Nov. 13, 1951 J. E. PETEK 2,575,293

SOUND PRODUCING INSTRUMENT AND DIAPHRAGM THEREFOR

Filed Aug. 27, 1948 2 SHEETS—SHEET 1

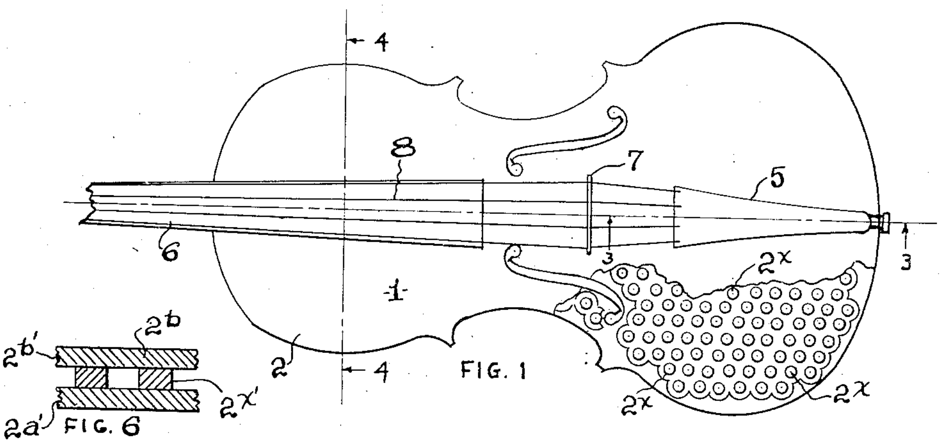

FIG. 1

FIG. 6

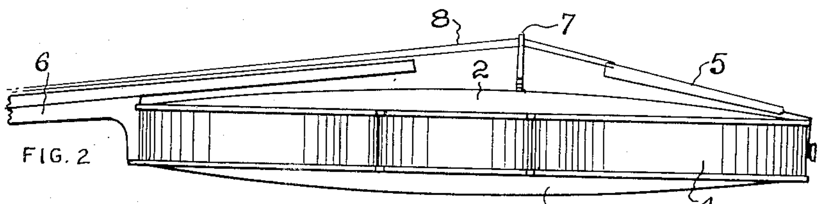

FIG. 2

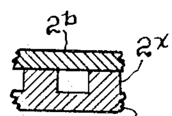

FIG. 5

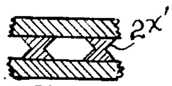

FIG. 7

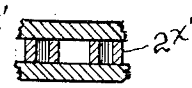

FIG. 8

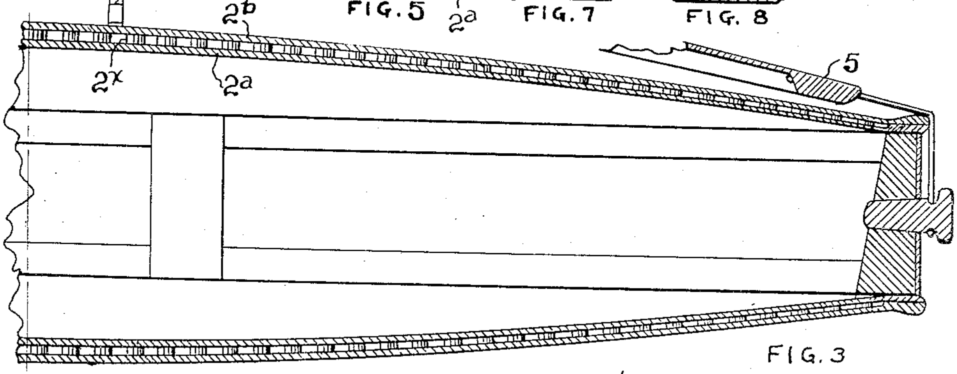

FIG. 3

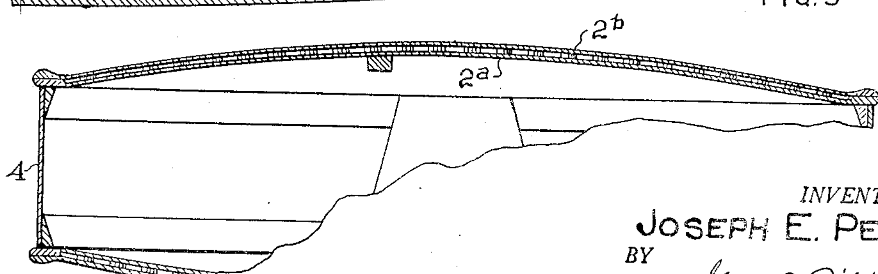

FIG. 4

INVENTOR.
JOSEPH E. PETEK
BY
Geo. B. Pitts
ATTORNEY.

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SOUND PRODUCING INSTRUMENT AND DIAPHRAGM THEREFOR

Filed Aug. 27, 1948 2 SHEETS—SHEET 2

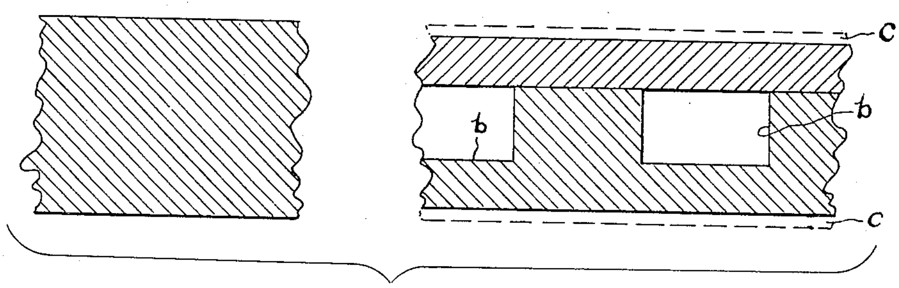

FIG. 9

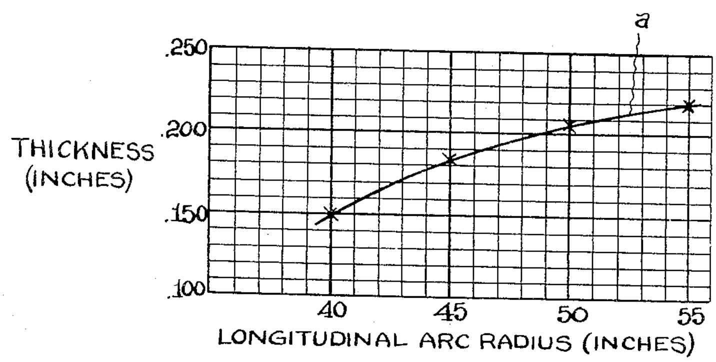

FIG. 10

INVENTOR.
JOSEPH E. PETEK
BY
Geo. B. Pitts
ATTORNEY

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SOUND PRODUCING INSTRUMENT AND DIAPHRAGM THEREFOR

Joseph E. Petek, Cleveland, Ohio

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6 Claims. (Cl. 84—275)

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This invention relates to instruments or devices having sound transmitting or producing diaphragms. The invention is shown incorporated in a musical instrument wherein the produced sounds are generated in response to vibrated strings. The invention is disclosed as embodied in a violin as illustrating the preferred application of my invention.

In the fabrication of violins, it has been the practice, so far as I have knowledge, to use special kinds of wood and to select those portions thereof that were devoid of various imperfections and to vary the thickness of the belly and back dependent on the stiffness and weight of the wood for the purpose of attaining desirable tone qualities.

I have discovered that the tone quality of an instrument can be improved by employing a diaphragm of reduced thickness and having a predetermined degree of arching and a predetermined resonant frequency, the effect of which is to reduce damping and tone distortion, whereby the produced tones of the instrument are louder, clearer and more uniform.

One object of the invention is to provide for a sound producing device an improved diaphragm constructed to reduce damping of the vibrations thereof and distortion of the tones.

Another object of the invention is to provide an improved violin or like instrument wherein the belly or both the belly and back are constructed to reduce damping of the vibrations thereof and distortion of the tones when the instrument is played.

Another object of the invention is to provide an improved violin wherein the belly, for a specified degree of arching and having a resonant frequency corresponding to the musical note "B," may be made relatively thin, whereby the tones of the violin are improved with respect to loudness, clearness and uniformity.

Another object of the invention is to provide in a violin or like instrument an improved belly consisting of a composite member having predetermined arch radii and a predetermined resonant frequency and relatively thin, as compared to a belly formed of solid wood and having the same arch radii and the same resonant frequency, so that an increased amplitude of vibration of the belly, in response to string vibration, takes place when the instrument is played, to provide an improved tone quality.

Another object of the invention is to provide in a violin or like instrument an improved belly consisting of a composite member having a predetermined arch radii and a predetermined resonant frequency capable of vibrating, in response to string vibration when the instrument is played, at amplitudes which produce louder, clearer and more uniform tones, as compared to a violin the belly of which is solid and formed of the selected wood, has the same arch radii and the same resonant frequency.

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Another object of the invention is to provide an improved process of fabricating a violin or like instrument, to insure louder, clearer and more uniform tones.

Other objects of the invention will be apparent to those skilled in the art to which my invention relates from the following description taken in connection with the accompanying drawings, wherein

Fig. 1 is a plan view of a violin embodying my invention, parts being broken away.

Fig. 2 is a side elevation.

Fig. 3 is a fragmentary section on the line **3—3** of Fig. 1.

Fig. 4 is a fragmentary section on the line **4—4** of Fig. 1.

Fig. 5 is a section on the line **5—5** of Fig. 3.

Figs. 6, 7 and 8 are sections similar to Fig. 5, but showing modified forms of construction.

Figs. 9 and 10 are diagrammatic views.

In the drawings, referring particularly to Figs. 1, 2 and 3, **1** indicates as an entirety a violin having a diaphragm or belly **2**, a back **3**, sides **4**, tail **5**, neck **6**, bridge **7** and strings **8**. The belly **2** and back **3** each have (*a*) a thickness and curvature longitudinally as later set forth herein and a curvature transversely thereof on arcs of circles, (*b*) a length of fourteen inches and (*c*) a maximum width of eight and one-quarter inches. The diaphragm or belly **2** and back **3** are fabricated in the manner later set forth. The belly **2**, back **3**, sides **4** and neck **6** are formed from selected wood or woods and assembled and glued together and reinforced according to well known practice. The belly **2** and back **3** may be respectively formed of two composite side-by-side sections glued together as practiced by some makers, but each will be described herein as consisting of a single fabricated composite wall or member. By preference, the belly and back are of substantially similar construction so that only one of these parts—the belly—and the process of making it will be described, although the invention is not to be limited to a construction where both of these parts embody the invention.

In carrying out my process the first step consists in (*a*) selecting the wood of which the belly is to be fabricated, as later set forth, (*b*) predetermining the thickness of the belly at the point engaged by the bridge and (*c*) predetermining the longitudinal arc radius of the belly.

In selecting the wood, I first cut from each of several available suitable woods a test member having a length of six inches extending parallel to the wood grain and a width of one-half inch extending radially of the growth rings and an initial thickness of ⅜ inch or more; the thickness of the test members are then gradually reduced until the resonant frequency thereof corresponds to the musical note "B" above and adjacent to the note "A" on the musical scale having a resonant frequency of 440 cycles per second. The wood of the test member (later referred to as "primary test member") which is the thinnest is then selected.

Since it is preferred to have a fixed ratio of stiffness to weight in the complete belly which has a resonance corresponding to the said musical note "B," and it is also preferred to have a fixed stiffness, no matter what wood is used, then a thickness for the selected wood must be chosen to give a fixed weight for the completed belly. I have found that a thickness of .170 inch for a wood with a density of .245 ounce per cubic inch, will provide a belly with a satisfactory stiffness, constructed as hereinafter set forth, and arched to resonate at the said note "B." To determine the thickness of the selected wood which will provide the desired stiffness, the following formula is used:

$$T=\frac{.04165}{D}$$

where T is the sought for or predetermined thickness and D is the density of the wood expressed in ounces per cubic inch. The thickness of each ply (hereinafter referred to) is indicated by the formula:

$$T_p=\frac{.01225}{D}$$

D have the same value as above and the thickness of the spacing devices (hereinafter referred to) is indicated by the formula: $S=T-2T_p$.

In determining the longitudinal arc radius, I select a sufficiently large section of a suitable wood to provide therefrom a secondary test member and at least four test diaphragms or bellies having a predetermined outline and taper pattern. The secondary test member, when cut, is similar to the primary test member as to length and width and relation thereof to the grain and growth rings, respectively, with an initial thickness of ⅜ inch or more, and then its thickness is trimmed down until the member has a resonant frequency corresponding to the said musical note "B"; also, the four diaphragms or bellies are arched on different longitudinal arc radii, for example, **40″**, **45″**, **50″** and **55″** radius, respectively, and transversely curved on arcs of circles, and the thickness of each thereof is trimmed down until it has a resonant frequency corresponding to the said musical note "B." On a graph (Fig. 10) whose coordinates are longitudinal arc radii and thickness in inches and using the above values and the derived thicknesses of the bellies, I draw a line *a* on the graph. By determining the ratio of thickness of the secondary test member to that of the primary test member, I obtain the "thickness factor" and then multiply the predetermined thickness T of the selected wood as determined by the foregoing formula by the

thickness factor and the product by the composite thickness factor of approximately 1.15, this latter factor being the ratio of thickness of a solid belly *x* formed of the selected wood to the thickness of a belly *x′* formed of the selected wood fabricated as hereinafter set forth (see Fig. 9) and the final product determining the thickness value by which to identify on the graph the longitudinal arc radius to be employed for the belly to be fabricated as hereinafter set forth from the selected wood, that is, the wood corresponding to that wood of the primary test member.

Next, the diaphragm or belly **2** is formed of inner and outer plies **2*a***, **2*b***, from the selected wood, each ply having a longitudinal arc radius, as above set forth, and an outline and taper pattern corresponding to the test diaphragms above referred to. In carrying out this step, one ply (the outer or upper ply as viewed in these figures) is formed preferably with a thickness as determined by the formula for thickness (T_p), whereas the other ply is preferably formed with a thickness equal to that of the upper ply and the spacing devices between the plies, which devices preferably have a thickness equal to $T-2T_p$.

Next, approximately 80% of the wood on that face of the other ply (the inner ply as viewed in these figures) which—when assembled with the outer ply—is opposed to the inner face of the latter, is removed. Such removal consists in removing the wood within the marginal edges of the ply along uniformly spaced longitudinal and transverse channels to a depth substantially equal to $T-2T_p$, such removal providing upstanding devices **2*x*** at the inter-sections of the channels, which devices serve as spacers in the composite member, as later set forth in side-by-side parallel rows. In forming the channels as above set forth the wood is preferably removed so as to provide devices **2*x*** that are round in cross section, each having a diameter of approximately $\frac{5}{32}$ of an inch and spaced, center to center, approximately $\frac{5}{16}$ of an inch, with the devices in adjacent rows in staggered relation.

Next, the top surfaces of the devices **2*x*** are covered with a suitable adhesive material and the two plies are then related and subjected to pressure to form a composite diaphragm or belly.

The composite member is then tested, after positioning the bass bar and cutting of the holes, to determine whether it has a resonant frequency corresponding to the said musical not "B." If the resonant frequency corresponds to a musical note above or below the note "B," the foregoing steps must be repeated with the same kind of wood, to fabricate a new belly, which in turn must be tested. If the tests show that the resonant frequency is high, the ratio value 1.15 in the formula is increased approximately .02 or .03 of an inch; if the resonant frequency is low, the ratio value 1.15 is reduced approximately .02 or .03 of an inch.

It will be observed that in carrying out the above steps, those portions of the composite belly (that is, its inner portions) which contribute least to the stiffness thereof have been removed, as shown at *b* in Fig. 9, such removal tending to increase the resonant frequency of the belly, while by employing plies of the thickness hereinbefore referred to, thereby in effect removing wood from the opposite surfaces of the belly, as shown at **C** in Fig. 9, its resonant frequency is lowered; accordingly, it will be seen that by removing the wood from the center or inner portions of the belly (as herein set forth) and from its opposite surfaces, the resonant frequency of the belly is maintained substantially constant and when incorporated in position damping of the produced tones will be materially reduced.

Next, the back is formed according to the steps above referred to, except that its arching and the thickness are modified to provide a slightly higher resonant frequency and a heavier back, for example, a thickness

$$T=\frac{.1666}{D}$$

and plies having a thickness

$$T_p=\frac{.049}{D}$$

next, the parts are assembled and secured together according to the well known practice.

As a belly formed of solid wood (Fig. 9) undergoes an increased flexing of its wood fibers, it therefore unduly damps the vibrations, thereby affecting the loudness of the reproduced tones; also, in flexing, the fibers generate heat which is most pronounced at the greater amplitudes of the lower frequencies, thereby creating a distortion thereof. By reducing the thickness of the belly those portions, designated *c*, *c*, in Fig. 9, are omitted, the effect of which is to reduce damping and tone distortion and this in turn insures louder, clearer and more uniform tones. Reducing damping causes all reproduced tones to be louder, but is most effective in the lower frequencies due to their greater amplitudes of vibration; reducing damping also maintains a better intensity balance between the fundamental frequencies of the tones and their accompanying harmonics. This, in effect, reduces distortion of the tones and insures greater uniformity of tone throughout the range of the instrument.

In carrying out the step of fabricating the belly or the back it will be observed that the plies and spacing devices may be formed separately and thereafter assembled into a composite member, this form of construction being shown in Fig. 6, wherein the inner and outer plies are indicated at **2a'**, **2b'**, respectively, and the spacing devices at **2x'**.

Figs. 7 and 8 show modifications wherein the spacing devices **2x'** are separate from the plies **2a'**, **2b'**, and have a different cross sectional shape, each device shown in Fig. 7 being formed with an annular V-shaped groove and each device shown in Fig. 8 being hollow from end to end.

In fabricating the belly and back, the plies therefor are cut from the wood so as to dispose the wood grain similarly to conventional practice where the belly is solid. Where the spacing devices are formed separately, they are positioned between the plies so that the grain of the devices is disposed perpendicularly thereto and the chords of the arcs of the growth rings are disposed parallel to the longitudinal axis of the belly.

From the foregoing description it will be observed that my invention is applicable to various kinds of woods; that is, it provides an improved quality of tone of a violin having a belly formed of any selected kind of wood, as compared to a violin having a solid belly formed of the same selected kind of wood.

To those skilled in the art to which my invention relates, many changes in construction and widely differing embodiments and applications of the invention will be apparent without departing from the spirit and scope thereof. My disclosures and the description herein are purely illustrative and not intended to be in any sense limiting.

What I claim is:

1. The herein disclosed process of forming a composite diaphragm for a musical or sound producing instrument to produce a predetermined resonant frequency, which consists in cutting from a selected wood a ply having a predetermined thickness and a predetermined longitudinal arc radius, then in cutting from the selected wood a separate ply the thickness of which is approximately twice that of the first mentioned ply and having a similar longitudinal arc radius, then in removing material from one surface of the last mentioned ply within its marginal edges to a depth of one-half its thickness and along spaced angularly related portions to form channels within the member and spacers between the channels, then assembling the first mentioned ply and spacers in contact with adhesive between them, and finally applying pressure to the plies.

2. The herein disclosed process of forming a diaphragm for a musical or sound producing instrument to produce a predetermined thickness and a predetermined resonant frequency, and employing a graph indicating longitudinal arc radii and thicknesses in predetermined units, which process consists first in selecting from a series of primary test members formed of different woods and having the predetermined resonant frequency the wood corresponding to that of the test member that is the thinnest, forming from a suitable wood a secondary test member having the predetermined frequency, determining the thickness factor between the primary and secondary test members, multiplying the thickness factor by the value of the predetermined thickness and by the composite thickness factor to determine the thickness value, determining the longitudinal arc radius of the diaphragm by the radius on the graph for the thickness corresponding to the thickness value and finally forming from the selected wood a diaphragm having the predetermined thickness and determined longitudinal arc radius.

3. The herein disclosed process of forming a diaphragm for a musical or sound producing instrument to provide a predetermined thickness and a predetermined resonant frequency, and employing a graph indicating longitudinal arc radii and thicknesses in predetermined units, which process consists first in selecting from a series of primary test members formed of different woods and having the predetermined resonant frequency the wood corresponding to that of the test member that is the thinnest, forming from a suitable wood a secondary test member having the predetermined frequency, determining the thickness factor between the primary and secondary test members, multiplying the thickness factor by the value of the predetermined thickness and the value of a solid diaphragm formed of the selected wood and having the same predetermined resonant frequency to determine the thickness value, determining the longitudinal arc radius of the diaphragm by the radius on the graph for the thickness corresponding to the thickness value, forming from the selected wood plies according to the formula

$$T_p=\frac{.01225}{D}$$

having the determined longitudinal arc radii and spacing devices therebetween according to the formula $S=T-2T_p$, and finally assembling the plies and spacing devices with adhesive material between them and applying pressure to the plies.

4. A sound transmitting diaphragm for a musical instrument adapted to produce musical tones in response to string vibrations and consisting of a single composite member all parts of which are formed of the same kind of wood and having inner and outer plies, adjacent respective portions of said plies throughout their areas having the same thickness and the thickness of the plies tapering toward their peripheral marginal edges, portions of the wood between the plies being removed to increase the ratio of stiffness to weight of the composite member as compared to that of a solid member formed of the same kind of wood and having the same thickness, to reduce flexing of the wood fibers of the composite member and damping of the vibrations of the composite member and to increase the loudness, clearness and uniformity of the tones of the instrument when the latter is played.

5. An instrument as claimed in claim 4 wherein said composite member has a predetermined thickness and a predetermined arch radius dependent upon a selected resonant frequency and a selected stiffness of said member.

6. A musical instrument adapted to produce musical tones in response to string vibrations and having a belly and a back, said belly comprising a single composite member all parts of which are formed of the same kind of wood and consisting of inner and outer plies and spaced spacing devices therebetween formed integrally with one of said plies, any three mutually adjacent spacing devices of said spaced spacing devices being in an equilateral triangular relationship to serve to increase the ratio of stiffness to weight of the composite member as compared to a solid member formed of the same kind of wood and having the same thickness, to reduce flexing of the wood fibers of the composite member and damping of the vibrations thereof and to increase the loudness, clearness and uniformity of the tones of the instrument when the latter is played.

JOSEPH E. PETEK.

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