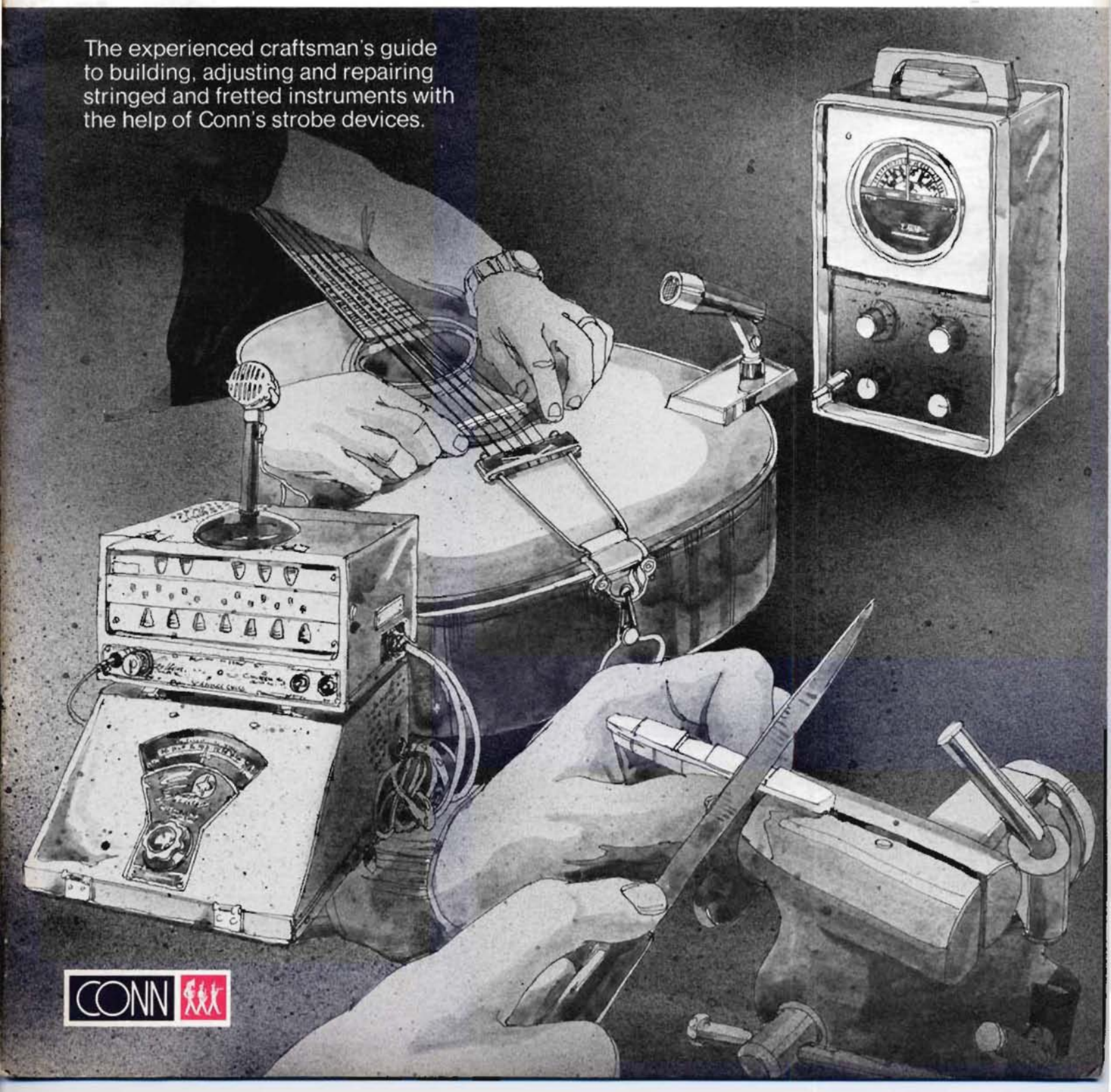
THE SECRET OF TUNING FRETTED INSTRUMENTS

The experienced craftsman's guide to building, adjusting and repairing stringed and fretted instruments with the help of Conn's strobe devices.



CONN

THE SECRET OF TUNING FRETTED INSTRUMENTS

Guide for the Experienced Craftsman

Here is the experienced craftsmen's guide to the use of the CONN STROBOTUNER and CONN STROBOCONN in building and repairing instruments. This booklet is *not* a general repair manual. It is assumed that the reader already has knowledge of repair techniques, procedures, tools, etc. Instead, this booklet shows you how to use the CONN STROBOTUNER and CONN STROBOCONN to help you repair, adjust, and construct fretted instruments.

Both pieces of equipment electronically translate sound into visual images, so you have a sure way to tune components, adjust intonation, and check fret position and bridge location.

Before you proceed, however, it is important to read the STROBOTUNER or STROBOCONN "Owner's Manual" as well as the booklet, "Making Sense Out of Cents," which describes frequency, intervals, scales and cents. Both are available from C. G. Conn, Oak Brook, Illinois.

Acknowledgment

We wish to acknowledge Roger H. Siminoff who authored the information in this book.

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THE SECRET OF TUNING FRETTED INSTRUMENTS

Table of Contents

The Strobe Equipment

The STROBOTUNER, a single wheel strobe device, is ideal for checking intonation and fret location. Simply turn the selector knob on the STROBOTUNER to set "target" notes or frequencies. Adjust the fretted instrument until you reach the target note. In this case, you're working *from the STROBOTUNER to the instrument.*

Conn Strobotuner®, Model ST-11 (110V, 60Hz)
Model ST-12 (220V, 50Hz)

The 12-wheel STROBOCONN is ideal for adjusting air chambers and tone bars because you must search for a note to which that part of the instrument is tuned. As you adjust the instrument, you can observe the change in notes or frequency as it moves through the frequency range—from wheel to wheel—until it reaches the desired level. In this case you're working *from the instrument to the STROBOCONN.*

Conn Stroboconn®, Model 6T-5

Part I–The Strobotuner

The Relationship of Many Parts

Because you are dealing with sensitive and delicate adjustments, it is important for you to understand that there is a great interaction between all of the elements of a stringed musical instrument. For example, finding the true position of a bridge also requires checking the accurate location of the 12th fret. Although you can generalize where the 12th fret should be, by measuring half of the distance between the bridge and nut, you can't determine the true bridge position unless you know what the distance should be between the nut, all of the frets, the bridge, and the strings.

Preparation

To tune the instrument to pitch, follow the instructions in the STROBOTUNER Owners Manual. If the strings are new, aurally tune the instrument, let the instrument stand for a period, then retune. Repeat until the strings settle and hold their pitch. Now carefully retune the instrument to precisely "stop" or "cage" the STROBOTUNER disc so that subsequent measurements will be as accurate as possible.

1. The term "stop" or "cage" means the strobe pattern is "as motionless as possible." Because strobe devices are extremely sensitive, the slightest variations in the circuit or power supply will cause very slight transient movements in the strobe pattern. These small movements show such insignificant variations that they may be ignored in all musical applications.

Locating the Bridge

Properly locating the bridge and the string contact point are the most common problems in fretted instrument construction.

Depending on its length, diameter, and tension, each string requires a different theoretical contact point at the bridge.

The first and most basic step is to determine the correct position of a moveable bridge. For our example we have chosen the one piece, movable banjo bridge.

With the instrument tuned to pitch, turn the STROBOTUNER selector knob to the note of the banjo middle string. Push the string down to the 12th fret, pluck it, and study the STROBOTUNER wheel. If the next octave line—outward from the hub—does not appear, or if the image rotates drastically, there are two possible errors:

1 The string is being fretted on the wrong fret. Recheck to be sure you're on the 12th fret.

2. The bridge is grossly out of position. Carefully move it forward or backward until the wheel image is more stable.

ONCE THE BRIDGE IS MOVED FROM ITS ORIGINAL POSITION, ALL STRINGS MUST BE TUNED AGAIN.

The 12th fret will always produce the note of the first octave (one octave above the open string) regardless of string scale. (With instruments such as the dulcimer, various fretting intervals are omitted. In such a case counting to 12 would be misleading.) In addition, the 12th fret is almost exactly centered between the bridge and nut. The Conn STROBOTUNER can help determine the *exact* locations, eliminating much trial and error.

Roughly position the bridge by measuring the distance between the nut and the 12th fret. The bridge should be placed at the same distance from the 12th fret.

To find the exact bridge location, fret the string at the 12th fret, pluck it and watch the STROBOTUNER to see if it is sharp or flat. If the wheel shows a "sharp" condition, the bridge is TOO CLOSE to the peghead and must be moved away. If the wheel shows a flat condition, the bridge is TOO FAR from the peghead.

Each Time the Bridge is Moved, the Strings Must be Tuned Again in the Open Position.

You will quickly find that a different bridge position is ideal for each string. In the case of the normal one piece banjo bridge, only a compromise is attainable.

As previously mentioned, the variation in the perfect bridge position for each string is caused by the differences in string gauge, tension, and the height or action of the strings. Fretting a string causes it to stretch from its normally straight position. As this happens, greater tension is exerted on the string and it "chokes" or increases in pitch. Because each of the strings are of different gauges, they increase in pitch at different rates, and a special bridge position or "intonation" adjustment is required for each.

Therefore, on a straight bridge an average position must be determined. This "average position" will result in the bridge being turned slightly counter-clockwise, with the bass side further away from the peghead than the treble side. It is also important to realize that the intonation will change when the gauge of strings is changed such as switching to a heavier gauge. Thus, in making fine adjustments for intonation in good shop conditions, it is important to determine the gauge of strings that the instrument owner intends to use on his instrument.

Correcting Adjustable Bridges
Electric guitars and basses

On electric solid-body instruments, the string supports are actually small individual bridges which can be fully adjusted for each string. The strings are held by small castings which can be moved forward or backward by adjusting a machine screw. These individual saddles allow an ideal adjustment for each string.

Follow this sequence to make the adjustment:

1. Tune all strings to pitch with the STROBOTUNER.
2. Fret and pluck the 12th fret of each string, checking the sharp or flat condition on the STROBOTUNER wheel.
3. If the wheel indicates "sharp," turn the adjusting screw so that the string saddle moves away from the peghead. (Lengthening the string.)
4. If the wheel indicates "flat," turn the adjusting screw so that the string saddle moves toward the peghead. (Shortening the string.)
5. After each adjustment, the open (unfretted) string must be retuned.
6. Follow the same procedure for all of the strings.
7. Re-check the tuning of each open string and the intonation at the 12th fret.

A final setting of the string saddles *might* resemble the bridge in photo #1.

Correcting Fixed Bridges
Flattop acoustic guitars

Adjusting the fixed bridge on a flattop acoustic guitar is a bit more involved. There is no way to easily adjust the contact points as there is on an electric instrument. However, the bridge insert or saddle can be altered to some extent to compensate for intonation error. In normal factory installations, the straight insert is positioned for an *average* correction for all strings.

One of the most common deviations found in this type of bridge assembly is the tendency for the insert to lean forward toward the peghead

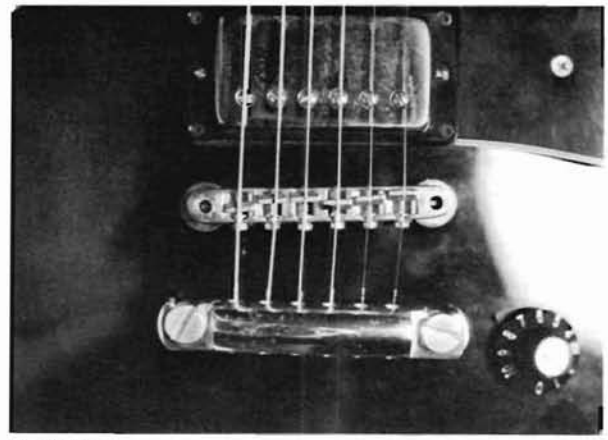


Photo #1

The saddles on an adjustable bridge will be positioned similarly to these when the intonation is adjusted to the STROBOTUNER.

due to the natural "pull" of the string. This phenomenon generally produces a sharp condition on all strings when using the 12th fret technique. If you wish to keep the simple straight bridge insert, it may be necessary to install a wider and taller insert for better fit, leverage, and rigidity. You may find it necessary to enlarge or deepen the bridge insert slot.

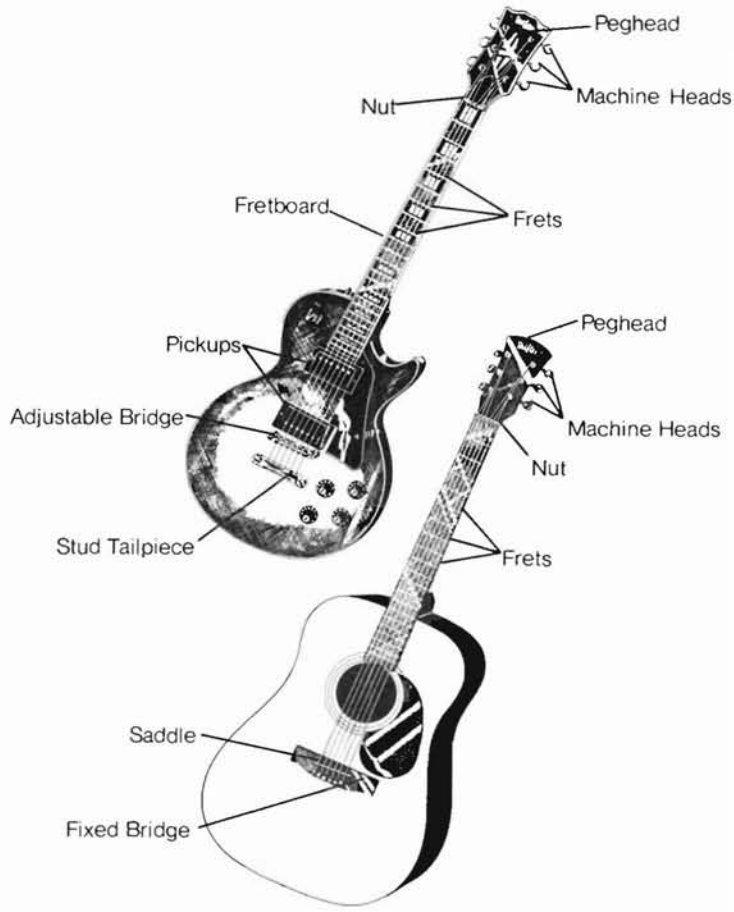


Photo #2
A platform is prepared for a router tool.

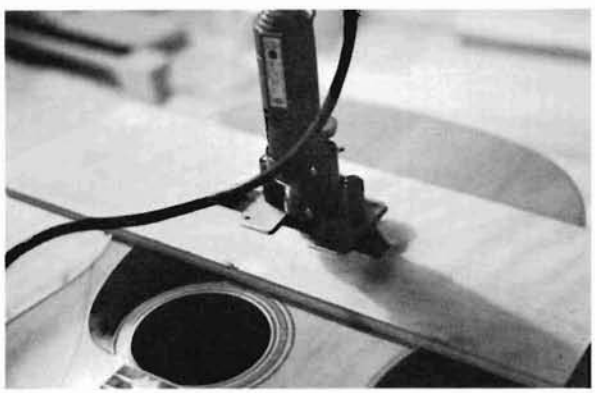


Photo #2A
A mini router tool is used to deepen the bridge insert slot.

Routing a deeper slot in the bridge base can be done easily with a small router tool and platform as seen in photo #2 and 2A.

If the insert is not leaning forward, and minor correction is desired, then the following steps are suggested:

1. Tune all strings to pitch with the STROBOTUNER.
2. Check the correction required by fretting and plucking at the 12th fret. Make a note of the desired correction (sharper or flatter).
3. Loosen all the strings and remove the bridge insert.
4. Carefully file the top of the insert in order to move the contact point forward or backward according to the correction desired. This can be done separately for each string or groups of two or three strings. The narrow width of the insert will make it impossible to precisely correct it, but you can at least improve the straight factory insert.
5. Re-install the insert, tune all strings and check for the improvement.

Other Adjustments

The following is offered for reference only. To make a change of 5 cents on a guitar of approximately 25" string scale, (bridge to nut dimension) the contact point must be moved forward approximately 3/32" to sharpen, or backwards 1/8" to flatten.

Making a New Insert for a Fixed Bridge

A new insert can be made from bone or hard plastic with correctly compensated contact points (without altering the bridge base). The correct location of each string's contact point must be first determined. Proceed as follows:

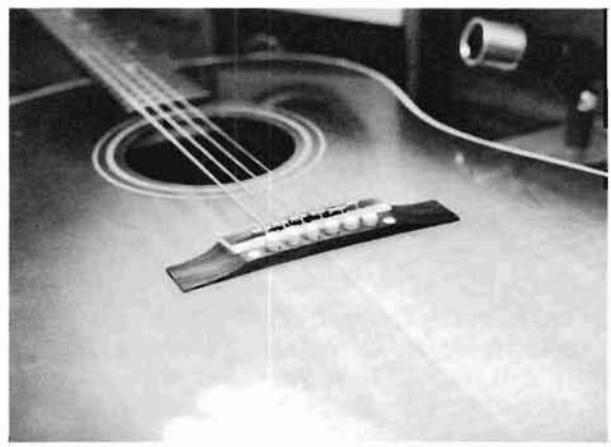


Photo #3
A small plastic plate is positioned over the bridge insert slot and 6 individual "rods" are positioned under the strings.

1. Measure the height of the top of the insert above the bridge base.
2. Loosen the strings and remove the insert.
3. Make a small piece of 1/16" clear plastic and place it over the bridge slot as in photo #3.
4. Cut 6 pieces of wire, or nails whose thickness, when added to the 1/16" plastic, equals the height of the saddle measured in step 1.
5. Position each of the wires beneath a string as seen in the photo and tune the strings to pitch. The tuning process will be a little awkward until the wires are held securely by the tension of the strings.
6. Check the correct intonation position for each of the strings and push the wires forward or backward until they are properly adjusted.
7. Carefully measure the contact points with reference to each other and with reference to the slot which can be seen directly through the clear plastic (sighting straight down).

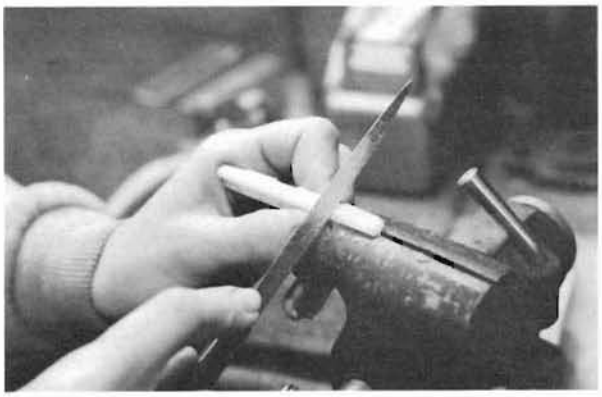


Photo #4

A new bridge insert can be fashioned from bone or hard plastic with correct contact points filed in.

8. Make a bone or hard plastic insert as seen in photo #4 by filling-in the correct intonation contact points. Notice that the bottom of the insert has been constructed so that it will fit into the existing slot, and the top piece will rest on the bridge base.
9. Install the new insert, check the intonation of each string, make necessary adjustments.

Correcting the Slot of a Fixed Bridge

Manufacturers differ in the angle at which they set the insert in the fixed bridge. If it can be determined that this angle must be changed, here is a suggestion:

1. Follow the procedure for the intonation corrected insert to determine the correct average position of the contact points. ("Average" is used here because the straight insert is still being employed.)
2. Make measurements and references for the new location of this straight insert.
3. Remove the insert, strings, bridge pins, etc. and fill the existing slot with a piece of wood stock similar to the bridge base (ebony or rosewood).
4. Locate the position of the new slot. Re-route for the insert.
5. Re-assemble

String Height or "Action"

As previously stated, "action" is another important factor influencing correct fretting or "intonation." The higher the action, the further the string must be depressed to contact the fret. As this happens, greater pressure is exerted on the string resulting in an increase in pitch.

A high action causes sharping—a low action causes buzzing.

Action adjustments can be made at the nut, saddle, or in extreme cases, by having the neck reset. On the banjo, coordinator rods or dowel sticks can be adjusted for proper action.

One way to determine if the action is causing an intonation problem is to set the strings as low as possible—almost to the buzz point—and check the intonation with the STROBOTUNER. If the intonation is true, reset the action to the desired height and recheck the intonation. If there is a tendency toward a sharp sound, compensation will have to be made at the bridge.

Checking Fret and Nut Location

It is uncommon to find improperly slotted fretboards among the major instrument producers. However, poor slotting occasionally occurs in one-of-a-kinds, or on instruments where the fret slots have been hand cut. There is also the possibility that a fret might not go in straight causing the crown or contact point to be improperly located.

Remembering that the 12th fret is at a point almost exactly halfway between the nut and the bridge, all of the other frets are positioned at intervals which are determined by a specific mathematical formula. However, each fret location can be checked simply by using the STROBOTUNER.

1. Tune all strings to pitch using the STROBOTUNER.
2. Set the selector to the note of the first string and check its tuning.
3. Set the selector to the next note or halfstep "up the scale" (higher).
4. Fret the string at the first fret and check the STROBOTUNER. If there is a deviation, it may be the nut. However, *before making adjustments,* adjust the cents knob until the image stops (do not retune the string).
5. Turn the selector knob to the next note "up the scale" and check the second fret. Do not touch the cents knob or readjust the string.
6. Continue this process to determine the relationship of the frets to each other and to the position of the bridge.
7. Switch the selector knob back to the note of the open string. Do not touch the cents knob.
8. If the open string indicates a deviation, there may be a problem with the location of the nut, or of the contact points at the nut.
    a. Move the contact point forward or backward as required by filing. Be careful not to lower the action at the nut unless desired.
    b. If excessive change is required, the nut may have to be repositioned.

9. There will be some deviation from fret to fret. Due to the straight fret—for all strings—this cannot be avoided. A tolerance of 3-5 cents sharp or flat could be considered normal. A deviation of 10 cents or more might indicate an improperly positioned fret, in which case filling and repositioning will be necessary. The repositioning of one fret may cause repositioning of other frets as well.

Fret Height

High frets can also cause intonation problems, especially when coupled with the use of light gauge strings. When the string is fretted, the additional travel from the contact point at the fret to where the finger forces the string to touch the fretboard will cause "choking" and sharping of notes. There are two solutions for this problem:

1. All of the frets must be dressed lower to reduce the crown of the fret.
2. Increase the gauge of the strings so that "choking" is not as easily accomplished.

The "choking" can be watched on the STROBOTUNER dial by fretting and playing the note, then exerting more pressure on the string. The deviation will be seen as a sharp condition on the dial.

Creating a New Scale Length

(for construction of new instruments)

By using the Conn STROBOTUNER, you can create a totally new fretting scale for any given length.

1. For this procedure, make a jig or fixture from scrap wood stock. Affix a nut at one end and a bridge at the other. The distance between them is to be the intended new scale length. Install a set of tuning machines into the fixture. With tape, hold in place the unfretted, unslotted fretboard. The fixture should be constructed so that the string action is identical to that desired in final construction. Strings of the gauge to be used on the final instrument are installed and tuned to pitch by using the STROBOTUNER.
2. Choose a piece of wire with a diameter that is the same as the height of the fret crown to be used. Bend the last ½" into an "L" shape.
3. Set the selector switch to the next note "up the scale" of the first string.
4. Position the short end of the bent wire beneath the first string at a position which approximates that of the first fret.
5. Fret the string behind the wire (the wire is now acting as the fret) and move the wire until the STROBOTUNER® disc appears motionless. Mark that position on the fingerboard with a white pencil.
6. Continue up the scale until all of the intervals are marked.
7. Repeat the process for each of the strings.
8. Remove fingerboard and tape it onto a drawing board or similar straight-edged surface.
9. Make sure the vertical axis of the fingerboard is parallel to the straight edge.
10. Using a "T" square, carefully scribe a line across the *average* of the white marks at each fret location. The new scale has been created.
11. Remove the fingerboard and slot at the scribed lines.

Relocating a Fixed Bridge

There are numerous instances in which a fixed bridge must be refitted:

1. When replacing a broken or damaged bridge.
2. When relocating an existing bridge.
3. When replacing an entire top or sounding board.
4. When building a new guitar.

In all of the above instances, the bridge must be properly located so that it may be glued to the sounding board in its permanent, immovable position.

In situations where the bridge has just come loose and has to be reglued, the bridgepin holes often act as reliable locating pins. The following procedure is recommended to assure that the optimum bridge location is achieved:

1. Obtain a trapeze type tailpiece.
2. Make some sort of holding device so that the end piece of the trapeze tailpiece can be securely affixed to the end pin. Photo #5 shows that a leather lace can be used effectively. Protect the underside of the endpiece

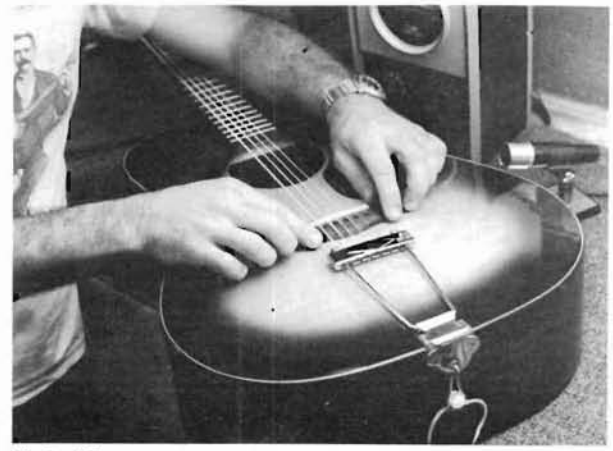


Photo #5

The trapeze tailpiece is protected with a leather caul, and a leather lace is used to tie it to the end-pin. The fixed bridge can then be moved around until the correct position is located.

with leather cauls. (The greatest pressure is at the corner of the end piece and the leather lace is employed merely to keep the endpiece from sliding up.) On instruments without endpins, a large "C" clamp can be used to hold the endpiece down. Only moderate pressure is required, and the clamp should be protected with leather cauls.

3. String the guitar with the gauge of strings to be used. Do not clip the end of these strings as they can be used later when the instrument is completed. (The kink around the machine post will not cause a problem because the strings will be shorter when the final fixed bridge is used.)
4. Slide the fixed bridge under the strings to its approximate position.
5. Tune the instrument up to pitch using the STROBOTUNER.
6. Check the intonation as previously described and move the bridge accordingly to obtain the correct location.
7. Carefully mark the bridge position on the guitar top by using a sharp pencil.
8. Remove strings, bridge, tailpiece, etc.
9. Install the fixed bridge by gluing it in a position *1/32" further from the peghead* to compensate for string pull and twist at the bridge. Scraping finish, doweling old pin holes and other commonly accepted practices should be followed.

Part II–The Stroboconn

The STROBOCONN should be used in tuning sounding boards, tone bars, braces, and air chambers. The STROBOCONN has twelve viewing windows with seven octaves each. This allows you to view a wide spectrum of fundamental tones and harmonies without having to switch or change the controls. The STROBOCONN permits you to quickly locate the resonant frequency of the component being tuned, while observing its movement up and down the scale as physical changes are made to the instrument.

Operation

Set up and adjust the STROBOCONN according to the owner's manual. Some STROBOCONNS require a warm-up period and the use of a switch for this purpose. (Refer to Owner's Manual.)

Additional Equipment

When tuning the tonebars in mandolin and guitar sounding boards, you may want to use a contact transducer instead of the microphone supplied with the unit. Here's why:

1. The transducer will produce an image longer on the STROBOCONN since it is attached directly to the wood and can detect the vibrations without "air loss."
2. When tuning sounding boards, the contact transducer eliminates a great deal of background noise which might otherwise be "read" by the regular microphone.

Mandolin Sounding Boards

Mandolin sounding boards are tuned and adjusted by removing wood from the sounding boards or back plate.

1. Removing wood from the center of the sounding board quickly lowers the resonant frequency.
2. Removing wood from the outer edges of the sounding board slowly lowers the resonant frequency.

Attach the transducer near the head block section of the sounding board, and tap the wood by striking with a soft, felt-covered hammer. Determine which STROBOCONN window (or between which window) the most distinct image is displayed.

Carefully remove wood until you achieve the desired note. Mandolin design dictates that arched top plates be thicker in the center than at the edges. Any carving and adjusting must follow these contours. Adjust mandolin tops by sizing and adjusting the tone bars; adjust mandolin backs by removing wood from their surfaces.

Tone Bars

Tone bars are used to adjust the natural resonance of sounding boards. They enable the entire sounding board to function as a unit.

Since every piece of wood is different, no two mandolins, (or violins), if made and tuned the same way, will have the same size tone bars.

1. Removing wood from the center of the tone bar quickly lowers the resonant frequency.
2. Removing wood from the ends of the tone bar slowly lowers the resonant frequency.

To achieve the proper note or frequency in some guitars, mandolins and violins, you may have to use a "scalloped" configuration. This means adjusting the tone bars and braces so that they appear to be lower in the center than at the ends.

Tune mandolin tone bars by striking them in the center with a felt covered hammer. Adjust them until they are a semitone apart.

Guitar Sounding Boards

In order to tune and adjust the guitar sounding board, you must shape and adjust each of the tone bars and braces affixed to the underside of the top.

Attach the transducer above the sound hole, directly over the typical cross brace as shown in photo #6. Strike the brace or tone bar to be adjusted with a felt covered hammer. Read the resonant frequency from the STROBOCONN. Numerous tonal adjustments (frequencies) can be obtained. Adjust all tone bars and braces to various intervals of ±0 cents.

When the tone bar on a guitar top is excited (tapped), the STROBOCONN will display images similar to those shown in photo #7. Striking each tone bar or brace will display a different series of fundamentals and overtones.

Sound Holes

In tuning sound holes, you must first analyze the frequency of the sound (in air) emitted from the air chamber. The tuning can be accomplished with the microphone supplied with the STROBOCONN.

1. Enlarging the sound holes (round, oval, or "f") raises the resonant frequency (makes it a higher note).
2. Decreasing the size of the sound holes lowers the resonant frequency (makes it a lower note).

Strike the center of the sounding board with a felt covered hammer to excite the resonant frequency of the air chamber. Then observe the STROBOCONN discs for the resonant frequency. Test the phenomenon by sliding a piece of cardboard over the opening while striking the sounding board. The change (down the scale) can be observed on the STROBOCONN discs.

Decreasing the size of the sound holes can only be done by adding wood. If it is necessary to reduce the size of the hole, then it may be desirable to add a ring of purfling, or binding. It is best to remove the wood as carefully as possible.

Tuning Frame

Plates in suspension (held in the air) vibrate differently than plates held around their perimeter Therefore all plates should be adjusted while being held in a heavy, dense frame that clamps the entire edge. Construct this frame out of particle board or the like. So that the tuning process is not interrupted, the frame should have large, heavy legs with large openings so that it (or the space under it) has no specific resonant frequency of its own.

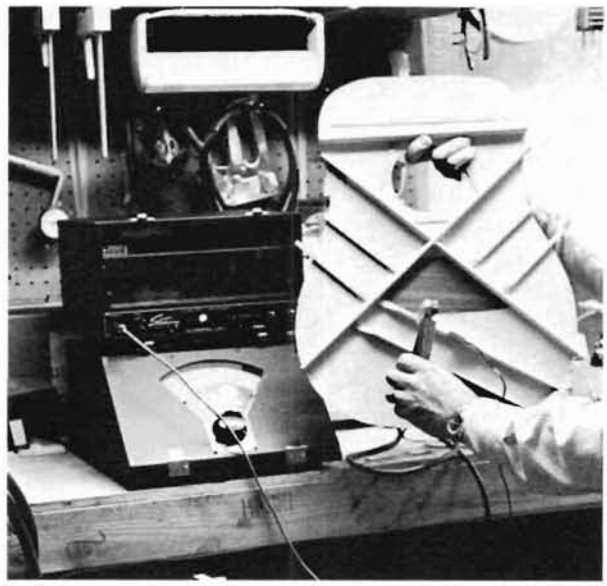


Photo #6

Photo of transducer above the sound hole, directly over the typical cross brace.

Photo #7

Image on STROBOCONN when tone bar on guitar top is excited.

Tuning Note

There is a vast spectrum of tuning possibilities for each and every type of wood and each combination of woods. Therefore it isn't possible for us to recommend special frequencies, or optimum tuning notes. You will need to learn and record these notes for future reference and individual or private standards. Your tuning capabilities will be learned and reinforced by using the STROBOCONN equipment. The extreme accuracy and stability of the STROBOCONN—with its ability to display the entire musical spectrum—makes it almost a necessity for the truly serious technician.

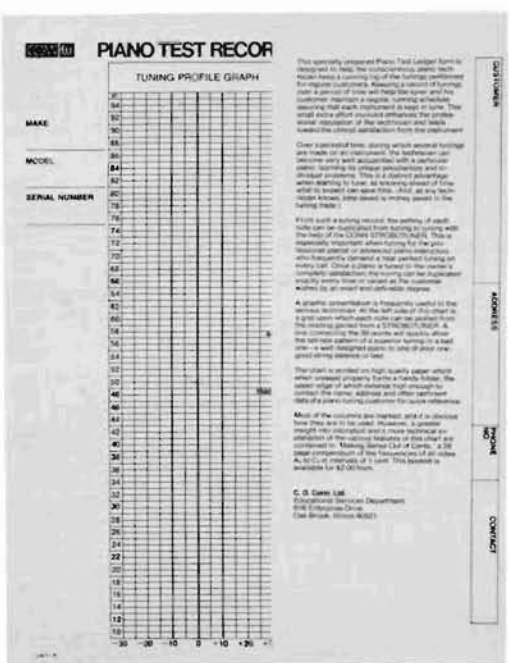
Conn Publications and Accessories

Making Sense Out of Cents

A comprehensive Frequency Table listing all notes from A0 to C8 by cycles per second in 1 cent increments. Also information on scales other than diatonic. . . . . #CM13...$3.50

Piano Test Record Ledger

An 8½" x 11" plus flap form suitable for making permanent record of tunings. Ideal for students, engineers, and the professional technicians. . . . . #CM11...$1.50/doz.



Owner's Manual

For model ST-11 . . . . . #CM3...$1.50 ea.
For model ST-12
(export model) . . . . . #CM23...$1.50 ea.

How To Use The Conn Strobotuner In Piano Tuning

The tuner's guide to more accurate piano tuning with the aid of Conn's strobotuners. #CM7...$3.50

Beat Locator Strip Set.

#CM9...$1.00 per set

Order the above items from: C. G. Conn, Ltd., Advertising Dept., 616 Enterprise Drive, Oak Brook, IL 60521.
Prices subject to change without notice.