March 22, 1966 C. L. FENDER 3,241,418

GUITAR INCORPORATING INERTIAL VIBRATO DEVICE

Filed June 5, 1964 2 Sheets-Sheet 1

FIG. 1

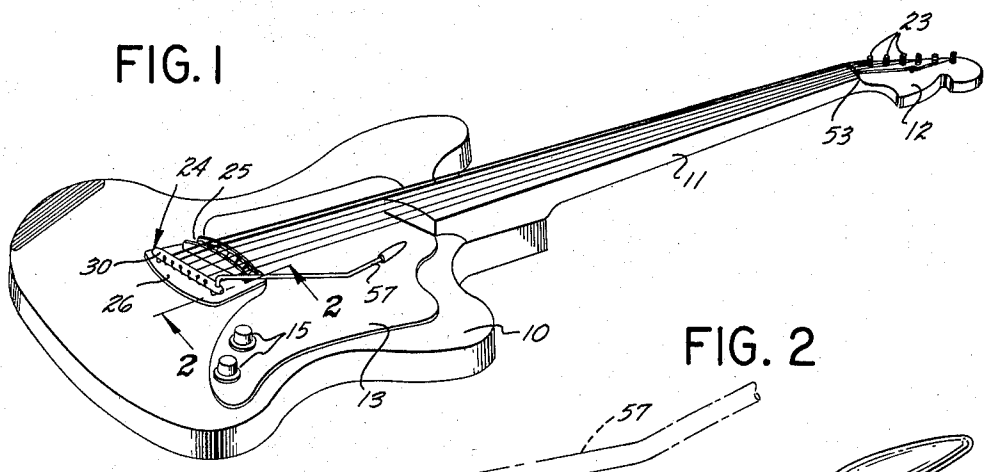
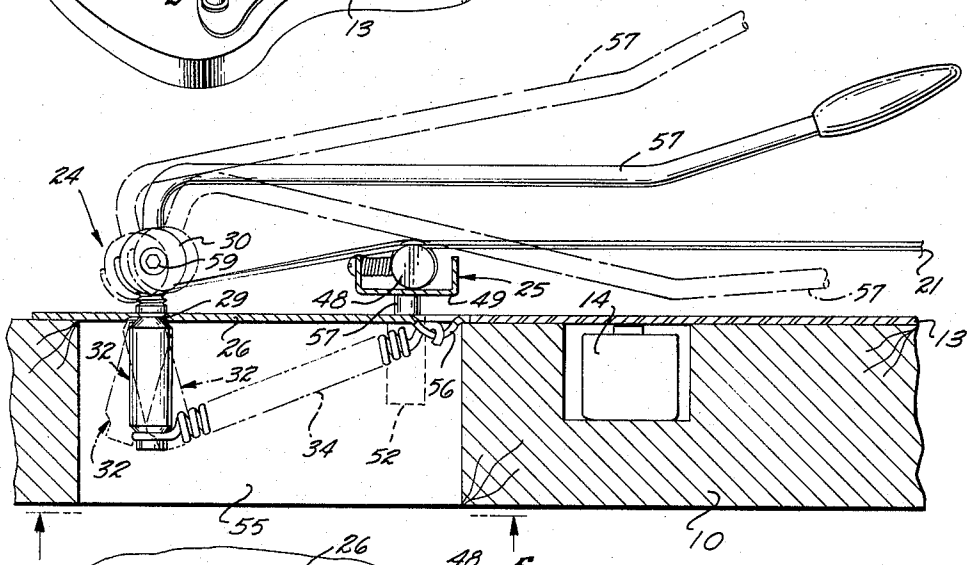


FIG. 2



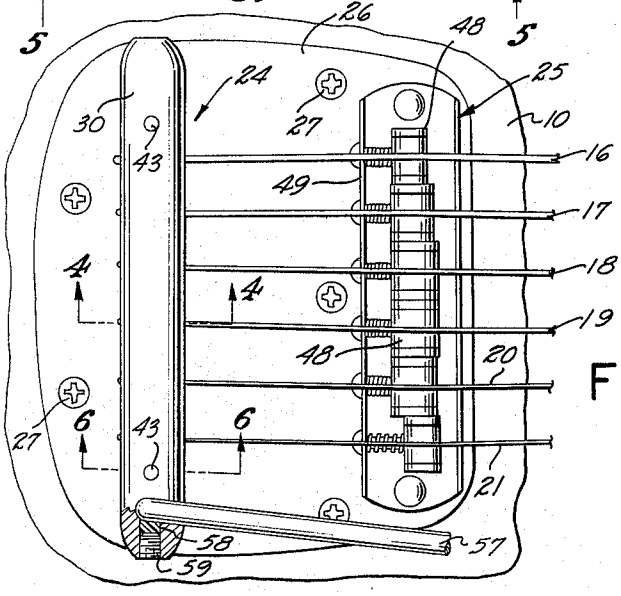


FIG. 3

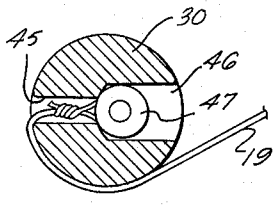


FIG. 4

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GUITAR INCORPORATING INERTIAL VIBRATO DEVICE

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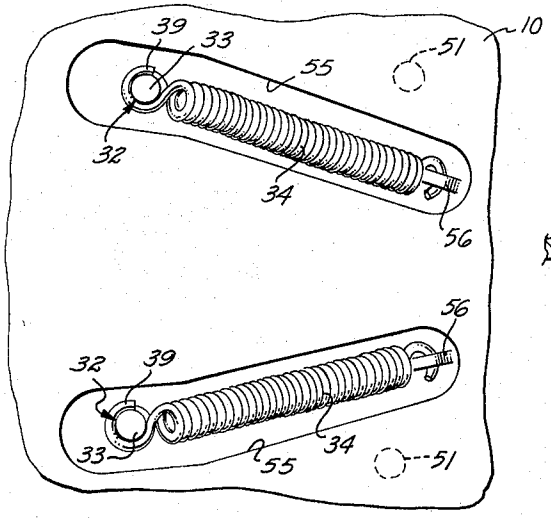

FIG. 5

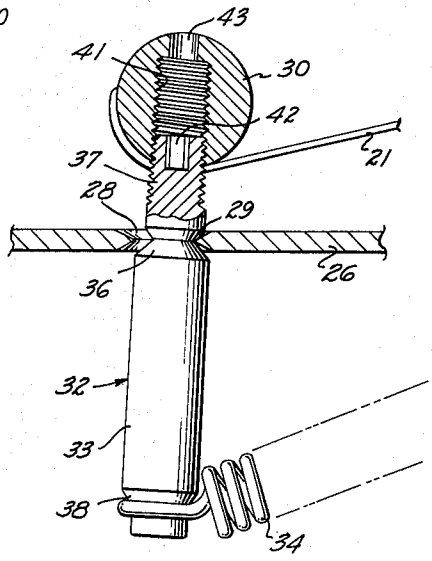

FIG. 6

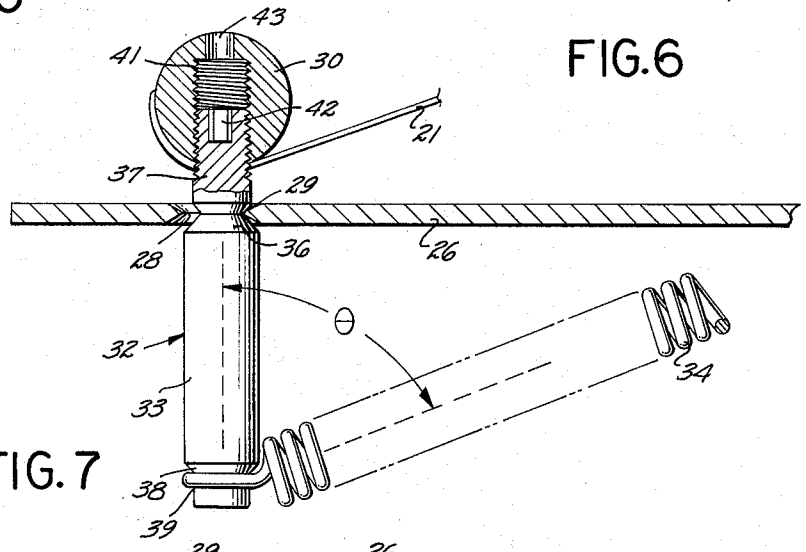

FIG. 7

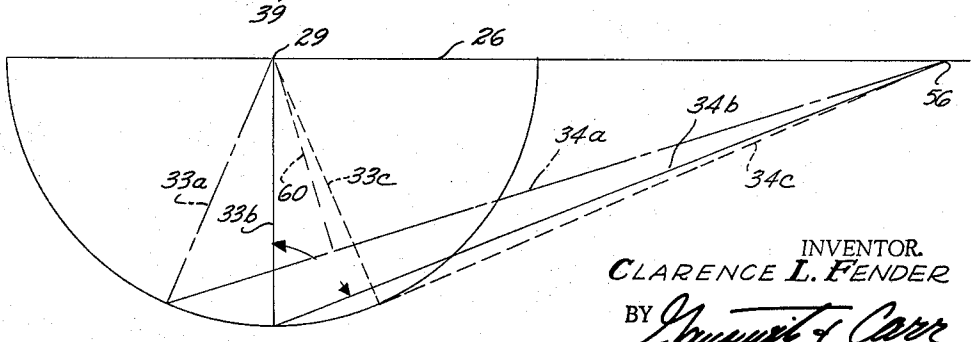

FIG. 8

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GUITAR INCORPORATING INERTIAL VIBRATO DEVICE

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Filed June 5, 1964, Ser. No. 372,908
14 Claims. (Cl. 84—313)

This invention relates to a vibrato construction for guitars and the like, and to a guitar incorporating such vibrato construction.

A primary object of the invention is to provide a vibrato device which, although light in weight and highly compact, is characterized by a surprisingly great inertial effect.

Another object is to provide a guitar incorporating a vibrato construction which requires relatively little effor to operate, the relationship being such that the effects resulting from tensioning and slackening of the strings are compensated for automatically by variations in the moment arms through which the compensating spring means operate.

An additional object is to provide a combination vibrato and bridge construction for guitars, such construction being highly compact in order to prevent or minimize interaction between the operative string portions and the string portions between the bridge and the vibrato.

An additional object is to provide a guitar incorporating a vibrato device which is extremely simple to assemble and adjust, regardless of variations in the characteristics of the particular guitar strings or of the spring-bias means.

These and other objects will become apparent from the following detailed description taken in connection with the accompanying drawings in which:

FIGURE 1 is a perspective view illustrating a guitar incorporating the inertial vibrato device;

FIGURE 2 is an enlarged fragmentary sectional view taken generally on line 2—2 of FIGURE 1, and showing the vibrato in various pivoted positions adapted to thereby vary the string tension and produce a vibrato effect;

FIGURE 3 is a fragmentary plan view illustrating the vibrato and bridge portions of the guitar;

FIGURE 4 is an enlarged fragmentary sectional view on line 4—4 of FIGURE 3;

FIGURE 5 is a fragmentary bottom view of the vibrato device, as viewed from the plane 5—5 indicated in FIGURE 2;

FIGURE 6 is an enlarged transverse sectional view taken generally on line 6—6 of FIGURE 3 and corresponding to portions of FIGURE 2, a neutral position being illustrated when the device is adjusted to a condition such that the levers are not perpendicular to the base plate;

FIGURE 7 is a view corresponding to FIGURE 6 but

illustrating a second adjusted condition such that the levers are substantially perpendicular to the base plate; and

FIGURE 8 is a diagrammatic view indicating variations in the moment arm through which the compensating spring means operate, which variations occur in response to pivoting of the levers and are such as to compensate automatically for variations in string tension resulting from such pivoting.

Referring first to FIGURE 1 of the drawings, the invention is incorporated in a guitar having a body **10**, a neck **11** and a head **12**. The guitar is illustrated as being of the solid-body type, including a finger board or face plate **13** which is suitably mounted on the upper surface or face of the body **10**. Other conventional components include an electromagnetic pickup (FIGURE 2), and suitable tone and volume controls **15** adapted to control the characteristics of the electrical signal generated by the pickup in response to vibration of the strings **16–21**.

The guitar strings **16–21**, which are formed of a suitable magnetizable material, are extended in stretched or tensioned relationship between tuning screws **23** (on head **12**) and the vibrato device **24** of the present invention. The arrangement is such that the strings lie generally in a single plane (or on a small section of an imaginary large-diameter cylinder) which is generally parallel to the face plate **13**.

The vibrato device **24**, and a bridge **25** which is closely associated therewith as will be described hereinafter, include a strong metal base plate **26** which is rigidly anchored, as by screws **27**, to the guitar body **10** adjacent face plate **13**. Openings **28** (FIGURES 6 and 7) are provided in base plate **26** along a line transverse (preferably perpendicular) to the guitar strings **16–21**, in order that fulcrum portions **29** will be formed. Such fulcrum portions **29** are adapted to support pivotal movement of an inertial string-mounting means **30** next to be described.

The inertial string-mounting means **30** comprises a metal bar extending transversely (preferably perpendicularly) to the strings **16–21** above the openings **28**. The illustrated bar is formed of steel and is generally cylindrical in shape, the diameter of the cylinder being sufficient to cause the bar to have the requisite mass as will be described subsequently.

First-class levers **32** are employed to effect the above-indicated pivotal association between the inertial string-mounting means **30** and the fulcrum portions **29** of base plate **26**. The levers are preferably identical to each other, each extending through one of the openings **28**. Each lever **32** comprises a lower portion **33** disposed beneath base plate **26** and connected to a tension spring **34**, a pivot portion **36** disposed in opening **28** and pivotally associated with a fulcrum portion **29**, and an upper portion **37** disposed above the base plate **26** and connected to the inertial member **30**.

The lower portion **33**, which preferably has a diameter larger than that of opening **28** in order to prevent ac-

cidental movement of the lever upwardly therethrough, has a reduced-diameter lower end in order to provide a shoulder **38** (FIGURES 6 and 7) adapted to seat the hook-shaped end **39** of the associated tension spring **34** which is of the helical-wire type. The relationship is such that the entire lever **32** may be rotated about the longitudinal axis thereof without in any way disturbing the connection between the lower lever end and the spring **34**.

The pivot portion **36** of each lever comprises a V-sectioned annular groove adapted to effect substantially friction-free pivotal association with fulcrum portion **29** of the base plate. The fulcrum portion **29** is preferably formed by countersinking opposite sides of base plate **26** to provide frustoconical surfaces which meet at a sharp fulcrum edge. The angle between such frustoconical surfaces is substantially smaller than the angle between the frustoconical walls which define the V-sectioned annular groove **36**, so that the lever may pivot as desired. Such pivotal movement is about an axis which is contained in the base plate **26** and extends transversely (preferably perpendicularly) to the guitar strings.

The upper portion **37** of each lever is shown as being externally threaded for threaded insertion into a corresponding internally-threaded opening **41** in the string-mounting bar **30**. A hexagonally-shaped socket **42** is formed in the upper end of lever portion **37** for reception of a wrench, the latter being adapted to be inserted through an opening **43** which forms an extension of the opening **41**. In this manner, the entire lever **32** may be rotated about the longitudinal axis thereof in order to adjust the distance between the string-mounting means **30** and the pivot axis through base plate **26**. This provides an important advantage relative to adjustment of the neutral position of the vibrato device, as will be discussed subsequently relative to FIGURES 6 and 7.

The ends of strings **16–21** are directly connected to the inertial means **30**, in the absence of any intermediate bars, levers or connectors, as best shown in FIGURE 4. Thus, each string end is extended beneath the bar **30** and through a horizontal passage **45** into a recess or counterbore **46**. An eyelet **47** is mounted at the string end in the usual manner, to prevent movement thereof through the passage **45**. The extension of the string end beneath the inertial member **30**, instead of thereabove, insures that the requisite downward pressure will be brought to bear on the bridge **25**.

The bridge **25** is a rocking or pivoting bridge which may be identical to the one described in my previous Patent No. 2,972,923, issued February 28, 1961, for Floating Tremolo and Bridge Construction for Lute-Type Musical Instruments.

Such a bridge has string-contacting barrels **48** which are supported on a channel **49** having legs or posts **51** which extend downwardly into sockets **52**, the latter being suitably mounted in the support plate **26** and guitar body **10**. The sockets **52** are sufficiently large to permit pivoting of the legs or posts **51** therein, so that the bridge rocks as the strings **16–21** are moved in response to pivoting of the levers **32**. Therefore, there is no relative movement between the bridge and the strings, and no rubbing or wearing engagement therebetween.

It is a feature of the present invention that the bridge **25** may be disposed very close to the vibrato device **24**. This produces an advantage in that the lengths of the string sections between the bridge and vibrato may be extremely short, thus preventing substantial interaction between such string section and harmonics in the operative string sections (which extend between bridge **25** and the second bridge **53**, adjacent head **12**).

Proceeding next to a further description of the tension springs **34**, which provide a spring bias compensating for the tension of strings **16–21**, these are mounted in suitable slots or recesses **55** (FIGURE 5) formed in guitar body **10**. In order to permit the desired close spacing between the bridge **25** and the vibrato device **24**, the springs **34** and the slots therefor are caused to converge in the direction toward head **12**, the result being that the slot and spring ends are located between the bridge posts **51** as illustrated. The spring ends adjacent head **12** are suitably hooked to slit portions **56** of the base plate **26**, in a manner which permits upward and downward pivoting of the springs without effecting distortion thereof.

The springs **34** are sufficiently tensioned that the coils thereof are separated considerably, thereby permitting the lower ends of levers **32** to pivot toward the head **12** without eliminating the spring tension.

The remaining element in the apparatus comprises a crank **57** which is connected to one end of the string-mounting bar **30**, extending therefrom to a position adjacent the operative portions of the strings. The manner of connecting the crank to the bar **30** is such that depression or raising of the crank causes pivoting of the levers **32** to the positions illustrated in FIGURE 2 and to various intermediate positions. The crank is also adapted to pivot about a generally vertical axis, as described in my previous Patent No. 2,741,146, issued April 10, 1956, for a Tremolo Device for Stringed Instruments, in order to permit movement of the end thereof with the hand of the guitarist.

A suitable nylon friction element **58**, with associated set screw **59** (FIGURE 3) should be provided in order to prevent undesired pivoting (or play) of the crank about the vertical axis.

Description of various critical relationships, operations and advantages

The inertial string-mounting means **30** should have a mass sufficiently large to resist vibrations induced by at least the higher-pitched ones of strings **16–21**, so that the strings vibrate in a sustained manner as is desired. Furthermore, the mass should be sufficient to prevent the strings from interacting with or modulating each other. It has been found that, in the present construction wherein the strings are connected directly (over the rocking bridge **25**) to an inertial member which is pivotally supported in floating relationship (the string tension being balanced by the spring means) above the base plate **26**, the mass of the inertial member may be surprisingly low and still achieve the requisite results. For example, the mass of bar **30** may be approximately three ounces. This results in important advantages relative to portability, manufacturing costs, etc.

It will be understood that, during the mass production of guitars, the tension exerted by various springs **34** will vary within a considerable range. Furthermore, the tension exerted by the guitar strings **16–21** varies considerably. According to one important feature of the present invention, the results of such variations may be readily compensated for by merely rotating the levers **32** about their longitudinal axes, by means of wrenches inserted through openings **43** into sockets **42** as stated above.

Referring to FIGURE 6, the illustrated adjusted condition is such that the string-mounting bar **30** is relatively remote from base plate **26**, so that the lever arm through which the strings act is relatively long. Therefore, the illustrated neutral position is such that the levers **32** are pivoted somewhat clockwise from the vertical. This may be compensated for by merely rotating the levers **32** in directions effecting lowering of the string-mounting bar **30** to the position shown in FIGURE 7, for example. The illustrated neutral position is then such that the levers **32** are vertical, that is to say perpendicular to base plate **26**. Particularly for reasons to be described below, it is preferred that the neutral or floating position (at which the spring bias exactly counterbalances the string tension, with no force being ex-

erted on crank 57) occur when the levers 32 are vertical as shown in FIGURE 7.

Referring next to schematic FIGURE 8, the solid line 33*b* represents the lower portion 33 of lever 32, when the same is perpendicular to base plate 26. Thus, the angle θ is the same in FIGURE 7 and in FIGURE 8, it being understood that the solid line 34*b* represents the axis of each spring 34. The horizontal line 26 represents the base plate, whereas the center of the indicated semicircle in FIGURE 8 represents the fulcrum portion 29 of the base plate.

The lines 33*a* and 33*c* represent substantially the extreme pivoted positions of each lower lever portion 33, whereas the lines 34*a* and 34*c* represent the corresponding pivoted positions of each tension spring 34.

It is emphasized that the angle θ is substantially less than ninety degrees, and that the relationship should not be such that such angle over becomes more than ninety degrees regardless of the pivoted position (within the usual range of vibrato operation) of the lever portion 33. Because of this relationship, raising of the crank 57 (FIGURE 2) will cause the tension spring 34 to operate through a progressively longer moment arm (for example, coincident with line 33*c*) relative to fulcrum 29, as is desired in order to counteract the resulting increased string tension. Conversely, lowering of crank 57 will cause the spring 34 to operate through a progressively shorter moment arm, as is also desired in that the string tension is thereby lessened and requires less force to counteract. For example, the short moment arm relative to line 33*a* is shown at 60.

Thus, it will be observed that the moment arm 60 through which spring 34*a* operates when the lever is in the 33*a* position is very much shorter than is the moment arm through which spring 34*c* operates when the lever is in the 33*c* position. As the result of such relationship, the crank 57 may be manually operated with a very minimum of force or effort.

In summary, therefore, the described vibrato device 24 and associated bridge means 25 are very lightweight, simple and economical, yet produce many advantages some of which will next be briefly re-stated.

(1) The string ends are directly connected to the inertial string-mounting element 30, which floats above plate 26, thereby resulting in a surprisingly great inertial effect for an inertial element of given mass.

(2) The crank 57 may be operated with a minimum of effort, because of the automatically-compensated bias action of springs 34 as described in detail above.

(3) The vibrato device may be readily adjusted to compensate for variations in spring bias and string tension, merely by rotating the levers 32 about their longitudinal axes as described relative to FIGURES 6 and 7.

(4) The bridge 25 may be mounted very close to the vibrato device 24, in straddling relationship relative to the ends of springs 34, thereby causing the string sections between the bridge and vibrato to be very short in order to minimize interaction with harmonics in the operative string portions.

(5) The string ends are mounted beneath the string-mounting element 30 in order to provide the requisite downward pressure on the bridge 25, without the necessity of providing additional bearing elements.

(6) The combination vibrato and bridge construction is highly compact, and attractive in appearance.

The use of the term "bodily" in the appended claims denotes substantially translational movement of the string-mounting element 30, and is to be distinguished from mere rotation of such element about its own longitudinal axis.

The foregoing detailed description is to be clearly understood as given by way of illustration and example only, the spirit and scope of this invention being limited solely by the appended claims.

I claim:

1. A guitar-type musical instrument, which comprises:
a body,
a plurality of guitar strings mounted over said body in tensioned relationship,
an inertial string-mounting element having sufficient mass to resist vibrations induced by at least the higher-pitched ones of said strings,
means to connect said guitar strings directly to said string-mounting element,
means to mount said string-mounting element in spaced relationship above said body and in a floating manner such that said string-mounting element may be moved bodily relative to said body in directions changing the degree of tension in said strings and thus the pitch thereof, and
means to move said string-mounting element bodily in said directions.

2. A guitar-type musical instrument, which comprises:
a body,
a plurality of guitar strings mounted over said body in tensioned relationship,
an inertial string-mounting element having sufficient mass to resist vibrations induced by at least the higher-pitched ones of said strings,
means to connect said guitar strings directly to said string-mounting element,
means to mount said string-mounting element in spaced relationship above said body and in a floating manner such that said string-mounting element may be moved bodily relative to said body in directions changing the degree of tension in said strings and thus the pitch thereof,
said means including springs arranged to counteract the tension of said strings,
means to move said string-mounting element bodily in said directions, and
movable bridge means to space said strings above said body, said bridge means being adapted to move with said strings,
said bridge means being independent of said string-mounting element.

3. A guitar-type musical instrument, which comprises:
a body,
a plurality of guitar strings mounted over said body in tensioned relationship,
an inertial string-mounting element disposed above said body and having sufficient mass to resist vibrations induced by at least the higher-pitched ones of said strings,
means to connect said guitar strings directly to said string-mounting element,
fulcrum means supported on said body, lever means having an intermediate portion pivotally associated with said fulcrum means,
means to connect one end portion of said lever means to said element,
spring means operatively associated with the other end portion of said lever means and with said body,
said spring means being sufficiently strong to balance the tension of said strings and cause said lever means to remain normally in a neutral position, and
means to pivot said lever means about said fulcrum means to shift said lever means in either direction away from said neutral position, thereby moving said element and changing the degree of tension in said strings.

4. A guitar-type musical instrument, which comprises:
a body,
a plurality of guitar strings mounted over said body in tensioned relationship,
an inertial string-mounting means having sufficient

mass to resist vibrations induced by at least the higher-pitched ones of said strings,
means to connect said guitar strings directly to said string-mounted means,
fulcrum means supported on said body,
lever means having an intermediate portion pivotally associated with said fulcrum means,
means to connect one end portion of said lever means to said string-mounting means,
spring means operatively associated with the other end portion of said lever means and with said body,
said spring means sufficiently strong to balance the tension of said strings and cause said lever means to remain normally in a neutral position,
means to pivot said lever means about said fulcrum means to shift said lever means in either direction away from said neutral position, thereby moving said string-mounting means and changing the degree of tension in said strings, and
adjustment means to vary the distance between said fulcrum means and at least one of the means connected to said lever means, thereby determining said neutral position.

5. A guitar-type musical instrument, which comprises:
a body,
a plurality of guitar strings mounted over said body in tensioned relationship,
fulcrum means provided on said body,
elongated first-class lever means having an intermediate portion pivotally associated with said fulcrum means,
means to connect one end portion of said lever means to said strings,
tension spring means operatively connected to the other end portion of said lever means and also connected to said body,
said spring means being sufficiently strong to balance the tension of said strings and thereby cause said lever means to remain normally in a neutral position,
means to pivot said lever means about said fulcrum means to shift said lever means away from said neutral position and thereby change the degree of tension in said strings, and
means to adjust through small increments the distance between said fulcrum means and at least one of the elements connected to said lever means, thereby determining said neutral position and compensating for factors including the tension of said strings and the characteristics of said spring means.

6. A guitar-type musical instrument, which comprises:
a body,
a plurality of guitar strings mounted over said body in tensioned relationship,
fulcrum means provided on said body,
an elongated first-closs lever having an intermediate portion pivotally associated with said fulcrum means,
means to connect one end portion of said lever to said strings,
elongated tension-spring means connected between the other end portion of said lever and said body to balance the tension of said strings and thus cause said lever to remain normally in a neutral position,
said spring means being disposed at an acute angle relative to said lever when the same is in said neutral position, and
means to pivot said lever about said fulcrum means to selectively increase and decrease the tension in said strings,
said elements being related in such manner that the size of said acute angle is increased when the tension in said strings is increased whereby to increase the moment arm through which said spring means acts and thereby compensate for said increased tension in said strings, and in such manner that the size of said acute angle is decreased when the tension in said strings is lessened whereby to reduce said moment arm and thus compensate for the decreased tension in said strings.

7. In combination with a guitar-type musical instrument having a body and a plurality of guitar strings mounted over said body in tensioned relationship, a combination vibrato device and bridge mounted on said body and operatively associated with said strings, said vibrato device and bridge comprising:
an inertial string-mounting element having substantial mass,
means to pivotally associated said string-mounting element with said body to permit movement of said string-mounting element to effect variations in the tension in said strings,
bias means to cause said string-mounting element to remain normally in a predetermined neutral position,
a bridge element pivotally mounted on said body in supporting relationship relative to said strings,
said bridge being disconnected from said string-mounting element, and
means to move said string-mounting element to thereby vary the tension in said strings and also effect pivotal movement of said bridge.

8. The invention as claimed in claim **7**, in which said strings are extended over said bridge and beneath said string-mounting element, and in which means are provided to connect the ends of said strings to said string-mounting element by extending said string ends generally horizontally through said string-mounting element at points located above the lower region of said string-mounting element.

9. A vibrato device for guitar-like musical instruments, which comprises:
a base plate having first and second openings therein,
first and second levers inserted, respectively, through said openings,
said levers and the portion of said base plate defining said opening being shaped to permit pivoting of said levers about an axis extending between said openings and also to permit rotation of each of said levers about the longitudinal axis thereof without interfering with said pivotal movement about said axis,
an inertial string-mounting bar having substantial mass and extending generally parallel to said base plate above said openings,
said bar having threaded openings therein to threadedly receive the upper ends of said levers whereby rotation of said levers about the longitudinal axes thereof will effect raising and lowering of said bar relative to said base plate,
means to connect the ends of guitar strings directly to said bar in spaced relationship therealong, and
tension springs connected to the ends of said levers remote from said bar in a manner permitting rotation of said levers about the longitudinal axes thereof.

10. The invention as claimed in claim **9**, in which said tension springs comprise elongated helical springs the ends of which remote from said levers are connected to said base plate, said springs being disposed at acute angles relative to said levers when said levers are perpendicular to said base plate.

11. The invention as claimed in claim **9**, in which said bar has wrench-openings formed therein adjacent the threaded openings therein, and in which the threaded ends of said levers have wrench sockets formed therein, whereby said levers may be rotated about the longitudinal axes thereof by means of wrenches inserted through said wrench-openings in said bar.

12. The invention as claimed in claim 9, in which said base plate has convergent frustoconical surfaces formed at said openings whereby knife edges are formed in said openings, and in which said levers have annular grooves of V-shaped section, the angle between the walls of each of said grooves being substantially greater than that between said convergent frustoconical surfaces.

13. The invention as claimed in claim 9, in which a bridge is mounted on said base plate in spaced relationship from said bar and generally parallel thereto.

14. The invention as claimed in claim 13, in which said bridge is adapted to pivot about an axis generally parallel to said axis.

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