of the strings to the body of the guitar **400**. The string anchor **450** is positioned with the body of the guitar **400** on the shelf section **442** of the bridge plate **440**. The string anchor **450** is not glued or otherwise affixed or adhered to the bridge plate **440**; it is a floating piece. The edge of the string anchor **450** away from the tail abuts against and interfaces with the cleat section **444** of the bridge plate **440**. In some implementations, the string anchor **450** may be removably attached to the shelf section **442**, for example, with double sided tape or a small set of opposing magnets in each of the string anchor **450** and the shelf section **432** in order to hold the string anchor in position while stringing the guitar **400** before tension is applied to the strings **416** to firmly hold the string anchor **450** in place. The string anchor **450** defines a series of six anchor eyeholes **452** that are formed as keyhole-shapes of the same size and form as the soundboard eyeholes **422** and are positioned underneath and directly aligned with the soundboard eyeholes **422** and the bridge plate eyeholes **446**. The string anchor **450** further defines a recessed ball tray **454** behind the anchor eyeholes **452** toward the tail of the guitar **400**. As best shown in FIG. **11**, the recessed ball tray **454** is adjacent to the slot portions of the eyeholes **452** and is oriented parallel to the bridge **428**. The recessed ball tray **454** is of a width designed to receive and retain the ball ends **417** of the strings **416** as depicted in FIGS. **11** and **12**.

When the guitar **400** is strung, the ball ends **417** of the strings **416** are passed through the circular openings in the soundboard eyeholes **422**, the bridge plate eyeholes **446**, and the string anchor eyeholes **452** and are seated within the recessed ball tray **454**. As the strings **416** are placed under tension by turning the keys and pegs attached to the far ends of the strings **416** at the headstock, the string anchor **450** is pulled tightly against the cleat **444** on the bridge plate **440**, which holds the string anchor **450** in place. The bracing **460** abutting the bridge plate **440** provides additional resistance to the string tension. The strings **416** extend from within the body of the guitar within the slot portions of each of the eyeholes **422**, **446**, **452** and are held firmly against the saddle **430**.

Depending upon designed location of the components of the bridge system **405**, the angle of the strings **416** extending from the tail side of the saddle **430** may be preset across an acceptable range. For example, in the implementation shown in FIGS. **9-13**, the strings **416** extend from the bridge **430** at an angle of about 40 degrees, which is less steep than typical angles using prior art pin bridges. At a 40 degree angle, the downward vector of the string tension force is reduced (similar to a jazz or classical guitar with a tailpiece for securing the ends of the strings), resulting less rotational or twisting force on the saddle **430** and bridge **428**. Additionally, because the bridge **428** is floating and not adhered to the surface of the soundboard **420**, the torque on the bridge **428** is not significantly translated to the soundboard **420**, reducing the likelihood of cracking the soundboard **420** due to humidity stress.

The string anchor **450** of the bridge system **405** of the disclosed implementation, functions like a "deadman" anchor in construction and other fields. As described above, typical steel string bridges have a pin bridge. Nylon string guitars usually have a string-through tie block or have a floating bridge and a tailpiece to which the strings are tied off. Each of these prior art designs load the bridge and the bracing under the soundboard differently. The disclosed design of the bridge system **405** separates the bridge into two parts with different jobs: a floating bridge **428** to hold the saddle **430**, and an internal floating string anchor **450** that also braces the soundboard **420** laterally. The string anchor **450** functions more like a tailpiece (although connected to the soundboard rather than the tail block), assuming a greater amount of the longitudinal load and reducing the torque across the bridge **428**.

Since the internal string anchor **450** is not glued in place, it can be replaced when the ball-ends **417** wear out the recessed ball tray **454**. In contrast, patching or replacing a worn-out bridge plate under a standard pin bridge can be costly. As an added benefit, the guitar builder can string up the guitar before finishing to assess quality of construction, tolerances, and even tone before applying final finishes (e.g., stains and lacquers). With typical guitar construction, the bridge cannot be glued to the soundboard until after the body finishes are completed, thus preventing the guitar to be strung until completely built.

Additionally, interchangeable string anchors **450** of different wood species can be swapped in and out to change the tone of the guitar or to pair with different string types. For example, a lighter, more flexible wood species spring anchor may be used with extra-light gauge strings. String anchors made of stronger or denser wood species can be inserted to increase the stiffness of the soundboard **402** and thus change the tone and increase sustain of the guitar.

All directional references (e.g., proximal, distal, upper, lower, upward, downward, left, right, lateral, longitudinal, front, back, top, bottom, above, below, vertical, horizontal, radial, axial, clockwise, and counterclockwise) are only used for identification purposes to aid the reader's understanding of the structures disclosed herein, and do not create limitations, particularly as to the position, orientation, or use of such structures. Connection references (e.g., attached, coupled, connected, and joined) are to be construed broadly and may include intermediate members between a collection of elements and relative movement between elements unless otherwise indicated. As such, connection references do not necessarily infer that two elements are directly connected and in fixed relation to each other. The exemplary drawings are for purposes of illustration only and the dimensions, positions, order and relative sizes reflected in the drawings attached hereto may vary.

In addition, any disclosure of components contained within other components or separate from other components should be considered exemplary because multiple other architectures may potentially be implemented to achieve the same functionality, including incorporating all, most, and/or some elements as part of one or more unitary structures and/or separate structures.

The detailed description set forth above in connection with the appended drawings describes examples and does not represent the only instances that may be implemented or that are within the scope of the claims. The terms "example" and "exemplary," when used in this description, mean "serving as an example, instance, or illustration," and not "preferred" or "advantageous over other examples."

As used herein, including in the claims, the term "and/or," when used in a list of two or more items, means that any one of the listed items can be employed by itself, or any combination of two or more of the listed items can be employed. For example, if a composition is described as containing components A, B, and/or C, the composition can contain A alone; B alone; C alone; A and B in combination; A and C in combination; B and C in combination; or A, B, and C in combination. Also, as used herein, including in the claims, "or" as used in a list of items (for example, a list of items prefaced by a phrase such as "at least one of" or "one or more of") indicates a disjunctive list such that, for example, a list of "at least one of A, B, or C" means A or B or C or AB or AC or BC or ABC, or A and B and C.

The above specification, examples and data provide a complete description of the structure and use of exemplary embodiments of the invention as defined in the claims. Although various embodiments of the claimed invention have been described above with a certain degree of particularity, or with reference to one or more individual embodiments, other embodiments using different combinations of elements and structures disclosed herein are contemplated, as other iterations can be determined through ordinary skill based upon the teachings of the present disclosure. It is intended that all matter contained in the above description and shown in the accompanying drawings shall be interpreted as illustrative only of particular embodiments and not limiting. Changes in detail or structure may be made without departing from the basic elements of the invention as defined in the following claims.

What is claimed is:

**1**. An adjustable neck joint for a stringed instrument comprising:

a neck with a heel portion formed as a first half of a rotating joint; and

a neck block formed as a second half of the rotating joint; wherein

the first half of the rotating joint and the second half of the rotating joint are each configured to connect with each other and movably interface with each other such that the neck is rotatable with respect to the neck block about an axis perpendicular to a longitudinal axis of the neck;

the first half of the rotating joint is one of an arcuate mortise or an arcuate tenon structure; and

the second half of the rotating joint is an opposing one of the arcuate mortise or arcuate tenon structure to the first half of the rotating joint.

**2**. The adjustable neck joint of claim **1**, wherein:

the first half of the rotating joint is an arcuate, T-shaped tenon structure; and

the second half of the rotating joint is an arcuate mortise structure configured to accept and retain the arcuate, T-shaped tenon structure.

**3**. The adjustable neck joint of claim **1**, wherein:

the first half of the rotating joint comprises one of an arcuate trunnion extending from sidewalls of or a corresponding arcuate channel defined within sidewalls of one of the heel portion and the neck block; and

the second half of the rotating joint comprises an opposing one of the arcuate trunnion or the arcuate channel to the first half of the rotating joint.

**4**. The adjustable neck joint of claim **3**, wherein the trunnion is formed of metal as an arcuate section of a cylinder.

**5**. The adjustable neck joint of claim **1** further comprising an adjustment mechanism attached at a first end to the first half of the rotating joint and constrained with respect to the neck block at a second end, wherein the adjustment mechanism is configured to finely move the heel portion with respect to the neck block through an angle of at least 1 degree, such angle having a vertex located on the axis.

**6**. A stringed instrument comprising:

a neck with a heel portion formed as a first half of a rotating joint; and

a body with a neck block formed as a second half of the rotating joint; wherein

the first half of the rotating joint and the second half of the rotating joint are each configured to connect with each other and movably interface with each other such that the neck is rotatable with respect to the body about an axis perpendicular to a longitudinal axis of the neck;

the first half of the rotating joint is one of an arcuate mortise or an arcuate tenon structure; and

the second half of the rotating joint is an opposing one of the arcuate mortise or arcuate tenon structure to the first half of the rotating joint.

**7**. The stringed instrument of claim **6**, wherein

the neck further comprises

a peghead on an opposite end of the neck from the heel; and

a fingerboard extending along a top surface of the neck from the peghead to beyond the heel;

the body further comprises

a top surface;

a bridge mounted on the top surface; and

a string termination structure connected to the body; and

the stringed instrument further comprises a plurality of strings, each connected at a first end to the peghead and at a second end to the string termination structure, extending above and along the fingerboard, and supported above the top surface of the body by the bridge at an intermediate location along a length of each string; and further wherein upon rotation of the first half of the rotating joint with respect to the second half of the rotating joint, the fingerboard moves toward or away from the strings, thereby adjusting an action; and

upon such adjustment of the action, the strings remain in tune.

**8**. The stringed instrument of claim **7**, wherein the axis is positioned immediately adjacent to and above a position along the neck within a plane defined by two or more of the strings.

**9**. The stringed instrument of claim **6**, wherein:

the first half of the rotating joint is an arcuate, T-shaped tenon structure; and

the second half of the rotating joint is an arcuate mortise structure configured to accept and retain the arcuate, T-shaped tenon structure.

**10**. The stringed instrument of claim **6**, wherein:

the first half of the rotating joint comprises one of an arcuate trunnion extending from sidewalls of or a corresponding arcuate channel defined within sidewalls of one of the heel portion and the neck block; and

the second half of the rotating joint comprises an opposing one of the arcuate trunnion or the arcuate channel to the first half of the rotating joint.

**11**. The stringed instrument of claim **10**, wherein the trunnion is formed of metal as an arcuate section of a cylinder.

**12**. The stringed instrument of claim **6** further comprising an adjustment mechanism attached at a first end to the first half of the rotating joint and constrained with respect to the neck block at a second end, wherein the adjustment mechanism is configured to finely move the heel portion with respect to the neck block through an angle of at least 1 degree, such angle having a vertex located on the axis.

**13**. The stringed instrument of claim **12**, wherein the adjustment mechanism comprises a tie rod.

**14**. The stringed instrument of claim **12**, wherein the adjustment mechanism comprises a differential screw.

**15**. The stringed instrument of claim **6**, wherein the stringed instrument is a guitar.

**16**. A method for adjusting an action of a stringed instrument, wherein the stringed instrument comprises:

a neck with a heel portion formed as a first half of a rotating joint;

a body with a neck block formed as a second half of the rotating joint, wherein:

the first half of the rotating joint and the second half of the rotating joint are each configured to connect with each other and movably interface with each other such that the neck is rotatable with respect to the body about an axis perpendicular to a longitudinal axis of the neck;

the first half of the rotating joint is one of an arcuate mortise or an arcuate tenon structure; and

the second half of the rotating joint is an opposing one of the arcuate mortise or arcuate tenon structure to the first half of the rotating joint; and

an adjustment mechanism attached at a first end to the heel portion in the first half of the rotating joint and constrained with respect to the neck block at a second end; wherein

the method comprises operating the adjustment mechanism to finely move the heel portion with respect to the neck block within the rotating joint through an angle of at least one degree, the angle having a vertex located on the axis, such that the a surface of the neck is movable toward and away from strings of the stringed instrument while the strings remain in tune.

**17**. The method of claim **16** further comprising:

operating the adjustment mechanism to disengage attachment of the first end of the adjustment mechanism from the heel portion in the first half of the rotating joint; and

rotating the heel portion through the rotating joint until the heel portion disengages from the neck block.

**18**. The method of claim **17** further comprising:

inserting the heel portion into the neck block to connect the heel portion to the neck block and form the rotating joint;

engaging the first end of the adjustment mechanism with the heel portion;

rotating the neck with respect to the body about the axis of the rotating joint; and

tightening the adjustment mechanism to firmly affix the heel portion within the neck block and resist rotation of the neck with respect to the body through the rotating joint.

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