

# **peterson**

## ***AutoStrobe*<sup>™</sup> 490-ST Strobe Tuner**

### **Instruction Manual**

Revised 4-99 for Software Revision 1.04

by  
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# THE ORGANIZATION OF THIS MANUAL

Congratulations on your purchase of the **peterson AutoStrobe™ 490-ST** strobe tuner. For your convenience, this manual is organized into three major sections. The first, “The *AutoStrobe* 490-ST—At A Glance”, comprises just three short pages of “must read” information that everyone should read before attempting to turn the Model 490-ST on and use it.

The next section, “The *AutoStrobe* 490-ST—In Depth”, provides detailed information about all controls and features available in this device, how they are used, accessed, viewed, and manipulated.

The last section includes a glossary of terms used in this manual, two appendices with supporting background about some of the exclusive capabilities of your *AutoStrobe* 490-ST, and an index of terms for easy access to specific areas of the manual by subject. Terms found in the glossary first appear in the main sections of this manual with a superscripted “ ” for “glossary”.

## THE *AutoStrobe* 490-ST—AT A GLANCE

### 1. INTRODUCTION

The **peterson AutoStrobe™ 490-ST** combines the best from over 40 years of strobe tuner technology with our latest advances in automatic note detection, image stability/clarity, and alternate temperament/stretch capabilities. We've integrated the classic eight-octave strobe disc tuning system with precision digital microprocessor and motor control technologies to provide a versatile tuner with unsurpassed accuracy and features. This instrument is designed for simple “user-friendly” operation with little need to press buttons once the initial desired settings have been entered. It is the best choice for music educators, musicians, manufacturers, and for any application where an accurate and versatile tuner is required.

### 2. BEFORE TURNING IT ON: READ THIS SECTION!

OK, OK! We know you're all aflutter with anticipation, but it's really important (you can always tell by all the **bold** and *italics* stuff!) to take care of a few details to avoid unintentionally wreaking some havoc. The following short sub-sections will guide you through turning the *AutoStrobe* 490-ST on and using the basic features without damage to the unit or to your ears!

**IMPORTANT PRECAUTION:** The Model 490-ST is designed to be used with 95-105V, 110-120V, 210-230, or 230-250V, 50/60 Hz AC power sources. ***IT IS VERY IMPORTANT FOR THE VOLTAGE SELECTOR CARD LOCATED IN THE FUSE CASE AT THE BACK OF THE TUNER TO BE SET FOR THE PROPER VOLTAGE BEFORE PLUGGING IN THE LINE CORD..... FAILURE TO DO SO MAY RESULT IN SEVERE DAMAGE TO THE INSTRUMENT!***

#### Checking the AC Voltage Selection

- 1) First remove the power-line cord from the unit.
- 2) Slide the small, clear, plastic safety door of the power entry/fuse module completely to the left so as to expose the fuse chamber.
- 3) A small fiberglass wafer or Voltage Selection Card is inserted horizontally just below the fuse and fuse-pull lever in this chamber. The currently selected voltage setting (100, 120, 220, or 240) will be plainly visible in large, dark numerals on this card. If the current selection matches the power-line voltage in your area, you do not need to change the selection. Simply slide the plastic window back to the right and plug the tuner line cord into the power entry receptacle at the left. You can even skip ahead over the next section—just remember that if you ever need to accommodate different power line voltages, this next sub-section will guide you through it.

#### Changing the AC Voltage Selection

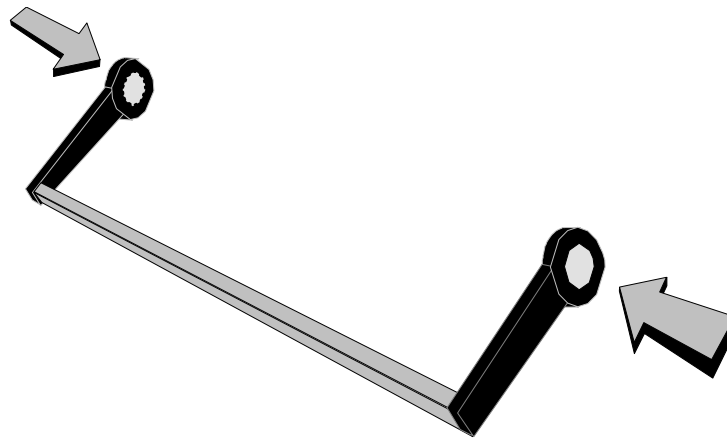
If the visible indication on the Voltage Selection Card does NOT match the power-line voltage in your area:

- 4) Pull the “Fuse Pull” lever out and to the left until the fuse is released on one end.
- 5) Completely remove the fuse from the unit.
- 6) Make sure the “Fuse Pull” lever is in the absolute far left position, completely clear of the Voltage Selection Card.
- 7) Insert the tip of a needle-nose pliers, scissors, or other suitable item through the small hole at the edge of the selection card. (NOTE: if you believe that you will need to switch this card often, you might consider acquiring a special extraction tool available from Peterson.)
- 8) Gently but firmly pry the card straight back and out of the fuse chamber by using the upper lip of the power entry/fuse module as a leverage point and pushing on the upper part of the tool you've selected.
- 9) Flip or rotate the card so the proper voltage indication will be visible when the card is re-inserted (top, left).
- 10) Re-insert card by pushing firmly with fingers.
- 11) Reconfirm that the proper voltage selection is now the one that is visible on the card.
- 12) Push the “Fuse Pull” lever about halfway to the right and reinstall fuse (left end first).
- 13) Slide safety door back to the right.
- 14) Plug the tuner line cord into the power entry receptacle at the left.

### Changing the Handle Position

On all hand-held versions of *AutoStrobe* tuners, a convenient handle is included which can function as an angled stand for optimal viewing.

#### Repositioning the Tuner Handle



To change the position of the handle, locate the two spring-loaded, circular, silver plates on each end of the handle where the handle is attached to the tuner. Simultaneously pressing these plates in toward the tuner will free the handle to rotate in any position around the tuner. While pressing these plates, simply swing the handle into the desired position and release the plates. Moving the handle slightly will allow it to lock in the nearest latch position (approximately every 30° of rotation).

### Basic Operation: A Quick Tutorial

We will first give a summary of how to use the *AutoStrobe* 490-ST for basic tuning using an unstretched equal-tempered scale and A=440 Hz as the pitch reference. We follow later with detailed instructions on how to use the other features available on the tuner.

The Model 490-ST responds to direct acoustic input through a built-in microphone which is active whenever the EXTERNAL INPUT jack is empty. The jack permits input from an external microphone, electric guitars and basses, or any signal in electrical form.

After you have checked the back of the Model 490-ST as detailed above to verify that the voltage selector switch is set to the correct position of 100, 120, 220, or 240 Volts AC, connect the line cord to an AC outlet receptacle, push the power switch at the right of the strobe disc to the “up” position and follow these easy steps to use the tuner.

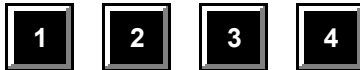
**PETERSON  
MODEL 490-ST TUNER  
REVISION X.XX  
SERIAL # T490 XXXXX**

The initial screen during the power up phase is depicted here. Line three shows the software revision number and line four the serial number of the particular tuner.

**NOTE:** We advise that you write down the serial number shown on this initial screen and keep it with your records for future reference in case anything should happen to your unit that would prevent this screen from appearing.

At the conclusion of the power-up tests, the strobe wheel will begin rotating and will flicker slightly due to random noise in the room. The display panel will then change to the normal RUN screen as shown on the next page:

KEY= C  
A=440            C            00 ¢  
          AUTO  
SETUP    MODE



The first line indicates that the tuner is set for instruments referenced to the Key of C. Line two indicates that the standard for A is 440 Hz, the current note setting is “C”, and that the global pitch offset is set at 0 cents deviation. Line three shows that the tuner is currently set to automatically detect the nearest standard pitch present in the audio input and use it as the current note reference for tuning. The items on line four always indicate the current function, if any, of the four Function buttons (labeled 1 through 4) directly beneath the LCD display. This is explained in greater detail later in this manual.

The built-in microphone will pick up an instrument from across a relatively quiet room. However, if you are working in a noisy environment or with sounds which decay quickly, it may be helpful to use an external microphone (inserted in the EXTERNAL INPUT jack on the front panel) to be more selective and point the microphone directly at the instrument you wish to tune.

Your *AutoStrobe* 490-ST tuner can function in either of two ways: MANual mode or AUTOMATIC mode. Unless you choose to change the default, the tuner will power up in the AUTO mode. In this condition, any strong audio tone input to the built-in microphone (or EXTERNAL INPUT jack) will be internally analyzed—usually in well under a second—and the standard-pitched semitone nearest in frequency to that of the input sound will appear on the LCD screen. The motor for the strobe disc will automatically adjust in speed so that you can view the tuning of this input sound relative to this nearest standard pitch. Although it is rotating very rapidly, one or more circular bands on the disc will appear to be moving very slowly or will appear to be standing still. The lowest band exhibiting this effect indicates which octave the audio input signal occupies. If the rotation appears to be to the left (counter-clockwise), your input sound is flat compared to this nearest standard-pitched semitone. If the rotation appears to be to the right (clockwise), the input sound is sharp compared to the standard. If the image appears to be standing still, the input is perfectly in tune with the standard. Furthermore, the slower the disc appears to be rotating, the closer the input sound is to the standard. This makes for a very simple and natural visual feedback when bringing an input sound into tune.

To tune to a different note, simply cease the current audio input and sound a different pitch. If the new input is closer to a different standard-pitched semitone, the tuner will re-analyze the input, indicate this new pitch on the LCD screen, and, once again, automatically adjust the motor so that the disc will properly indicate the relative tuning of this new input to the nearest standard-pitched semitone.

**NOTE:** When tuning an instrument like a piano, it is expected that the automatic note selection may not respond well at either extreme of pitch. The unit’s circuitry is less sensitive at these extremes, and the naturally short duration of the highest

notes and strong, non-harmonic overtones of the lowest notes can interfere with the note detection. Automated note selection at these extremes is best optimized by using an external microphone (at the EXTERNAL INPUT jack on the front panel) and placing it near the sound source. Alternatively, of course, MANUAL mode note selection may be chosen to avoid the difficulty entirely.

**NOTE:** The automatic note detection feature is based on reference tuning of A=440 Hz and Global Cent Offset (which appears on the second line of the RUN screen) set to 0 cents. Any deviation from these tuning references will limit proper note sensing to less than the usual  $\pm 50$  cents range. For most applications, deviations in the range of A430 to A450 or, separately, up to about  $\pm 40$  cents Global Cent Offset will yield reasonable results for automatic note selection. Of course, there are no limitations over the full range of offsets available in the tuner when using MANUAL note selection.

**HINT:** When tuning a stringed instrument like a guitar or bass, image clarity and automatic note selection are usually improved by plucking away from the bridge with a fingertip (as opposed to a fingernail or pick) using medium force. This minimizes the harmonic (overtone) content of the tone while maximizing the fundamental frequency that is to be tuned.



4. **EIGHTY-CHARACTER LCD MENU SCREEN** — Simplicity and ease of operation are enhanced by the intuitive and user-friendly menu screen displays which address all the functional features of the tuner.
5. **FOUR MENU-DRIVEN FUNCTION BUTTONS** — The action of each of these four push buttons is defined by whatever specific description is currently displayed immediately above them on the bottom line of the LCD screen. These software-defined buttons permit great flexibility and simple user interaction with the Model 490-ST. The functions of buttons “3” and “4” are paralleled on the “tip” and “ring” connections, respectively, of the “OCT- / OCT+” stereo 1/4-inch jack at the back of the Model 490-ST. This allows “hands-free” setting of the currently selected octave through a momentary-close footswitch when a stretch file is active. (A proper footswitch is available from **peterson** as part #: 140069.)
6. **TWELVE MANUAL NOTE-SELECTION BUTTONS** — These 12 push buttons permit traditional manual selection of the scale note to which the audio input is to be tuned. The Model 490-ST also permits (by default) an “AUTO” or “hands-off” tuning mode where the standard scale note closest in pitch to the incoming audio signal is automatically selected by the unit.
7. **ENTER** — This push button is used to select specific values of scale note cent deviations when editing customized temperament or stretch files used in specialized tuning applications. It is also used to make some of the user selections under the temperament/stretch programming menus of the tuner. Under the normal RUN screen, ENTER is used in conjunction with the UP ARROW/DOWN ARROW buttons to access enhanced resolution of the global cent offset parameter displayed on that screen.
8. **KEY** — This push button is used to allow the Model 490-ST to reference scale notes in the same key base as the instrument to be tuned. Note names are internally transposed from “Concert Standard” notes allowing the user to see and access notes in the transposition with which he is most comfortable. For example, if a clarinetist enters a KEY of B= and plays the “C” position of a B= clarinet, the strobe disc will indicate the “in tune” standing pattern when the LCD display indicates note “C” even though the pitch being played is Concert B=. Each press of the KEY button will advance the current key of the tuner one step within the sequence: C, B=, F, E=, and back to C. (Please note that all buttons which affect motor speed are disabled while the motor is accelerating to a new speed.)
9. **UP ARROW / DOWN ARROW** — These two push buttons increment or decrement various parameters on the LCD screen depending upon which screen is currently active. While the RUN screen is active, they control the global cent offset parameter displayed on the second line of the LCD. (Individual note cent offsets are separately programmable under Temperament and Stretch File menus.) While controlling either global cent offset in the RUN screen or individual note offsets under the File menus, pressing both the UP and DOWN arrow buttons simultaneously will provide an immediate “reset value to 0” operation. When either button is depressed and held to continuously increment or decrement these cent values, advancement will proceed, after one initial step, at 5 times the currently set resolution. These new features help to speed manipulation of the cents parameter.  
  
Each time the ENTER button is pressed simultaneously with either arrow button, the resolution of the global cent offset parameter is advanced one step within the sequence: 1, 0.5, 0.1, and back to 1 cent resolution. Under some Temperament and Stretch File menus, the arrow buttons advance a cursor to select characters when naming files.
10. **DISPLAY +2 / -1** — This push button alters the strobe motor speeds so as to cause audio input in a given octave to be read on higher or lower bands on the strobe disc. While this effectively expands the range of tuning to an unprecedented 11 octaves, it is most often used to push the standing strobe pattern for very high or low-pitched instruments toward the more easily-read middle strobe disc bands. However, with our latest innovations in automatic strobe clarity, this will often be unnecessary. Each press of this button will advance the current display mode one step within the sequence: normal, +2, -1, and back to normal. For a given input pitch, the “+2” mode shifts the lowest strobe disc band exhibiting a standing pattern two positions higher than would appear in the “normal” display. This would be most useful with very low-pitched notes. For a given input, the “-1” mode shifts the lowest strobe disc band exhibiting a standing pattern one position lower than would appear in the “normal” display. This would be most useful with very high-pitched notes. (Please note that all buttons which affect motor speed are disabled while the motor is accelerating to a new speed.)

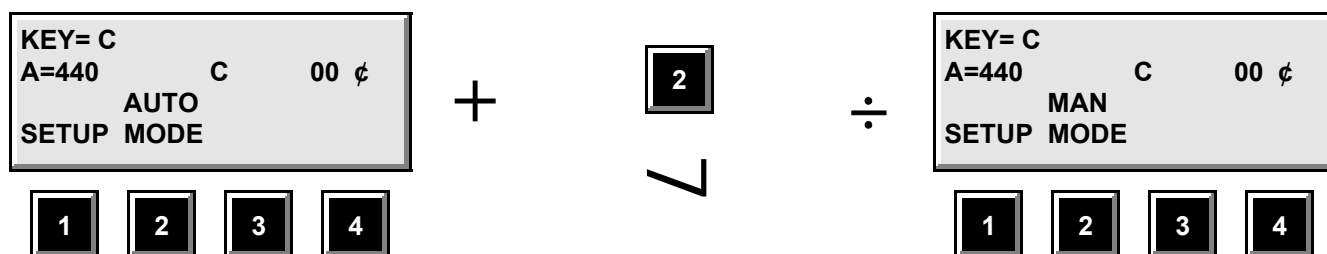
11. **MUTE** — The *AutoStrobe* 490-ST has an external input and “through” output with mute to allow silent on-stage tuning of instruments without having to disconnect the tuner from your audio signal chain. When MUTE is active, any audio signal (originating from the EXTERNAL INPUT jack or built-in microphone) to the front-panel EXTERNAL THRU jack is suppressed. Each press of the MUTE button toggles the MUTE function on or off. When engaged, the word “MUTE” appears on the third line of the RUN screen on the LCD display. The MUTE button is connected in parallel with the 1/4-inch jack at the rear of the tuner labeled “MUTE SWITCH”. Any momentary-close contact device such as a footswitch may be used in place of or in addition to the MUTE on/off button. (The front-panel button will continue to operate with a device plugged into this rear jack unless the device is held in the closed position—make sure that the device operates in a *momentary-close* fashion. A proper footswitch is available from **peterson** as part #: 140070.)

## 2. AUTOMATIC AND MANUAL NOTE SELECTION ON THE *AutoStrobe* 490-ST

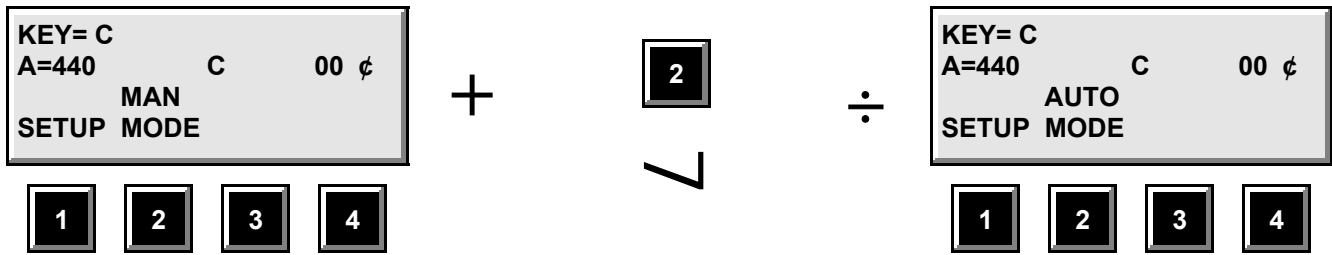
Your *AutoStrobe* 490-ST tuner can function in either of two ways: MANual mode or AUTOMATIC mode. Unless you choose to change the default, the tuner will power up in the AUTO mode. In this condition, any strong audio tone input to the built-in microphone (or EXTERNAL INPUT jack) will be internally analyzed—usually in well under a second—and the standard-pitched semitone nearest in frequency to that of the input sound will appear on the LCD screen. The motor for the strobe disc will automatically adjust in speed so that you can view the tuning of this input sound relative to this nearest standard pitch. Although it is rotating very rapidly, one or more circular bands on the disc will appear to be moving very slowly or will appear to be standing still. The lowest band exhibiting this effect indicates which octave the audio input signal occupies. If the rotation appears to be to the left (counter-clockwise), your input sound is flat compared to this nearest standard-pitched semitone. If the rotation appears to be to the right (clockwise), the input sound is sharp compared to the standard. If the image appears to be standing still, the input is perfectly in tune with the standard. Furthermore, the slower the disc appears to be rotating, the closer the input sound is to the standard. This makes for a very simple and natural visual feedback when bringing an input sound into tune.

To tune to a different note, simply cease the current audio input and sound a different pitch. If the new input is closer to a different standard-pitched semitone, the tuner will re-analyze the input, indicate this new pitch on the LCD screen, and, once again, automatically adjust the motor so that the disc will properly indicate the relative tuning of this new input to the nearest standard-pitched semitone.

The *AutoStrobe* 490-ST can also be placed in MANual mode by pressing the “2” button while the label above it in the LCD screen indicates “MODE” (that is, when the normal RUN screen is active). Directly above this MODE label on the LCD, an indication of the currently active note-select mode—AUTO or MAN—appears. Pressing the “2” button will toggle this note select mode and the LCD indication will be updated.



Accessing Manual Note Select Mode



### Accessing Auto Note Select Mode

While the MAN MODE is indicated, the selection of note will not be affected by the incoming audio signal and must be selected by pressing one of the note buttons below the strobe disc. This feature is useful when extraneous audio tones are present in the environment (making automatic selection difficult) or when one purposely wishes to measure tuning of various harmonics (partials) present in the audio input.

Alternatively, a simple, multi-purpose mono footswitch jack (farthest from the center of the rear panel) permits a hands-free note increment function while MAN MODE is active. (A proper momentary-close footswitch is available from **peterson** as part #: 140070.)

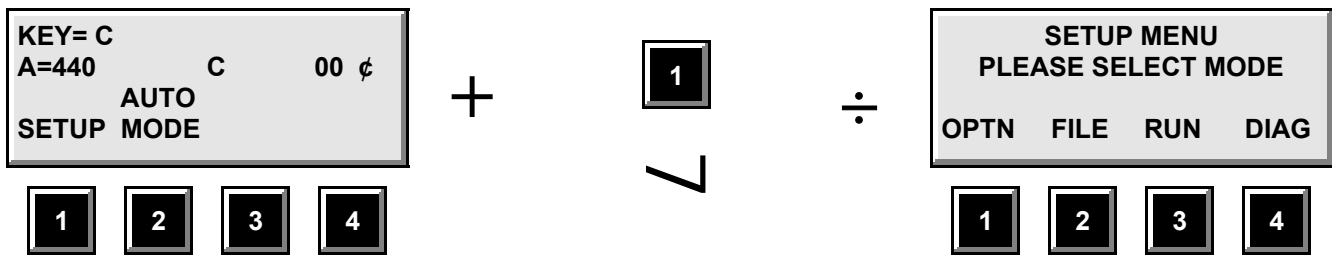
**NOTE:** The automatic note detection feature is based on reference tuning of A=440 Hz and Global Cent Offset (which appears on the second line of the RUN screen) set to 0 cents. Any deviation from these tuning references will limit proper note sensing to less than the usual  $\pm 50$  cents range. For most applications, deviations in the range of A430 to A450 or, separately, up to about  $\pm 40$  cents Global Cent Offset will yield reasonable results for automatic note selection. Of course, there are no limitations over the full range of offsets available in the tuner when using MANual note selection.

## 3. SETUP MENUS—CHOOSING POWER-UP DEFAULTS / TEMPERAMENTS

### a) DESCRIPTION AND INITIAL ACCESS

The *AutoStrobe* 490-ST allows the user to customize the power-up condition of several important parameters which a given user might otherwise have to set each time the unit is turned on. This capability is found under the SETUP menu. In addition, temperament and stretch files may be created, edited, activated, and stored or deleted from non-volatile memory in a separate branch under this menu.













The SETUP menu is activated from the normal RUN screen by pressing the “1” button:



### Accessing the Setup Screen

### b) VIEWING AND MODIFYING PARAMETER DEFAULTS

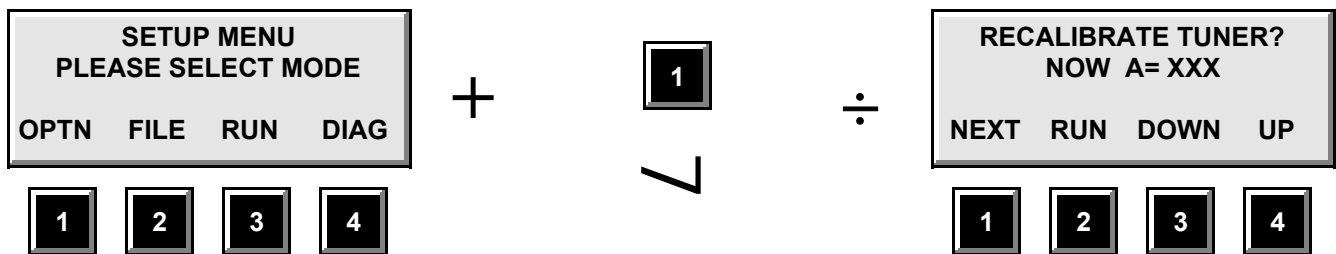
The “OPTN” or Option selection provides further menu screens, each of which is dedicated to viewing and/or altering a given SETUP parameter. The SETUP parameters, their valid ranges, and the buttons used to alter them are summarized below:

SCREEN	PARAMETER SETTING	VALID RANGE:	BUTTONS:
RUN (before entering SETUP)	Strobe Disc Band DISPLAY +2 / -1	+2, -1, Normal, ... Factory Default: Normal	  DISPLAY
1st SETUP parameter screen	Concert A Pitch Reference Recalibration	350 Hz to 550 Hz in 1 Hz increments Factory Default: A=440	  DOWN   UP
2nd SETUP parameter screen	Musical KEY Setting	C, B=, F, E=, ... Factory Default: KEY=C	 
3rd SETUP parameter screen	Auto-Note Selection Mode Setting	OFF, ON Factory Default: ON	  OFF   ON

Each press of the “1” button (labeled “NEXT”) will sequence through screens for each of these parameters except for the Strobe DISPLAY +2/-1 parameter which does not have a SETUP screen. Except for the Concert A pitch reference recalibration, these parameters can be altered more directly from the RUN screen. However, altering the power-up state of these parameters can only be effected under SETUP.

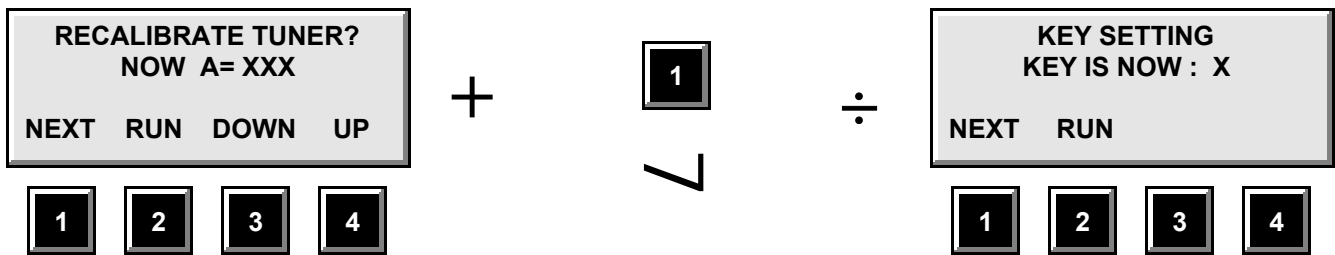
As each SETUP screen is accessed, the value of each parameter shown is the CURRENT state of the parameter as last altered by any method: directly under the RUN screen, a previous access to the SETUP screens, or, if neither of these occurred, the last power-up default settings. Conversely, any change to these parameters under a SETUP screen will be reflected immediately upon exiting SETUP whether the changes were stored or not.

Continuing in order from the SETUP screen, the screen for recalibrating the Concert A pitch reference is accessed by pressing the “1” button (labeled OPTN):



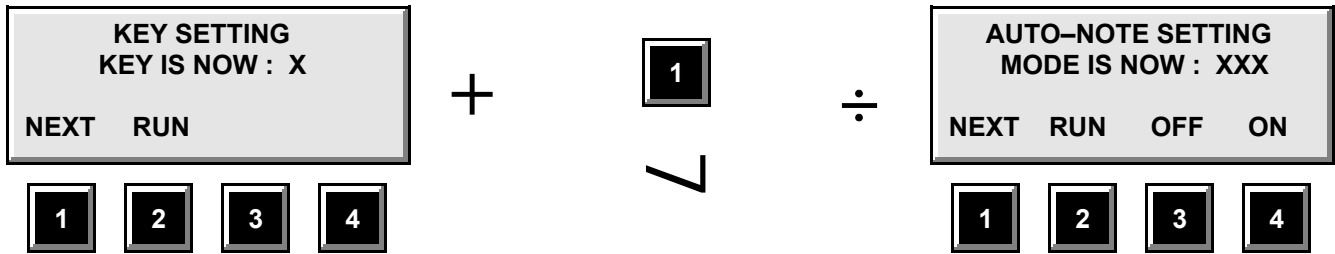
### Accessing the Concert A Recalibration Screen

As with all the SETUP parameter screens, an immediate escape to the normal RUN screen is an option if viewing or changing a particular parameter is all that is desired. Hitting the appropriate value-altering buttons—in this case, buttons “3” and “4”—will cause an immediate update of the LCD screen. Hitting the “1” button (NEXT) will activate the next parameter screen:



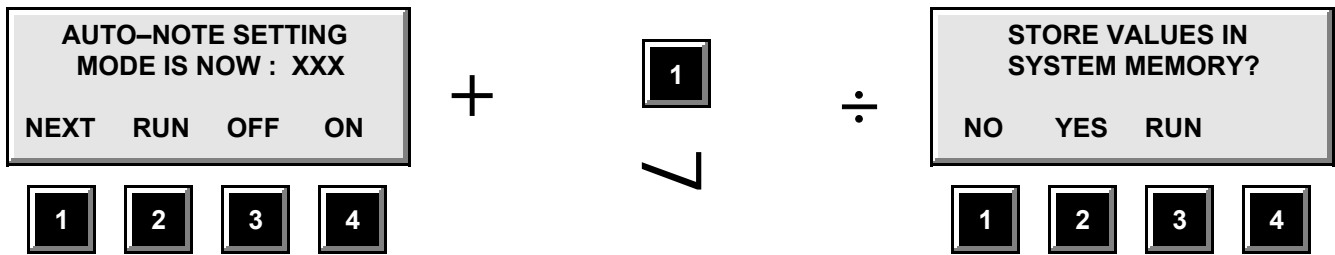
**Accessing the Key Setting Screen**

The KEY screen uses the front panel KEY button to alter the KEY setting just as it will under the RUN screen.

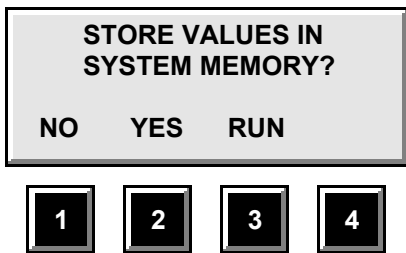


**Accessing the Auto-Note Setting Screen**

Finally, hitting the “1” button (NEXT) under the Auto-Note SETUP screen activates the Memory Store screen:



**Accessing the Parameter Memory Storage Screen**



Button #1 returns to the Setup menu.  
 Button #2 saves new values and returns to the SETUP menu.  
 Button #3 returns to RUN screen and uses new values  
 (new values are not put into startup memory with #3).

Pressing the “1” button (NO) at this time will cause no changes in stored memory and revert back to the SETUP menu screen. Pressing the “3” button (RUN) at this time will cause no changes in stored memory and revert back to the normal RUN screen.

Pressing the “2” button (YES) at this time will save the SETUP parameters in the state in which they were last placed and return the screen to the SETUP menu. The power-up condition of the Model 490-ST will now reflect these latest parameter settings until new values are once again stored under SETUP.

### **c) VIEWING AND ALTERING TEMPERAMENT FILES**

Temperament refers to the specific frequency (pitch) intervals placed between notes in a musical scale. With 12 notes per octave (the most prevalent case but, by no means, the *only* case), there are an infinite number of ways to set the audio frequencies of these notes relative to one another. Through the centuries, many have wrestled with the challenge of creating the most pleasing, yet universally flexible, temperament of these 12 intervals. It turns out that it is mathematically impossible to achieve both completely, that is, if by “pleasing”, one means smooth beat-free intervals, and, if by “flexible”, one means satisfactory harmony in all possible key signatures.

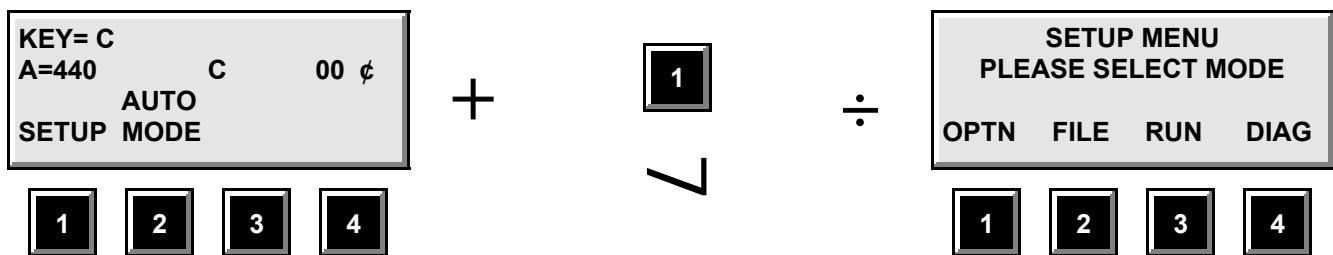
The *AutoStrobe* 490-ST always powers up with Equal Temperament and all offsets applied to notes when defining (editing) custom temperaments are relative to it. In other words, if one creates a temperament in which the C# note is 5.2 cents sharp from the pitch for C# in an equal-tempered scale, a setting of +05.2¢ would be entered. Since the overall frequency standard (both internationally and for the Model 490-ST) is “Concert A”, it is suggested that custom temperaments be created with the “A” scale note maintained at 00.0¢ offset and then adjusting the other scale notes appropriately. In this way, the “A=xxx” setting under the SETUP menu will still be physically accurate.

The Model 490-ST comes with 8 non-erasable, unmodifiable temperaments including standard equal temperament. They vary considerably in the “pleasing versus flexible” compromise that all temperaments must address. All unequal temperaments use “C” as the home key. Those familiar with published temperaments will recognize most of these eight temperaments as both historically and musically useful:

490-ST NAME	FULL NAME	DESCRIPTION
EQUA	EQUAL	All semi-tone intervals are identical: $^{12}/2$ or . 6% above previous note. All keys signatures are equally playable.
PYTH	PYTHAGOREAN	Perfect 4ths and 5ths; 3rds are poor. Avoid G< major and minor keys. F<, C< major and E=, B= minor diatonic keys are very good.
JUMA	JUST (MAJOR)	Perfect triads in 12 keys: C, G, A, E, E=, F major and A, E, F<, C<, C, G minor. “Wolf” tones in all other keys.
JUMI	JUST (MINOR)	Perfect triads in 12 keys: C, G, E=, A=, G=, F major and A, E, C, F, E=, G minor. “Wolf” tones in all other keys.
MEAN	QUARTER COMMA MEAN-TONE	Perfect/excellent triads in 16 keys. Avoid D=, G=, A=, B major and B=, E=, F, G< minor keys.
WRK3	WERCKMEISTER—III	Well-tempered; strong differentiation of key color. Avoid D=, G=, A=, B major and B=, E=, F minor keys.
KRN3	KIRNBERGER—III	Similar to WRK3 but also avoid E=, E major and C, C<, G< minor keys.
YONG	YOUNG	Well-tempered; mild differentiation of key color—most similar to equal temperament. Avoid D=, E=, G=, A= major and B=, C, E=, F minor keys.
KLNR	KELLNER	Well-tempered; pleasing differentiation of key color! Avoid G=, D=, A= major and E=, B=, F minor keys.
P5TH	POWER FIFTHS	Tempered for clean 5ths when playing electric guitar with distortion. (See also “G5TH” under stretch files in the next section)

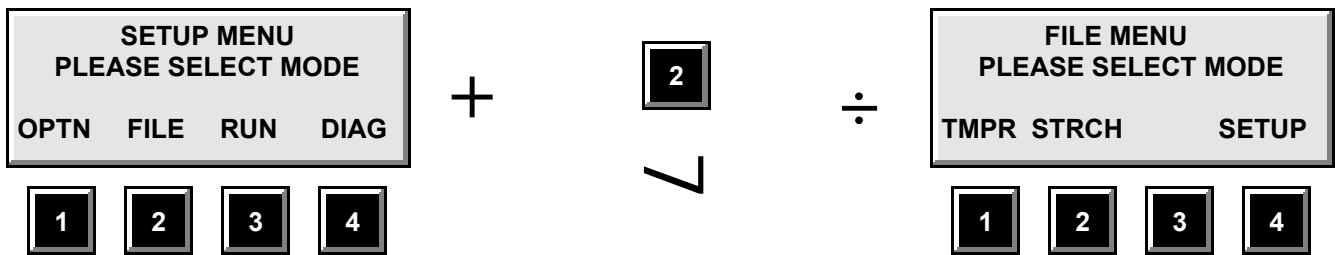
Although they cannot be edited directly, one may always copy any one of these permanent temperaments into a custom temperament which can then be viewed or edited further on a note-by-note basis. The Model 490-ST permits up to 255 user-programmable temperaments which can be created in this way or “from scratch”.

The FILE (temperament or stretch) menus are accessed under the SETUP screen. Thus, the first step when starting from the normal RUN screen is to press the “1” button to enter SETUP:



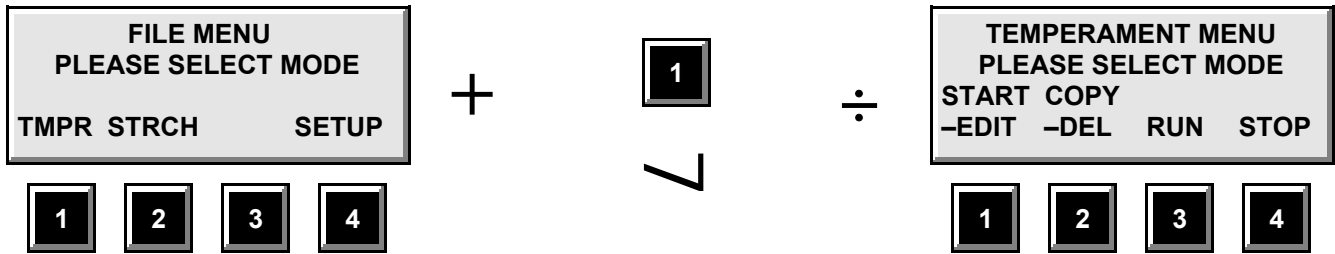
### Accessing the Setup Screen

The next step—accessing the FILE menus—is accomplished by pressing the “2” button (now labeled: FILE):



**Accessing the File Menu Screen**

Pressing a “1” (TMPR) will then allow access into temperament file activity:




**Accessing the Temperament Menu Screen**

Under this TEMPERAMENT MENU screen, all temperament-related activities are accessible through the four Function buttons below the LCD display and are summarized in the following table:

TEMPERAMENT ACTIVITY	ACCESSED THROUGH:	FUNCTION BUTTON:
Select and activate a pre-existing temperament	START -EDIT	L
Create(edit), name, and activate a new temperament	START -EDIT	L
Copy an existing temperament, edit the copy (if desired), name, and activate the new temperament.	COPY -DEL	L
Delete a non-factory temperament	COPY -DEL	L
Return to the RUN screen with no change	RUN	L
Deactivate(STOP) the current non-equal temperament and revert to equal temperament	STOP	L

The following flowcharts plot the various steps required to accomplish these temperament activities. The four examples highlight only the sequence of button presses typically necessary for just one of these activities, that is to say, with no mistakes or back-tracking.

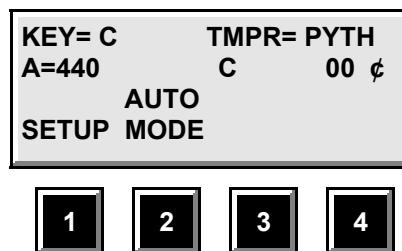
The following key will assist in understanding the “shorthand” of these flowcharts:

1. To the right (or sometimes above) each front panel function button—“1” through “4”—depicted on the flowchart is the exact label for that button as shown on the LCD display at the current step in the programming.
2. With the exception of the top two LCD screen drawings in each flowchart, the word descriptions at various steps do not necessarily appear on the LCD screens but are meant only to explain the action at these steps.
3. The appearance of the “ ” icon indicates that the user must press one of the buttons depicted horizontally to the right of it in order to execute a choice in the current step of the programming and advance to the next step.
4. The appearance of an asterisk “\*” near a button indicates that pressing that button in the current step of the programming will cause the LCD screen to be redrawn with new functions assigned to the four Function buttons.
5. A diamond (◇) box indicates that the next step in the programming depends upon specific choices made up to that point. For example, under the “Creating A New Temperament” flowchart, a box labeled “4 characters?” is encountered. If the user has entered four characters for the temperament name at this point, the next step will follow the “YES” path downward in the chart (at which point the LCD display re-labels the function buttons as indicated). If, at any given time, this diamond box is encountered when *less* than four characters have been chosen (as is normally the case for at least the first three times the box is encountered), the “NO” path is followed. In this example, that means that the function buttons continue to allow positioning of the cursor under various characters and/or selecting (or removing) a character from the current temperament name under construction.

**NOTE: When deleting temperaments, the motor for the rotating strobe disc will always be turned off. The motor will begin again upon returning to the RUN screen when temperament activity is concluded.**

A comprehensive flowchart at the end of this instruction manual shows ALL possible paths through the temperament menus and provides a good reference once the fundamental concept of these menus is understood. You may note that at almost every point, there is a button function (like BACK or REDO) which jumps to a logical earlier step of the current activity or a button function (like RUN or CNCL—short for “cancel”) which jumps out of the current activity with no changes made.

Once a temperament is activated, its name will appear at the upper right-hand corner of the RUN screen:



#### d) VIEWING AND ALTERING STRETCH FILES

“Stretch” refers to specific adjustments in the frequencies (pitches) of notes—both within octaves and over multiple octaves—to enhance the overall quality of tuning within an instrument. While such adjustments have traditionally been applied only to the acoustic piano, it has become increasingly popular to exploit this tuning consideration in allied instruments such as the harp, bass, and guitar as well as in percussive instruments such as the xylophone, vibraphone, and steel pan. The need for stretch adjustments arises from the “non-ideal” vibrational mechanisms that are inherent to such instruments. This is not to say that they are *inferior* in some way; on the contrary, it is the *non-ideal* vibrational modes of these instruments that lend unique interest to their tones. Rather, “non-ideal” refers to the fact that these sound vibrations do not precisely follow simple mathematical models that yield frequencies of sound at integer ratios to one another. In short, with *no* stretch tuning in these types of instruments, the *overtone* frequencies produced when striking lower-pitched notes do not match the *fundamental* frequencies of notes in higher octaves. This results in a subjective impression of discord even when the fundamental pitches of these notes are completely harmonious with one another!

In order to minimize this disparity, the pitches of notes in lower octaves must generally be made increasingly flat and the pitches of notes in upper octaves made increasingly sharp—hence, the term “stretch”. However, the proper degree of stretching depends on many factors. In a piano, for example, the thickness, tension, and type of construction of the strings as well as the “scale” of the piano all play a role in determining how much stretch should be employed. In reality, no two pianos would ever be properly tuned to the exact same note frequencies throughout.

Moreover, stretch tuning is a highly subjective adjustment which is necessarily a compromise between minimizing overtone beats and maintaining the “cohesiveness” of fundamental pitch. In fact, no two critical listeners (or even *one* listener at two distinct times or locations) would ever truly agree on the “ultimate” tuning of any given piano! Thus, customizing a stretch for a piano based on the vibrations of three or four strings—as at least one tuner manufacturer does—is, in some ways, providing a false sense of security. Even if your piano matches another perfectly at such points (yielding identical stretch curves under such a method), does your piano “break” into wound strings at the same note as the another? Have *each* of your strings really aged *uniformly* and in the *exact* same way as those on another piano? Seems unlikely, doesn’t it?!

Is there no *hope*! Are we destined to mire in a sea of cacophony!! Not really. True, there is no possibility of *mathematical* perfection in the tuning of a piano, but, after all, this is not why pianos exist. A piano is a wonderful tool for creating sounds that please the human ear and soul. The piano technician’s goal then is to maximize the playing and listening pleasure of his clients. A reasonable compromise (or at least a good starting point) for tuning pianos and related instruments is to employ stretch tuning to match those factors which have the greatest impact on the perception of pleasing pitch and harmony. For pianos, these factors are, overwhelmingly, the type (upright or grand) and scale (string lengths) of a given instrument. The Model 490-ST tuner addresses this need by supplying a number of preset stretch profiles which correspond to the range of instruments most piano technicians will likely ever encounter.

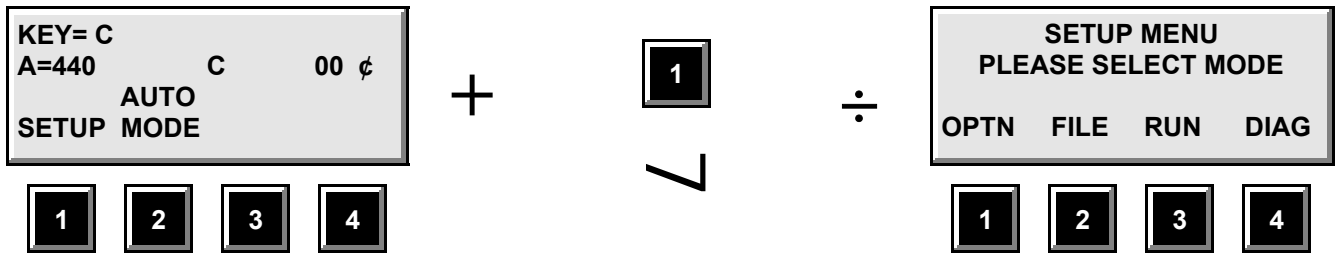
The Model 490-ST comes with 9 non-erasable, unmodifiable stretch profiles (including a proprietary “G5TH” stretch for guitar which cannot be copied). The first 8 “piano” stretches vary steadily in order from very minimal (CNGD—Concert Grand) to extreme (SPNT—Spinet). A table describing all included stretches is presented here:

490-ST NAME	FULL NAME	DESCRIPTION
CNGD	CONCERT GRAND	Useful for all concert style grand pianos of approximately 8 feet in length or greater. This minimal stretch profile may also be of use on smaller pianos strung with thin piano wire or in situations where the user wishes a greater coherence of fundamental pitch throughout the instrument.
STGD	STUDIO GRAND	Optimal for a 6' to 7'11" range of grand piano.
AVRG	AVERAGE (all classes)	Taken from optimal settings for vertical and grand pianos of many makes and sizes, this profile will produce a reasonable tuning for non-critical applications. It also provides a good starting point for creating your own stretch profiles.
SMGD	SMALL GRAND	Useful for grand pianos that are 5'10" or smaller in scale.
UPRT	UPRIGHT	Suitable for vertical pianos equal or exceeding 51".
VERT	VERTICAL	Taken from optimal settings for many makes and sizes of <i>vertical</i> pianos, this profile will produce good results for any vertical-style piano in typical playing environments for such pianos.
CNSL	CONSOLE	Designed for vertical pianos in 39" to 51" range.
SPNT	SPINET	Designed for vertical pianos smaller than 39", this profile is the most extreme (farthest bass and treble note stretching) of these piano preset stretches.
G5TH	GUITAR 5THs <b>OCT0:</b> E(low string), A <b>OCT1:</b> D, G, B <b>OCT2:</b> E	A unique tuning adjustment for standard-tuned guitars (or, additionally, for "1/2-step down" tuning: E=, A=, D=, G=, B=, E= as well as simple open chord tunings) in which "power-chord" 4ths and 5ths are optimized. This is very useful in situation where distortion is to be used as part of the guitar tone. (This "stretch" avoids a compromise of the P5TH temperament under the Temperament presets through the ability of stretch files to have independent adjustments for each "E" string.)

Although they cannot be edited directly, one may copy any of these permanent stretches (with the exception of the G5TH stretch) into a custom stretch which can then be viewed or edited further on a note-by-note basis. The Model 490-ST permits up to 31 user-programmable stretches which can be created in this way or "from scratch".

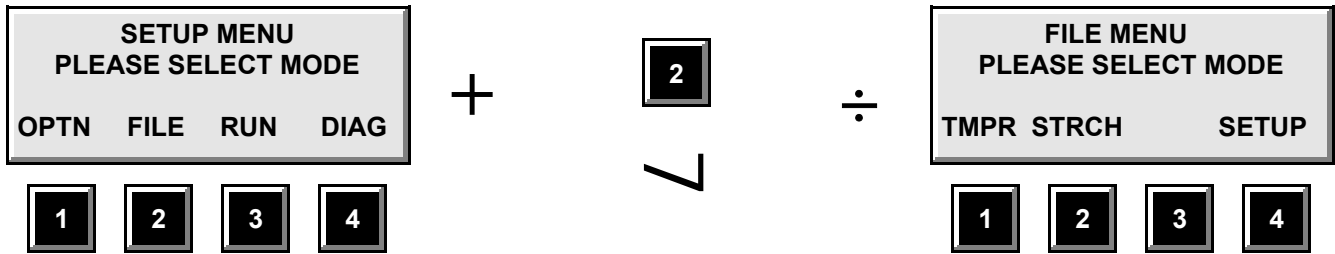
The actual note offset values for each of the piano presets is presented in Appendix C at the back of this document.

The FILE (temperament or stretch) menus are accessed under the SETUP screen. Thus, the first step when starting from the normal RUN screen is to press the "1" button to enter SETUP:



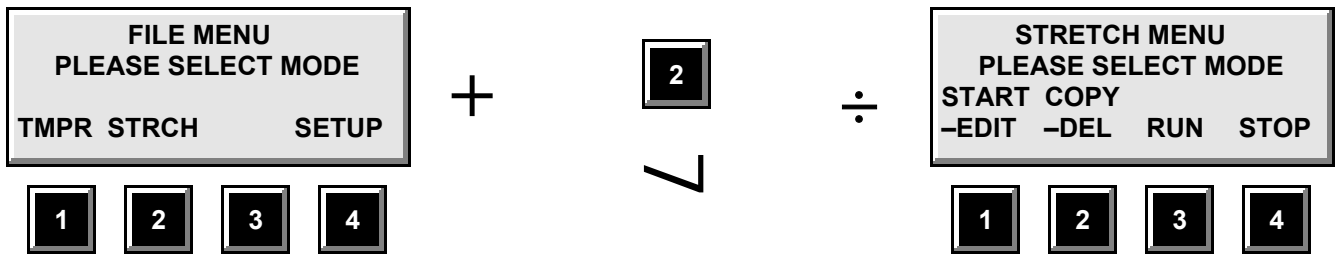
**Accessing the Setup Screen**

The next step—accessing the FILE menus—is accomplished by pressing the “2” button (now labeled: FILE):









**Accessing the File Menu Screen**

Pressing a “2” (STRCH) will then allow access into stretch file activity:



**Accessing the Stretch Menu Screen**

Under this STRETCH MENU screen, all stretch-related activities are accessible through the four Function buttons below the LCD display and are summarized in the following table:

STRETCH ACTIVITY	ACCESSED THROUGH:	FUNCTION BUTTON:
Select and activate a pre-existing stretch	START -EDIT	L 
Create(edit), name, and activate a new stretch	START -EDIT	L 
Copy an existing stretch (except for G5TH), edit the copy (if desired), name, and activate the new stretch.	COPY -DEL	L 
Delete a non-factory stretch	COPY -DEL	L 
Return to the RUN screen with no change	RUN	L 
Deactivate(STOP) the current stretch file and revert to unstretched tuning	STOP	L 

The following flowcharts plot the various steps required to accomplish these stretch activities. Each of these four examples highlight only the sequence of button presses typically necessary for just one of these activities, that is to say, with no mistakes or back-tracking. The screen steps outlined above for accessing the STRCH file menu are represented in sequence between the two screen drawings at the top of each flowchart. Depending on which stretch activity you wish to pursue, you would then follow along from the appropriate arrowed path exiting the second screen drawing in the flowchart.

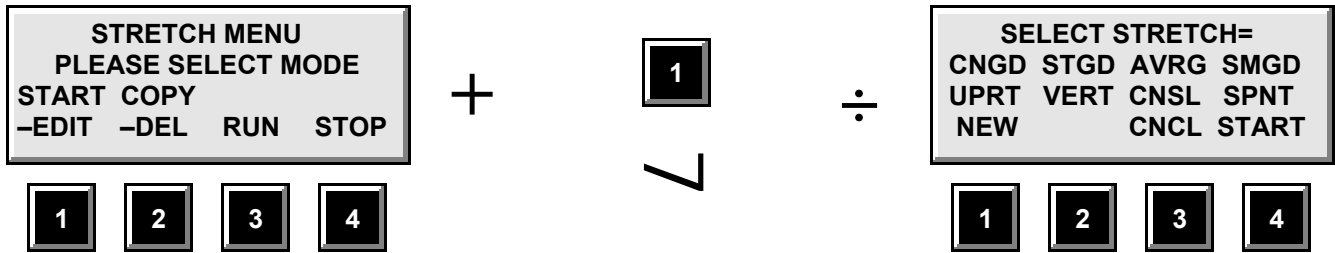
The following key will assist in understanding the “shorthand” of these flowcharts:

1. To the right (or sometimes above) each front panel function button—“1” through “4”—depicted on the flowchart is the exact label for that button as shown on the LCD display at the current step in the programming.
2. With the exception of the top two LCD screen drawings in each flowchart, the word descriptions at various steps do not necessarily appear on the LCD screens but are meant only to explain the action at these steps.
3. The appearance of the “L” icon indicates that the user must press one of the buttons depicted horizontally to the right of it in order to execute a choice in the current step of the programming and advance to the next step.
4. The appearance of an asterisk “\*” near a button indicates that pressing that button in the current step of the programming will cause the LCD screen to be redrawn with new functions assigned to the four Function buttons.
5. A diamond (◇) box indicates that the next step in the programming depends upon specific choices made up to that point. For example, under the “Creating A New Stretch” flowchart, a box labeled “4 characters?” is encountered. If the user has entered four characters for the stretch name at this point, the next step will follow the “YES” path downward in the chart (at which point the LCD display re-labels the function buttons as indicated). If, at any given time, this diamond box is encountered when *less* than four characters have been chosen (as is normally the case for at least the first three times the box is encountered), the “NO” path is followed. In this example, that means that the function buttons continue to allow positioning of the cursor under various characters and/or selecting (or removing) a character from the current stretch name under construction.

**NOTE: When deleting stretches, the motor for the rotating strobe disc will always be turned off. The motor will begin again upon returning to the RUN screen when stretch activity is concluded.**

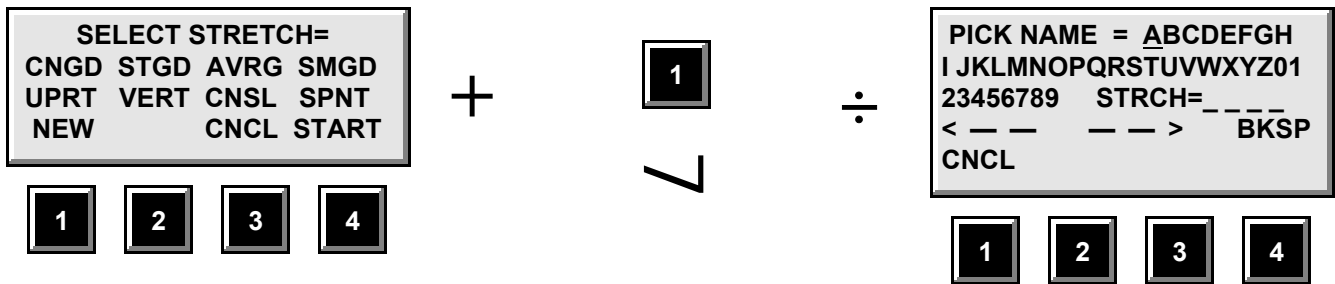
A comprehensive flowchart at the end of this instruction manual shows ALL possible paths through the stretch menus and provides a good reference once the fundamental concept of these menus is understood. You may note that at almost every point, there is a button function (like BACK or REDO) which jumps to a logical earlier step of the current activity or a button function (like RUN or CNCL—short for “cancel”) which jumps out of the current activity with no changes made.

Let’s run through one of the examples in detail. To create a new stretch file from scratch, follow the steps already outlined above to enter the STRCH menu. This takes us to the second screen shown on the flowcharts. For this example, we will be following along on the second stretch example flowchart entitled: EXAMPLE—CREATING A NEW STRETCH. We see from that flowchart that the next step is to press “1” which is, at this point, labeled START-EDIT:



Accessing the Stretch Select Screen

At this point we are given the choice of selecting from among the preset Stretch Files in the tuner or selecting more options with the Function buttons below the screen. In this example, we intend to create a new stretch, and, thus, we press the “1” button labeled “NEW”:

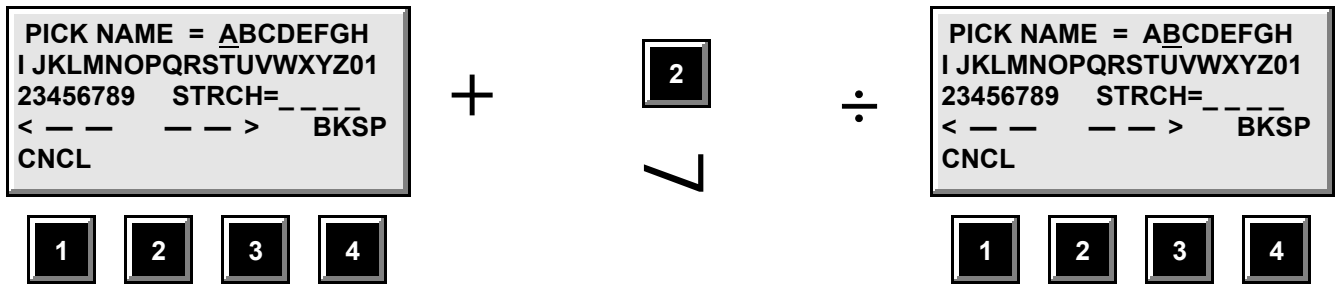


Accessing the PICK NAME Screen

Notice upon entering the PICK NAME screen that the cursor (underline) is positioned under the “A” in the selection string. While this screen is active, hitting the front panel ENTER button will cause whatever character is underlined to be added to the STRETCH FILE name shown on the third screen line (after “STRCH=”). The underlines here are simply place-holders that are replaced by selected characters. To select a different character to enter into the name, the “1” or “2” buttons will retreat or advance, respectively, the current cursor position (i.e., the character selection underline) as indicated by the back-arrow and forward-arrow over these buttons on the screen..

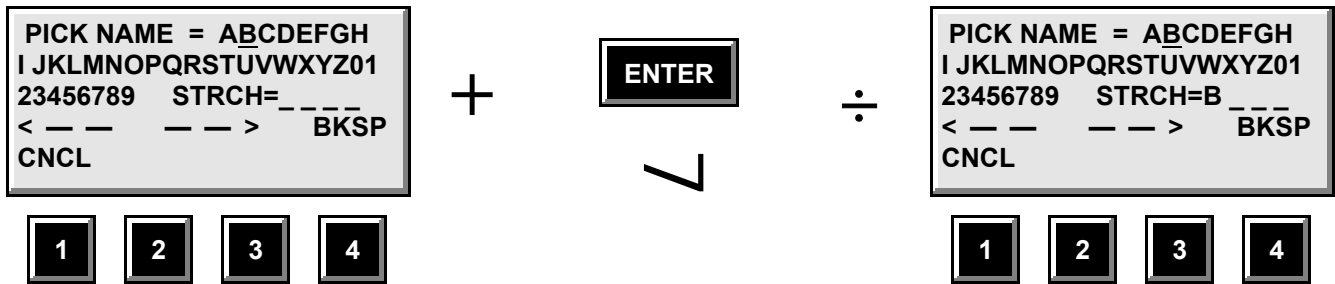
**NOTE:** Hitting the “1” button while the cursor is on “A” will cause the cursor to “wrap around” to the last selection character—the “blank” after “9” on the third screen line—to reduce the time it would take to scroll from a character at the beginning of the selections to one near the end. Similarly, hitting the “2” (advance or — — >) button while the current cursor selection is this last “blank” character will cause the cursor position to “wrap around” to the top (or “A”).

Since we are beginning on the very first selection character, “A”, we would now press the “2” button to move the cursor forward under the “B” (in anticipation of naming our Stretch File: “BG 1”, i.e., “B”, “G”, “blank”, “1”).



**Selecting a Character To Enter Into the New Stretch File Name**

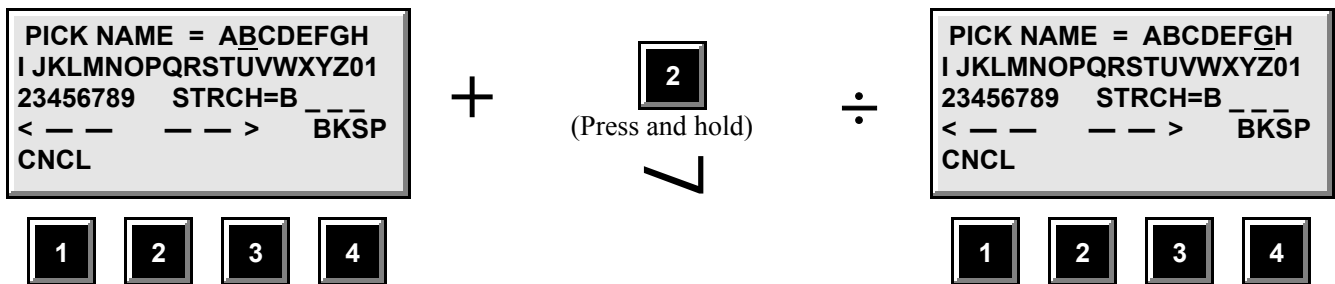
The cursor underline is now under the “B” in the selection string, but no character has been added to the stretch file name. To do this we must press the ENTER button on the front panel. (Note our position in the flowchart.)



**Entering a Selected Character Into the New Stretch File Name**

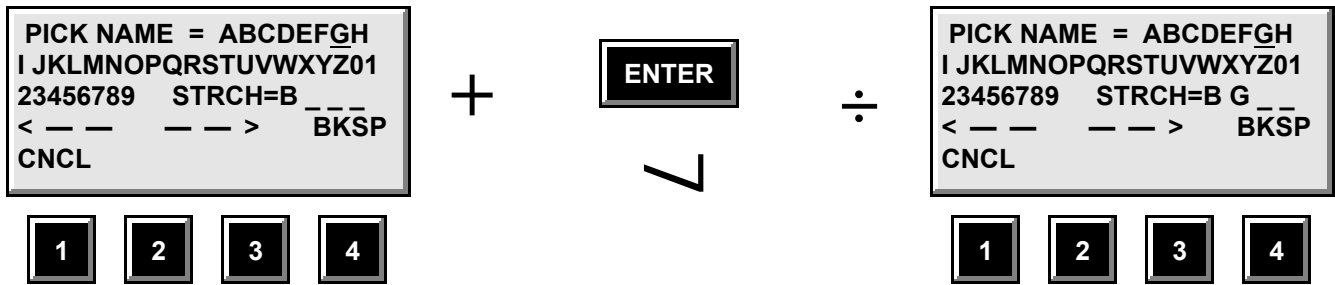
Notice that a “B” character has now been entered into the first of the four Stretch File name positions. Also note that we remain on the PICK NAME screen at this time. *All* file names must have exactly 4 characters (although any number of the four may be the “blank” character), and the tuner will remain on this selection screen until we have selected a character for all four positions in the name field area (or, alternatively, if we opt to cancel (CNCL) the whole operation with button “4”).

In order to advance the cursor to fall under the “G” (in anticipation of our next character selection), we could press the “2” button five times in quick succession. Alternatively, if the “2” button is held in the pressed position, the cursor will advance automatically one character at a time and several times a second. (This same hold feature is present on the “1” button when reversing the cursor.) This is typically how we would advance the cursor any time we would need to move the cursor by more than two or three characters.



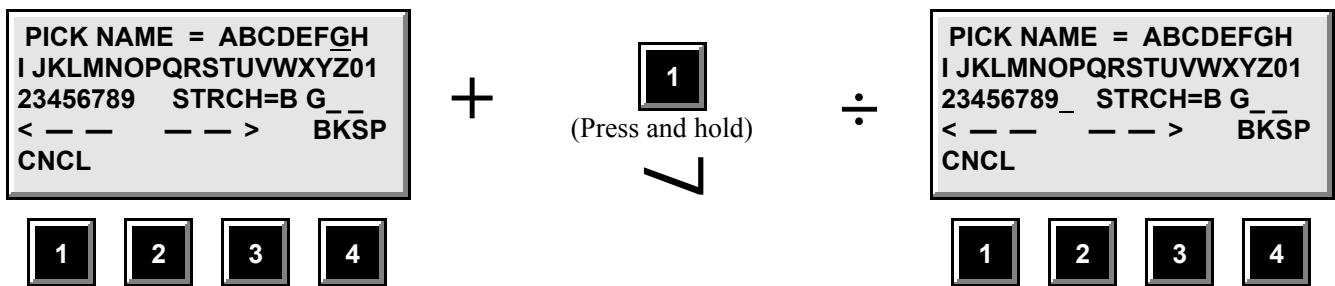
**Selecting the Second Character To Enter Into the New Stretch File Name**

Once again, we must press the ENTER button to actually add our selection to the Stretch File name:



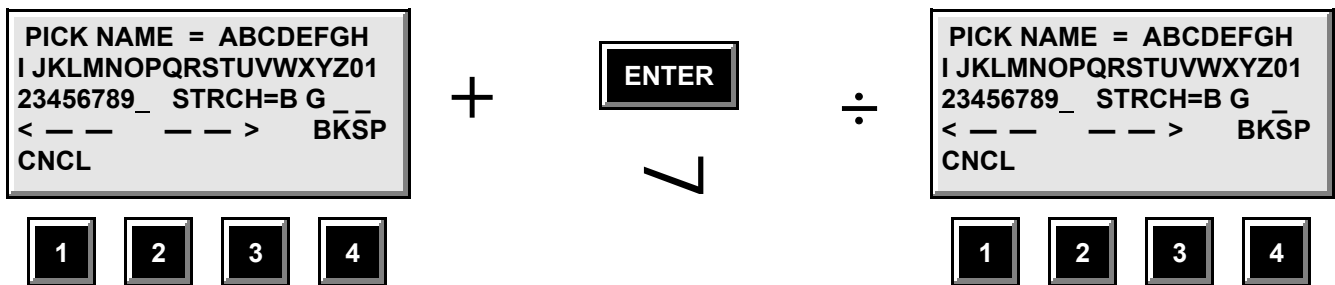
**Entering the Second Character Into the New Stretch File Name**

For the third character, a “blank” in our example of “BG 1”, we could either continue to advance through the letters and numbers in the selection string to arrive at the “blank” character or we could make use of the wrap-around feature and reverse the cursor through “A” to the “blank”. This requires traversing only seven characters, so let us proceed with the shortcut:



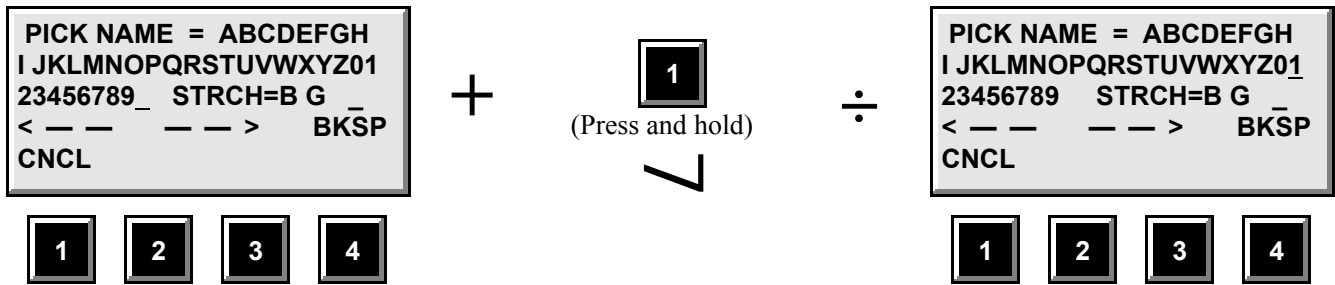
**Selecting the Third Character To Enter Into the New Stretch File Name**

And, once again, entering:



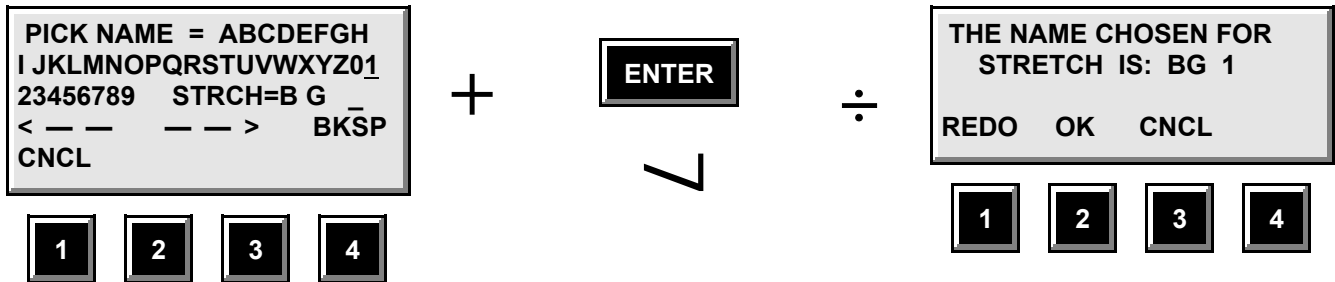
**Entering the Third Character Into the New Stretch File Name**

Notice the place-holding underline in the third position of the name is now completely blank. For our final character, we see that it will be faster to retreat the cursor back to the “1” character than to wrap-around forward through “A” and beyond:



Selecting the Final Character To Enter Into the New Stretch File Name

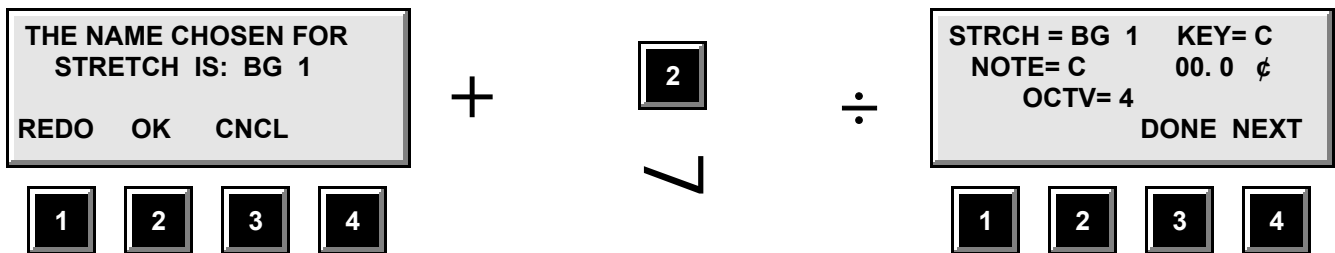
And, finally:



Entering the Final Character Into the New Stretch File Name

You may briefly see the PICK NAME screen updated with the final name character, but this new “verify” screen will appear as soon as you release the ENTER button at this point. On the flowchart, we have now exited the loop defined by the “4 characters?” decision box; in other words, since we have now entered four characters into our stretch file name we now exit through the path labeled “YES” (in answer to the “4 characters?” question). Note that, at any time up to this point, if we had mistakenly entered an incorrect character, we could have hit the “3” button (BKSP) to backspace through the last character entered into the name at the time. Backspacing and entering characters can be repeated indefinitely until the fourth name character is entered and this final verify screen is activated. We still have an opportunity to start completely from scratch in naming our stretch file by hitting the “1” (REDO) button at this point. We may also cancel the entire stretch creation process and return to the RUN screen with no permanent changes by pressing the “3” (CNCL) button.

Typically, however, being confident and consummate professionals, we will press “2” to OK our selection:



Verify Stretch File Name and Begin Note Editing

**NOTE:** If you had chosen either a name that you have already used and stored in the unit or a name used as one of the factory defaults, a different screen will be activated which indicates the problem and permits you to return to the STRETCH MENU screen with no changes. You must then decide which course of action you wish to take: proceed with creating a stretch file with a different name or delete the previously created user file and then create your *new* stretch file using this original name.

We are assuming that we have chosen a valid name for our file and have, consequently, followed the “NO” path from the “Name already exists?” decision box on the flowchart. Thus, we have now entered the “Edit Notes” phase of our stretch file creation. From this one screen, we can now define the note offsets for 96 notes (8 full octaves). Note that this screen shows you which stretch file you are editing as well as which octave and which note within that octave you are editing. Also note that a “KEY=C” indication is shown on the top line.

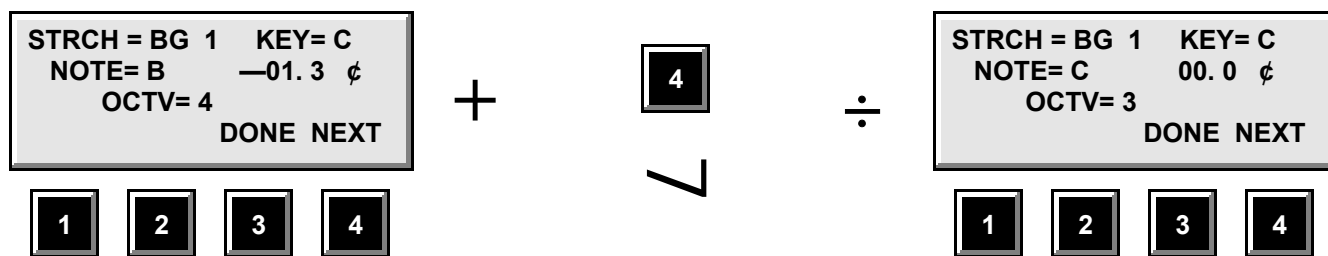
**NOTE:** Regardless of what key signature was current before entering the edit process for either temperaments or stretches, the key *always* reverts to “C” for the purposes of defining note offsets. Once the editing process is complete and you return to the RUN screen, you may enter any of the alternate keys with the usual results. However, if you applied an offset of 1.1 cents to D-octave 2, for example, this offset will always apply to “Concert D” regardless of the new KEY you have selected.

The “cents” indication on the second line of this screen is always indicates the individual offset currently selected for the displayed note in the displayed octave. Had we been editing a previously defined stretch file, this first screen may have shown a non-zero number here. Because we are creating a new stretch file this and all the remaining 95 notes will be initialized to 00.0 cents.

**NOTE:** Regardless of the resolution previously chosen under the RUN screen, temperament and stretch file editing is *always* carried out in the highest (0.1 cent) resolution of the tuner.

The octaves of the stretch file are numbered from 0 through 7. These need not correspond directly to the 0 to 7 bands on the strobe disc of the tuner. In fact, the preset piano stretch files begin (at OCTV=0) with the octave below the one shown on Band 0 of the strobe disc (with Display +2/-1 at “normal” viewing). This is to permit the definition of the low A, A#, and B on 88-note pianos (as well as the entire extra—and really cool—low octave on the those decked out imperial grands!) at the expense of omitting the highest “C” on most pianos. You could even define note offsets for the highest piano notes in OCTV=0 if you want and work backwards. OK, that’s probably *asking* for trouble—still there are other good reasons for making stretch octaves independent of “real” frequencies. For the now in vogue guitar stretch intonations, for example, you could apply all the note offsets within two consecutive octave numbers (because you need two distinct Es in traditional tuning of the six-string) rather than spread them out into their “proper” octaves. This saves keystrokes both in creating the stretch file and in accessing the notes when tuning.

Another apparently strange phenomenon you will note in editing stretch files is, while editing always proceeds from C through B within octaves, editing always begins at OCTV=4, then proceeds to OCTV=3, 2, 1, and 0; then jumps to OCTV=5, then 6, and finally OCTV=7.



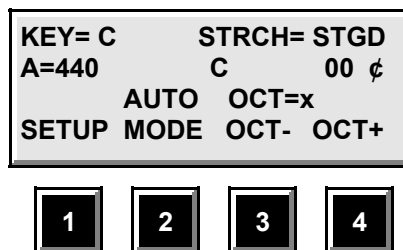
**Example of Octave Sequence When Editing Stretch (or Temperament) Notes**

This is to mimic a common practice of tuning a center piano octave, then proceeding downward (for tensioning purposes), and finally completing the upper octaves. The important point is to be careful when entering your stretch file so that you are confident that you placed your offsets where you *think* you did!

As you can see from the flowchart, changing the cent value for the current note offset is accomplished with the UP ARROW and DOWN ARROW buttons next to the screen. Once we set the desired offset for the displayed note, we may either hit button “4” (NEXT) or the ENTER button. Either one temporarily saves our offset selection and automatically points the

display to the next note in the sequence. At any time short of defining all 96 notes, we may exit and permanently save the file by hitting button “3” (DONE) and then the ENTER button. This will save our stretch file with all the note offsets we had entered to that point. Any notes that we declined to define in an editing session will be saved with the initial zero values (or previously defined offset values if we were editing a pre-existing file). Thus, if we were creating a stretch for a bass guitar, we would only need to define a handful of notes and not have to drone our way through 92 (96 minus 4) zero offset definitions. Similarly, had we been merely editing a pre-existing stretch file, we may have wished to only “tweak” several values and not redefine the whole file.

Once a stretch is activated, its name will appear at the upper right-hand corner of the RUN screen:



Whenever a stretch file is active under the RUN screen, an indication of the current octave (OCT) of scale note settings that the unit is referencing from that stretch file is displayed on the third line of the LCD display. The current octave is never automatically sensed but is chosen at the discretion of the user by pressing buttons "3" or "4" beneath the display. Specifically, button "3" (OCT-) will decrement the octave setting (octave 7 through octave 0). If held continuously, it will continue to decrement the setting shown on screen line 3, wrapping back around from OCT=0 to OCT=7. Conversely, button "4" will increment the octave setting, eventually wrapping from OCT=7 to OCT=0. The functions of buttons "3" and "4" are paralleled on the "tip" and "ring" connections, respectively, of the "OCT- / OCT+" stereo 1/4-inch jack at the back of the Model 490-ST. This allows "hands-free" setting of the currently selected octave through a momentary-close dual footswitch when a stretch file is active. (A proper footswitch is available from **peterson** as part #: 140069.)

In addition, a simple, multi-purpose mono footswitch jack (farthest from the center of the rear panel) performs an Octave *increment-only* function while a stretch file is active and AUTO note select mode is active. (A proper momentary-close footswitch is available from **peterson** as part #: 140070.) When in MANual note-selection mode (as determined by Function button "2"), this mono jack performs a note-increment function to allow convenient hands-free manual note selection during a tuning session.

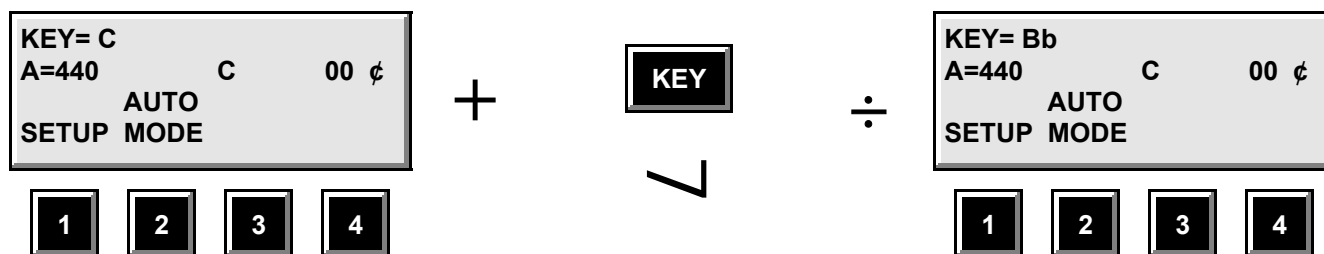
**NOTE:** The cent offset which appears on the second line of this screen *still* refers to the *global* cent offset for the tuner—*not* the individual note offsets applied by the current stretch file for the current note. This global offset number is a common offset to all notes *in addition* to the individual note offsets applied by the stretch table. The individual note offsets within a stretch file are only readable under the EDIT section of the STRETCH MENU.

#### 4. TUNING INSTRUMENTS THAT PLAY IN OTHER THAN THE KEY OF “C”

The Model 490-ST solves one of the biggest difficulties for wind players and other non-“C” instrument musicians when using a precision tuner. Mental transposition of your note into the key of “C” is no longer required. The tuner can be easily shifted to show the correctly transposed note names for tones played on C, B=, F, and E= instruments.

When the Model 490-ST is displaying the normal RUN screen, simply press the button labeled “KEY”. Multiple presses of this button will cycle the tuner through the musical instrument tuning keys of C, B=, F, and E=. You may press the KEY button as many times as you wish and the tuner will sequence through the keys of C, B=, F, E=, C, etc. The pitch referenced by the tuner will change as the speed of the strobe disc is internally transposed for the new tuning key. (Note that any button, such as KEY, which causes a change in strobe disc speed will be temporarily disabled while the motor is accelerating to its destination speed.) When in Auto-Note mode, sound your note and the scale note displayed on the LCD screen will reflect the transposition from “concert pitch” that corresponds with the currently selected KEY parameter shown in upper left hand

corner of the RUN screen.



Choosing Alternate KEY Transpositions

## 5. ENHANCED RESOLUTION OF INTONATION MEASUREMENTS

As you continue to practice your intonation with the Model 490-ST, you will find that your pitch accuracy continually improves. As you find yourself playing more and more closely to perfect intonation, you may wish to adjust the tuner more precisely to your pitch. The Model 490-ST has tuning accuracy to within 0.1 cents. The tuner may be adjusted to your note within that same accuracy. The tuner always powers up with a displayed resolution of 1 cent. This is shown as “00 ¢”. When operating under the RUN screen, the tuner can be set for enhanced resolution of either 0.5 cents or 0.1 cents. Press and hold the ENTER button, then press either the UP ARROW or DOWN ARROW button and the resolution will be changed to 0.5 cents. To further enhance the resolution to 0.1 cent increments, first release the ENTER button, then press and hold it again while you press either the UP ARROW or DOWN ARROW button. The LCD screen always presents enhanced resolution of 0.5 cents and 0.1 cents by showing “xx.x ¢”, that is, three digits with a decimal point in the number.

When the tuner is set for enhanced resolution, the UP ARROW and DOWN ARROW buttons increment/decrement the tuning adjustments of the tuner in steps of 0.5 cents or 0.1 cents. This permits intonation measurements with an accuracy of 1/200 or 1/1000 semitone.

The resolution of the tuner may be returned to 1 cent resolution by again using the UP ARROW or DOWN ARROW buttons in conjunction with the ENTER button (press and hold the ENTER button and then press either UP ARROW or DOWN ARROW). The tuner resolution cycles through a selection sequence of 1 cent, 0.5 cent, 0.1 cent, 1 cent, etc. Note that the tuner requires you to release the ENTER button between each step of this resolution selection cycle. Then press and hold it again to go to the next resolution selection.

**Note: Upon returning to the RUN screen from FILE (temperament) menus, 0.1 cent resolution remains active.**

Other possible uses of the enhanced resolution of 0.5 cents, or 0.1 cent could be for exact measurements of precise partial tone frequencies during the manufacture of percussive musical instruments (for example - bells, chimes, gongs, etc.), or for specific scientific research into the timbral structure of complex sounds and vibrations in the musical and audible frequency spectrum. Yet another use is to allow the tuner to more precisely match a currently sharp or flat instrument (such as a piano or organ) so that the tuner can then be used to tune other instruments in the ensemble.

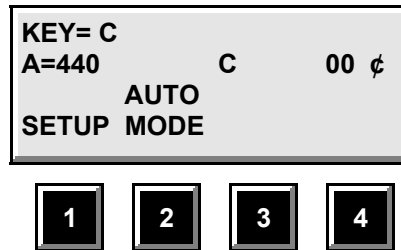
## 6. CHECKING INTONATION WITH THE *AutoStrobe* 490-ST

When you wish to check your playing intonation, the tuner can assist in a very simple manner. You will need a partner to adjust the tuner to the note(s) you are checking.

When checking and adjusting your own intonation, it is probably better to use an external microphone. Turn your back to the tuner while playing your note so you don't see the indications on the tuning disc while your partner is making the adjustments. That way you will be less likely to slowly change your intonation at the same time your partner is adjusting

the tuner to the note you are playing.

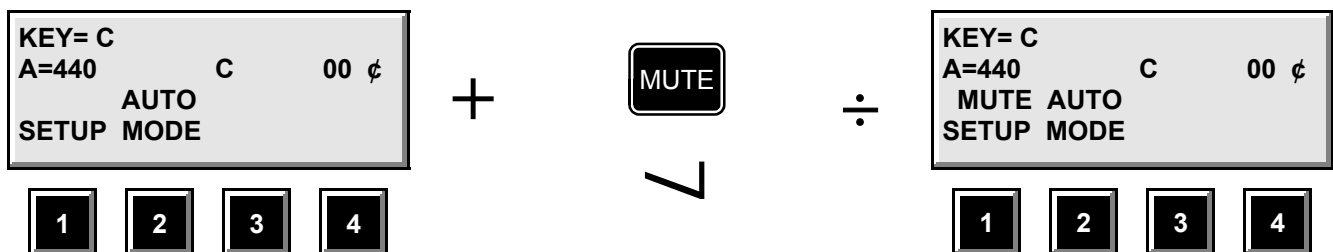
- Connect an external microphone to the EXTERNAL INPUT connector of the tuner. Set this microphone on a stand so that you can face away from the tuner.
- Adjust the tuner to the tuning key of your instrument as detailed above. If necessary, raise or lower the standard tuning reference pitch of the tuner (Concert A setting under the SETUP menu).
- You are now ready to begin. For the remainder of this section we will assume that your instrument is tuned in “C” to a pitch of A = 440 Hz. The normal RUN screen of the tuner will be displayed:



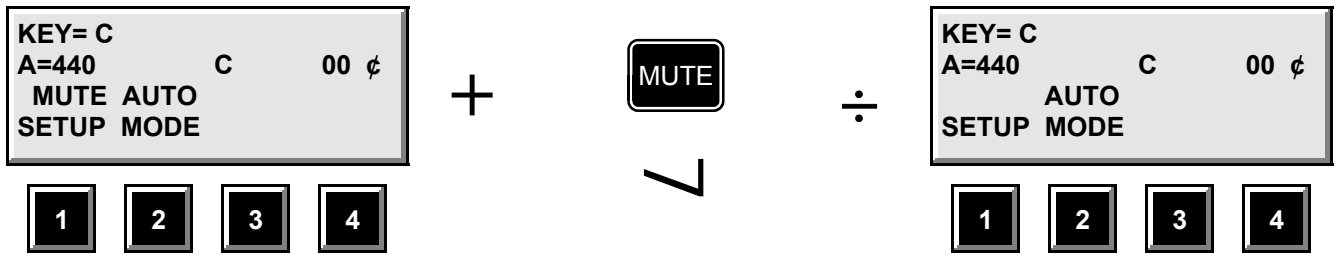
- Play your note into the microphone, while your partner watches the strobe window. While you are sounding your note, your partner will press the UP ARROW and/or DOWN ARROW buttons until the dark markings on the tuning wheel appear to be stationary. When these markings are stationary, the tuner is in tune with the note you are playing.
- The display will show the correctness of your intonation by indicating how many cents sharp or flat your partner adjusted the tuner to match the note as you actually played it. This is presented at the “+” (sharp) or “-“ (flat) “xx.x ¢” (cents) location of the display screen.
- Musical tuning is measured by a unit called cents, representing a 1/100 division of a semitone. There are 1200 cents in each octave, and exactly 100 cents between each half-step note in equal temperament tuning. The Model 490-ST is adjustable in a range of  $\pm 1/2$  semitone (+50.0 cents sharp to -50.0 cents flat) from being perfectly in tune (00.0 cents) at the selected temperament and scale note.

## 7. USING MUTE ON THE *AutoStrobe* 490-ST FOR SILENT TUNING

The Model 490-ST has an external input and “through” output with mute to allow silent on-stage tuning of instruments without having to disconnect the tuner from your audio signal chain. When MUTE is active, any audio signal (originating from the EXTERNAL INPUT jack or built-in microphone) to the front-panel EXTERNAL THRU jack is suppressed. Each press of the MUTE button toggles the MUTE function on or off:



Accessing the Mute Function



### Disengaging the Mute Function

When engaged, the word “MUTE” appears on the third line of the RUN screen on the LCD display. The MUTE button is connected in parallel with the 1/4-inch jack at the rear of the tuner labeled “MUTE SWITCH”. Any momentary-close contact device such as a footswitch may be used in place of or in addition to the MUTE on/off button. (The front-panel button will continue to operate with a device plugged into this rear jack unless the device is held in the closed position—make sure that the device operates in a *momentary-close* fashion. A proper footswitch is available from **peterson** as part #: 140070.)

## GLOSSARY

**cent** - an audio frequency interval which is defined by the division of an equally-tempered semitone interval into 100 equal-ratio steps. Each cent is  $^{1200}/2$  times the previous one in frequency, making it about 0.058% higher in frequency than the previous one.

**equal-tempered** - type of note scaling within a musical octave in which a perfect 2:1 octave frequency ratio is divided into equal-ratio scale notes. In a twelve-tone scale, each note's frequency is  $^{12}/2$  times the previous one making each scale note about 6% higher in frequency than the previous one.

**equal temperament** - a musical scale in which the scale notes are at equal ratios from one to the next. In a twelve-tone/octave scale, this ratio is  $^{12}/2$  making each scale note about 6% higher in frequency than the previous one. This scaling choice provides for identical musical intervals regardless of the root note used for the key signature. In exchange for this flexibility, all intervals have varying degrees of built-in dissonance associated with them.

**stretch** - a scaling of the musical octaves (and the notes within) in an instrument so as to cause overtones in the lower-pitched notes to more closely match the fundamental frequencies of higher-pitched notes. Such adjustments improve the overall impression of harmony in instruments which utilize physically non-linear sound-producing mechanisms (such as pianos, harps, and most percussive instruments).

**temperament** - frequency scaling of the notes within a musical octave.

**timbre** - the “character” or quality of a sound, distinct from pitch and volume, which distinguishes one sound from another. All natural sounds may be thought of as containing various simple-tone (sinusoidal) frequencies in varying strengths. It is the relative strength and frequency of these over-tones or “partials” and the manner in which these parameters change over the course of the sound that makes a note from a piano, for example, distinguishable from that of a trumpet.

## APPENDIX A: WHY USE A “REAL” STROBE TUNER?

There are many cheap “strobe pattern” tuners on the market which attempt to emulate the look of the image produced by an authentic rotating strobe disc. This is usually done with an array of LEDs (Light Emitting Diodes) which are simply turned ON or OFF in sequence so as to “appear” that the light image is drifting left or right.

While such schemes may satisfy an economic niche, they miss out on the almost magical (and supremely functional) aspects of a true strobe effect. All of these emulation schemes necessarily have one thing in common: a digital decision must be made to interpret when to indicate an “in tune” signal (either by lighting a special green LED or otherwise creating a non-sequencing pattern on the LEDs). This creates several problems.

The most glaring of these is the “dead band” problem. The circuitry to form an “In tune?/Out of tune?” decision can, indeed, be very simple and cheap but, by its very nature, it implies that some amount of “out-of-tuneness” must be tolerated when making an “in tune” indication. This is because a frequency that is EXACTLY in tune is an infinitely narrow point. If a circuit could be made to react to only this point (which is impossible by the way), getting that treasured “Green LED” to turn on would be even more of a frustration than it already is on such tuners. In fact, given the normal pitch fluctuations in a real instrument, the light would simply never be ON (or at best be turned on for such short periods that you would never see it). As the manufacturers of such tuners widen the band of “out of tuneness” around that ideal frequency—the deviation from perfect tuning that *they* decide is “in tune enough” for you—a more stable indication is made. Note that this is at the expense of your *ever* knowing how close or far from perfect tuning you are up to the limit of this “dead band”. Such devices typically give up at about  $\pm 1$  cent deviation and usually allow several times this degree of inaccuracy before the “in tune” signal reverts to an “out-of-tune” indication. Of course, the really bad news is: the total worst case error is double that. (You could tune your instrument near the sharp end of the dead band, another player might land near the flat end.)

How bad is this level of detuning? Pretty bad! Over the centuries, many have wrestled with the concepts of intonation and temperament—the art of setting appropriate pitch intervals for the various musical notes. As it happens, there is *no* one temperament that allows for truly in-tune musical intervals over multiple key signatures. The level of concern in these cases: as small as 1 or 2 cents! For example, music in modern western culture is overwhelmingly based upon equal temperament. We have grown accustomed to some of the inherent inaccuracies of this temperament, yet it does present problems. For instance, one of the milder imperfections is the production of intervals of fifths which are between 1 and 2 cents flat from “perfect” non-beating intervals (...and you don't even want to know how bad the thirds are!) In many cases, this is quite acceptable. However, with harmonically rich instruments—a brass section or an electronically distorted guitar, for example—even this level of detuning can be disturbing. (Good brass players actually adjust the intonation of the notes they play to minimize this problem. This is why “a good section is hard to find!”) In the case of the guitar where such on-the-fly adjustments are impossible, adding another couple of cents inaccuracy because of tuning device limitations can yield positively raucous results. In the orchestral case, the added imprecision could spread the instruments out to the point that even accomplished players would have difficulty “lipping” the notes accurately. Of course, with their limited precision, the pseudo-strobe tuners have no hope of properly distinguishing between temperaments. The best that they can do is center on equal-tempered notes (with their particular shortcomings) and lop on a “dead band” for good measure.

The magic of a true strobe lies in the responsiveness and “smoothness” of the effect from “flat” to “perfectly in tune” to “sharp”. Physically, no change of state occurs in the tuner—no discrete decision takes place. Your eye simply interprets the effect of the spinning pattern in relation to the blinking illumination behind it. Thus, the response to the user as the input pitch is adjusted is literally at the **speed of light!** This is a perfect visual analogy to the effect of hearing two sound sources “beat” against each other when they are out of tune. Moreover, your ability to discern movement in the strobe image (indicating an out-of-tune audio source) is actually **more sensitive** than that of hearing audio beats and much more sensitive (about 10 to 20 times more!) than “pseudo-strobe” tuners. This level of precision in your Model 490-ST tuner not only allows unprecedented accuracy in tuning to “standard” pitches, but permits one to utilize the subtler shades of altered temperaments—both pre-programmed and user-programmable—discussed in the SETUP section of this manual.

## APPENDIX B: WHY BE CONCERNED ABOUT UNEQUAL TEMPERAMENTS?

Temperament refers to the specific frequency (pitch) intervals placed between notes in a musical scale. With 12 notes per octave (the most prevalent case but, by no means, the *only* case), there are an infinite number of ways to set the audio frequencies of these notes relative to one another. Through the centuries, many have wrestled with the challenge of creating the most pleasing, yet universally flexible, temperament of these 12 intervals. It turns out that it is mathematically impossible to achieve both completely, that is, if by “pleasing”, one means smooth beat-free intervals, and, if by “flexible”, one means satisfactory harmony in all possible key signatures.

Since compromise is the only option, it should come as no surprise that there exists about as many different well-defined temperaments as there are people who have attempted to create them. The fact is: both of these goals—pleasing and flexible—are moving targets. The requirements of harmonicity and key signature flexibility have changed greatly over the centuries in general and vary just as greatly from person to person. For example, a piece in the 18th-century baroque style might never modulate from a single key signature (or perhaps just to the very similar “5th” key). A temperament which is functional in just a handful of keys might be (and was) satisfactory. In 20th-century western music, all keys and scale notes are fair game, sometimes even within a single piece. Moreover, through the years, people have become more accepting of complex and “closer” simultaneously sounded harmonic intervals. Harmonies that would have been considered unbearably dissonant 150 years ago are now considered “colorful”—even beautiful—by many today. With such complex harmony and effects like parallel harmonic movement, it is generally better to have harmonic relationships that are moderately imperfect, but *equally* imperfect over all key signatures. Thus, Equal Temperament has generally won out in modern music. You may never have considered before that it is the adherence to this temperament that allows one to unthinkingly transpose a musical piece to any key on a piano with no ill effects.

So, why worry about altered temperaments if equal temperament is so pervasive? The reasons are many and varied. Because equal temperament lands so squarely in favor of flexibility, some of the intervals are, well, not very pleasing. For example, major thirds are about 14 cents sharp from the “perfect” non-beating interval...and how often do you play a piece of music with *no* major thirds *anywhere*? In some music, on some instruments, this is bearable. (We certainly have had a lot of opportunity to get used to it!) But play a major third interval using a brass or reed sound (with no chorusing or other effects) on a standard equally-tempered synthesizer, and you will understand something about why people still want to hear “live” horn sections. No matter how good the actual timbre of the synthesized sound is, there is something very “unhorn-like” and disturbing about that simple harmony. Good brass and reed players constantly, and sometimes unconsciously, “lip” the notes they play to minimize intervallic beating with notes played by others in their section.

Players of other types of instruments are not so lucky. There can be no adjusting of strings on-the-fly while playing a fretted string instrument like a guitar; there is no “lipping” possible while playing several hundred pipes in a pipe organ. If one is playing a program which includes classical period pieces, he will simply never achieve on an equally-tempered instrument the beautiful effect that the composer had envisioned when composing the piece for a Just or Mean-Tone tempered instrument. Similarly, because of their unique use of certain musical intervals, instruments like the steel slide guitar can benefit by purposely tuning to *un*-equal temperaments.

Sometimes unequal temperament can be used to help correct inherent deficiencies in certain types of instruments. Fretted instruments like the guitar are designed to be equally-tempered but it turns out that slightly altered tunings of the open strings and harmonics relative to the fretted notes can improve the overall sound of the instrument. This is because real strings do not act quite the same as the theoretical models that must be assumed when designing musical instruments around them.

Similarly, makers of musical instruments (such as the steel drum, bells, xylophone, etc.) which have very inharmonic timbres can benefit from a tuner with altered temperament capabilities by using the note offsets to mimic the desired “harmonics” (or, more accurately, partial frequencies) inherent in a given sounded tone. The programmable nature of temperaments in the Model 490-ST means less work compared to constantly “dialing in” different harmonic offsets.

## APPENDIX C: STRETCH FILE DATA AND CHARTS

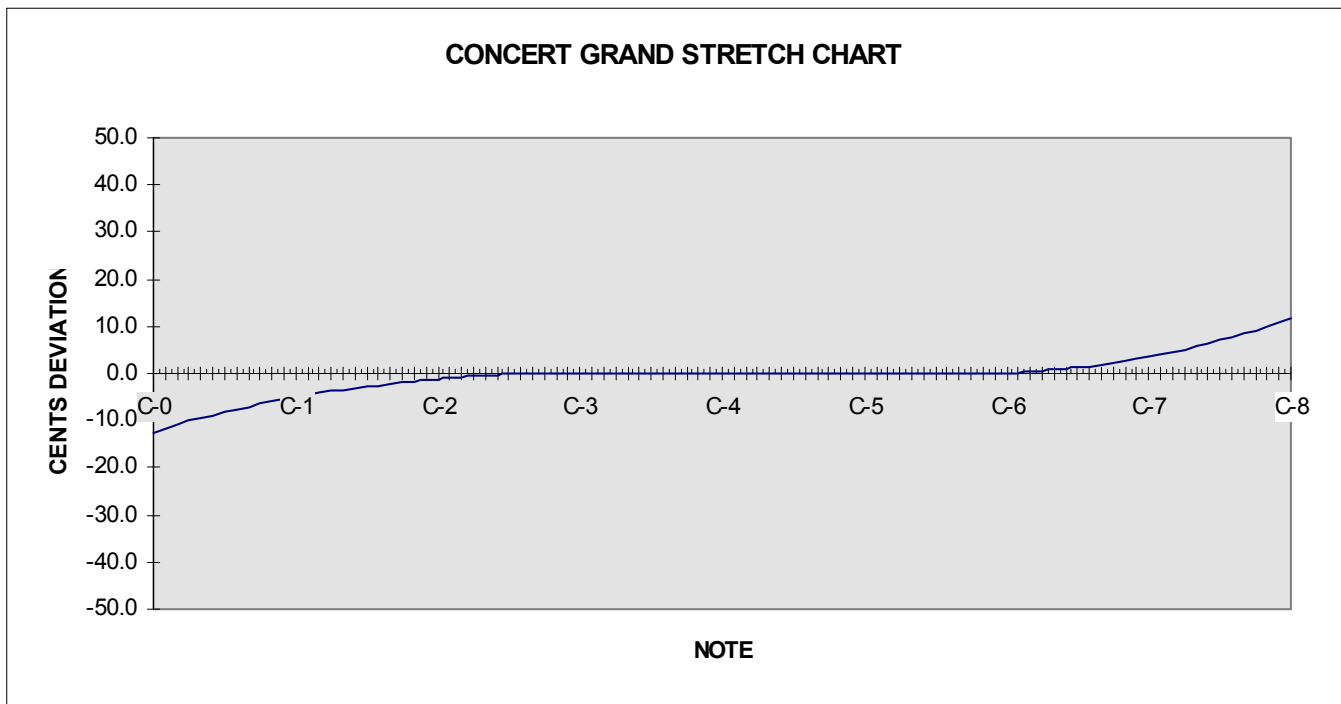
FILE: CNGD

Note No.	Note Name	Cents Deviation
1	C-0	-12.8
2	C#-0	-11.8
3	D-0	-10.9
4	D#-0	-10.1
5	E-0	-9.4
6	F-0	-8.8
7	F#-0	-8.2
8	G-0	-7.6
9	G#-0	-7.0
10	A-0	-6.5
11	A#-0	-6.0
12	B-0	-5.5
13	C-1	-5.0
14	C#-1	-4.6
15	D-1	-4.2
16	D#-1	-3.8
17	E-1	-3.4
18	F-1	-3.1
19	F#-1	-2.8
20	G-1	-2.5
21	G#-1	-2.2
22	A-1	-1.9
23	A#-1	-1.6
24	B-1	-1.4

Note No.	Note Name	Cents Deviation
25	C-2	-1.2
26	C#-2	-1.0
27	D-2	-0.8
28	D#-2	-0.6
29	E-2	-0.4
30	F-2	-0.3
31	F#-2	-0.2
32	G-2	-0.1
33	G#-2	0.0
34	A-2	0.0
35	A#-2	0.0
36	B-2	0.0
37	C-3	0.0
38	C#-3	0.0
39	D-3	0.0
40	D#-3	0.0
41	E-3	0.0
42	F-3	0.0
43	F#-3	0.0
44	G-3	0.0
45	G#-3	0.0
46	A-3	0.0
47	A#-3	0.0
48	B-3	0.0

Note No.	Note Name	Cents Deviation
49	C-4	0.0
50	C#-4	0.0
51	D-4	0.0
52	D#-4	0.0
53	E-4	0.0
54	F-4	0.0
55	F#-4	0.0
56	G-4	0.0
57	G#-4	0.0
58	A-4	0.0
59	A#-4	0.0
60	B-4	0.0
61	C-5	0.0
62	C#-5	0.0
63	D-5	0.0
64	D#-5	0.0
65	E-5	0.0
66	F-5	0.0
67	F#-5	0.0
68	G-5	0.0
69	G#-5	0.0
70	A-5	0.0
71	A#-5	0.0
72	B-5	0.0

Note No.	Note Name	Cents Deviation
73	C-6	0.1
74	C#-6	0.2
75	D-6	0.3
76	D#-6	0.5
77	E-6	0.7
78	F-6	0.9
79	F#-6	1.2
80	G-6	1.5
81	G#-6	1.8
82	A-6	2.2
83	A#-6	2.6
84	B-6	3.0
85	C-7	3.5
86	C#-7	4.0
87	D-7	4.5
88	D#-7	5.1
89	E-7	5.7
90	F-7	6.3
91	F#-7	7.0
92	G-7	7.7
93	G#-7	8.4
94	A-7	9.2
95	A#-7	10.0
96	B-7	10.9



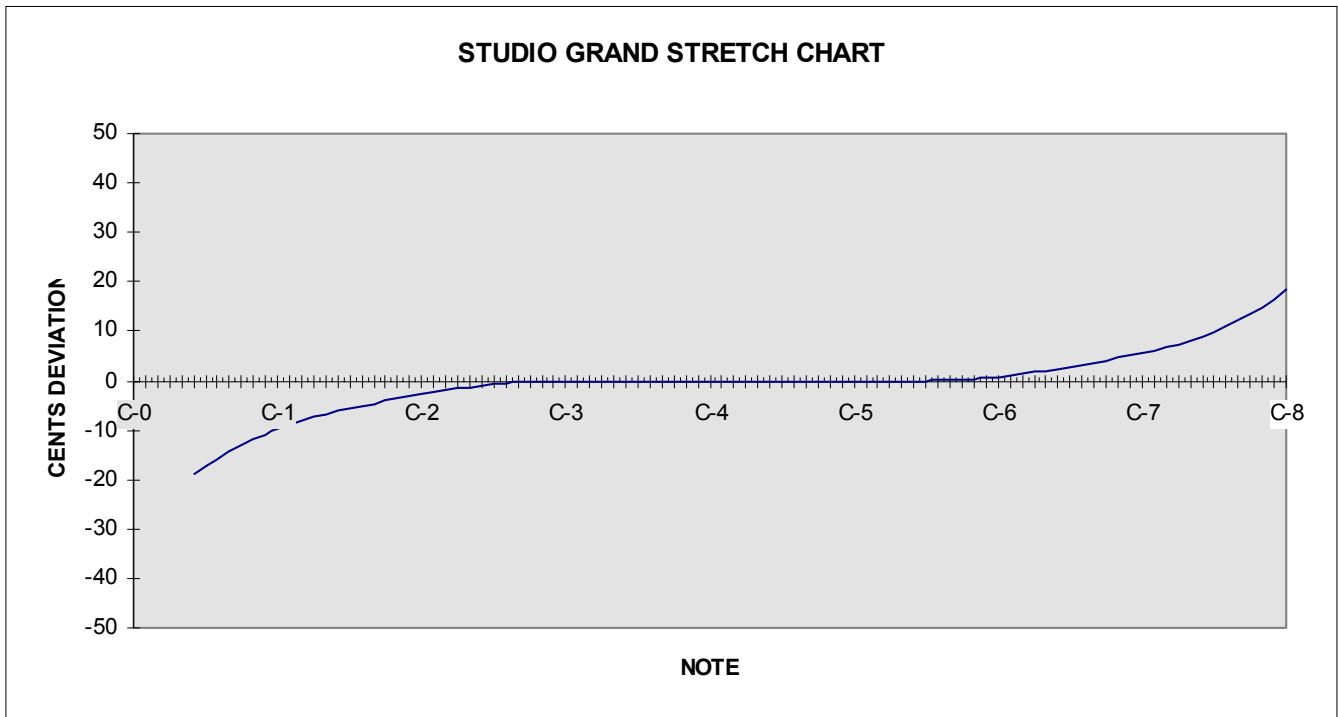
FILE: STGD

Note No.	Note Name	Cents Deviation
1	C-0	-28.3
2	C#-0	-26.3
3	D-0	-24.3
4	D#-0	-22.4
5	E-0	-20.6
6	F-0	-18.9
7	F#-0	-17.3
8	G-0	-15.8
9	G#-0	-14.4
10	A-0	-13.1
11	A#-0	-11.9
12	B-0	-10.8
13	C-1	-9.8
14	C#-1	-8.9
15	D-1	-8.1
16	D#-1	-7.4
17	E-1	-6.8
18	F-1	-6.2
19	F#-1	-5.6
20	G-1	-5.1
21	G#-1	-4.6
22	A-1	-4.1
23	A#-1	-3.6
24	B-1	-3.2

Note No.	Note Name	Cents Deviation
25	C-2	-2.8
26	C#-2	-2.4
27	D-2	-2.0
28	D#-2	-1.6
29	E-2	-1.4
30	F-2	-1.1
31	F#-2	-0.8
32	G-2	-0.6
33	G#-2	-0.4
34	A-2	-0.3
35	A#-2	-0.2
36	B-2	-0.1
37	C-3	0.0
38	C#-3	0.0
39	D-3	0.0
40	D#-3	0.0
41	E-3	0.0
42	F-3	0.0
43	F#-3	0.0
44	G-3	0.0
45	G#-3	0.0
46	A-3	0.0
47	A#-3	0.0
48	B-3	0.0

Note No.	Note Name	Cents Deviation
49	C-4	0.0
50	C#-4	0.0
51	D-4	0.0
52	D#-4	0.0
53	E-4	0.0
54	F-4	0.0
55	F#-4	0.0
56	G-4	0.0
57	G#-4	0.0
58	A-4	0.0
59	A#-4	0.0
60	B-4	0.0
61	C-5	0.0
62	C#-5	0.0
63	D-5	0.0
64	D#-5	0.0
65	E-5	0.0
66	F-5	0.0
67	F#-5	0.0
68	G-5	0.1
69	G#-5	0.2
70	A-5	0.3
71	A#-5	0.4
72	B-5	0.6

Note No.	Note Name	Cents Deviation
73	C-6	0.8
74	C#-6	1.1
75	D-6	1.4
76	D#-6	1.7
77	E-6	2.0
78	F-6	2.4
79	F#-6	2.8
80	G-6	3.2
81	G#-6	3.6
82	A-6	4.1
83	A#-6	4.6
84	B-6	5.1
85	C-7	5.6
86	C#-7	6.1
87	D-7	6.7
88	D#-7	7.3
89	E-7	8.1
90	F-7	8.9
91	F#-7	9.9
92	G-7	11.0
93	G#-7	12.2
94	A-7	13.5
95	A#-7	14.9
96	B-7	16.5



FILE: AVRG

Note No.	Note Name	Cents Deviation
1	C-0	-31.3
2	C#-0	-30.1
3	D-0	-28.9
4	D#-0	-27.7
5	E-0	-26.5
6	F-0	-25.3
7	F#-0	-24.1
8	G-0	-22.9
9	G#-0	-21.7
10	A-0	-20.5
11	A#-0	-19.3
12	B-0	-18.1
13	C-1	-16.9
14	C#-1	-15.7
15	D-1	-14.5
16	D#-1	-13.3
17	E-1	-12.2
18	F-1	-11.2
19	F#-1	-10.3
20	G-1	-9.5
21	G#-1	-8.8
22	A-1	-8.1
23	A#-1	-7.5
24	B-1	-6.9

Note No.	Note Name	Cents Deviation
25	C-2	-6.4
26	C#-2	-5.9
27	D-2	-5.5
28	D#-2	-5.1
29	E-2	-4.8
30	F-2	-4.5
31	F#-2	-4.3
32	G-2	-4.1
33	G#-2	-3.9
34	A-2	-3.8
35	A#-2	-3.7
36	B-2	-3.6
37	C-3	-3.5
38	C#-3	-3.5
39	D-3	-3.5
40	D#-3	-3.4
41	E-3	-3.3
42	F-3	-3.2
43	F#-3	-3.1
44	G-3	-3.0
45	G#-3	-2.8
46	A-3	-2.6
47	A#-3	-2.4
48	B-3	-2.2

Note No.	Note Name	Cents Deviation
49	C-4	-2.0
50	C#-4	-1.8
51	D-4	-1.6
52	D#-4	-1.4
53	E-4	-1.2
54	F-4	-1.0
55	F#-4	-0.8
56	G-4	-0.6
57	G#-4	-0.4
58	A-4	-0.2
59	A#-4	0.0
60	B-4	0.0
61	C-5	0.2
62	C#-5	0.4
63	D-5	0.6
64	D#-5	0.8
65	E-5	1.0
66	F-5	1.2
67	F#-5	1.4
68	G-5	1.6
69	G#-5	1.8
70	A-5	2.0
71	A#-5	2.2
72	B-5	2.4

Note No.	Note Name	Cents Deviation
73	C-6	2.6
74	C#-6	2.8
75	D-6	3.1
76	D#-6	3.4
77	E-6	3.8
78	F-6	4.2
79	F#-6	4.7
80	G-6	5.2
81	G#-6	5.8
82	A-6	6.4
83	A#-6	7.1
84	B-6	7.8
85	C-7	8.6
86	C#-7	9.5
87	D-7	10.5
88	D#-7	11.6
89	E-7	12.8
90	F-7	14.2
91	F#-7	15.8
92	G-7	17.6
93	G#-7	19.6
94	A-7	21.9
95	A#-7	24.5
96	B-7	27.2

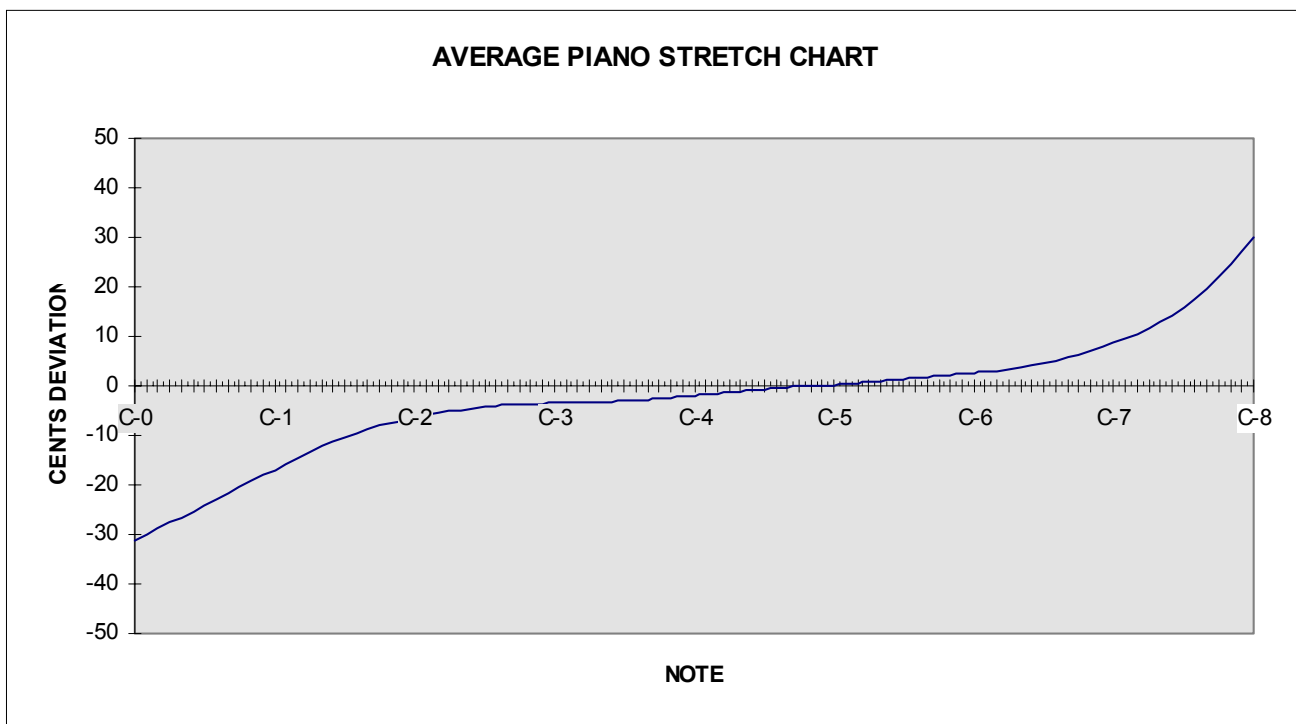
FILE: SMGD

Note No.	Note Name	Cents Deviation
1	C-0	-33.1
2	C#-0	-31.6
3	D-0	-30.1
4	D#-0	-28.6
5	E-0	-27.1
6	F-0	-25.6
7	F#-0	-24.1
8	G-0	-22.7
9	G#-0	-21.3
10	A-0	-20.0
11	A#-0	-18.7
12	B-0	-17.5
13	C-1	-16.3
14	C#-1	-15.2
15	D-1	-14.1
16	D#-1	-13.1
17	E-1	-12.1
18	F-1	-11.2
19	F#-1	-10.3
20	G-1	-9.5
21	G#-1	-8.7
22	A-1	-8.0
23	A#-1	-7.3
24	B-1	-6.6

Note No.	Note Name	Cents Deviation
25	C-2	-6.0
26	C#-2	-5.4
27	D-2	-4.8
28	D#-2	-4.3
29	E-2	-3.8
30	F-2	-3.3
31	F#-2	-2.9
32	G-2	-2.5
33	G#-2	-2.1
34	A-2	-1.8
35	A#-2	-1.5
36	B-2	-1.2
37	C-3	-1.0
38	C#-3	-0.8
39	D-3	-0.6
40	D#-3	-0.4
41	E-3	-0.2
42	F-3	-0.1
43	F#-3	0.0
44	G-3	0.0
45	G#-3	0.0
46	A-3	0.0
47	A#-3	0.0
48	B-3	0.0

Note No.	Note Name	Cents Deviation
49	C-4	0.0
50	C#-4	0.0
51	D-4	0.0
52	D#-4	0.0
53	E-4	0.0
54	F-4	0.0
55	F#-4	0.0
56	G-4	0.0
57	G#-4	0.0
58	A-4	0.0
59	A#-4	0.0
60	B-4	0.0
61	C-5	0.0
62	C#-5	0.0
63	D-5	0.0
64	D#-5	0.0
65	E-5	0.1
66	F-5	0.2
67	F#-5	0.4
68	G-5	0.6
69	G#-5	0.8
70	A-5	1.1
71	A#-5	1.5
72	B-5	2.0

Note No.	Note Name	Cents Deviation
73	C-6	2.5
74	C#-6	3.0
75	D-6	3.6
76	D#-6	4.2
77	E-6	4.9
78	F-6	5.6
79	F#-6	6.4
80	G-6	7.2
81	G#-6	8.1
82	A-6	9.0
83	A#-6	10.0
84	B-6	11.0
85	C-7	12.1
86	C#-7	13.2
87	D-7	14.4
88	D#-7	15.6
89	E-7	16.9
90	F-7	18.2
91	F#-7	19.6
92	G-7	21.0
93	G#-7	22.5
94	A-7	24.0
95	A#-7	25.6
96	B-7	27.2



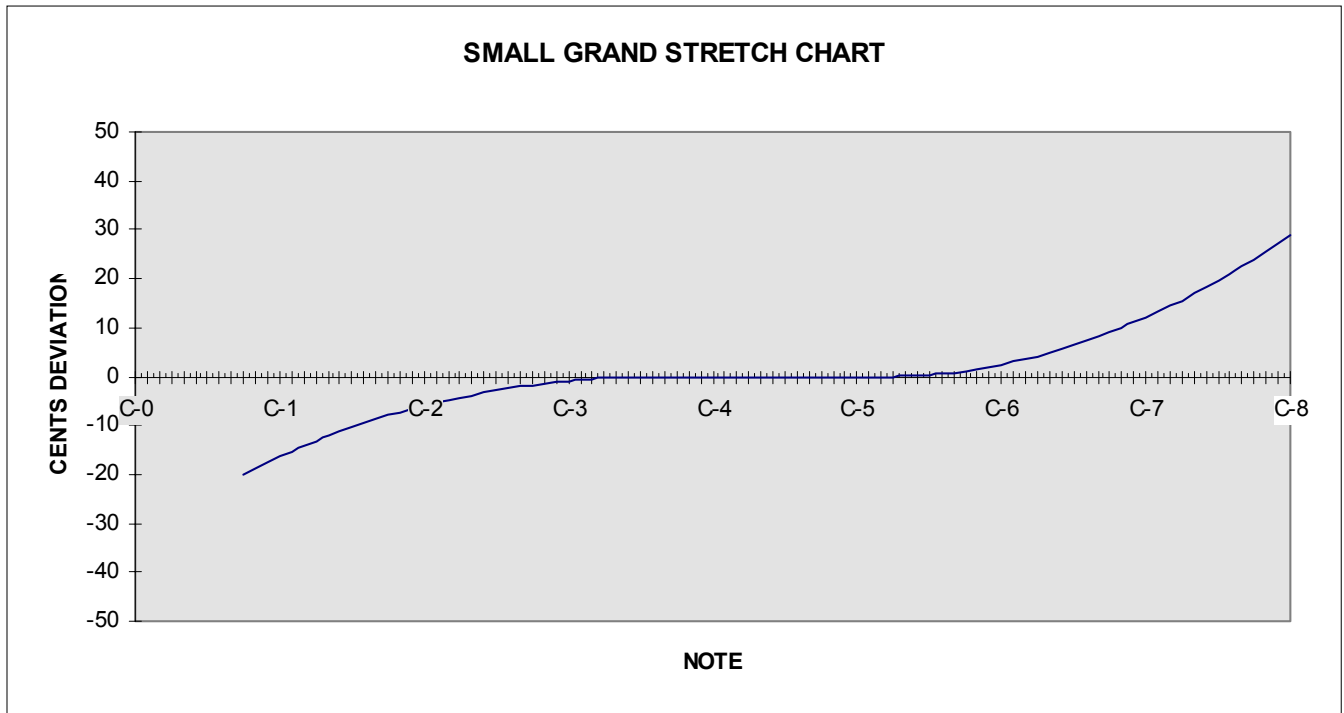
FILE: UPRT

Note No.	Note Name	Cents Deviation
1	C-0	-42.1
2	C#-0	-40.1
3	D-0	-38.1
4	D#-0	-36.1
5	E-0	-34.1
6	F-0	-32.1
7	F#-0	-30.1
8	G-0	-28.1
9	G#-0	-26.1
10	A-0	-24.1
11	A#-0	-22.2
12	B-0	-20.5
13	C-1	-19.0
14	C#-1	-17.6
15	D-1	-16.3
16	D#-1	-15.1
17	E-1	-14.0
18	F-1	-13.0
19	F#-1	-12.0
20	G-1	-11.1
21	G#-1	-10.2
22	A-1	-9.4
23	A#-1	-8.6
24	B-1	-7.9

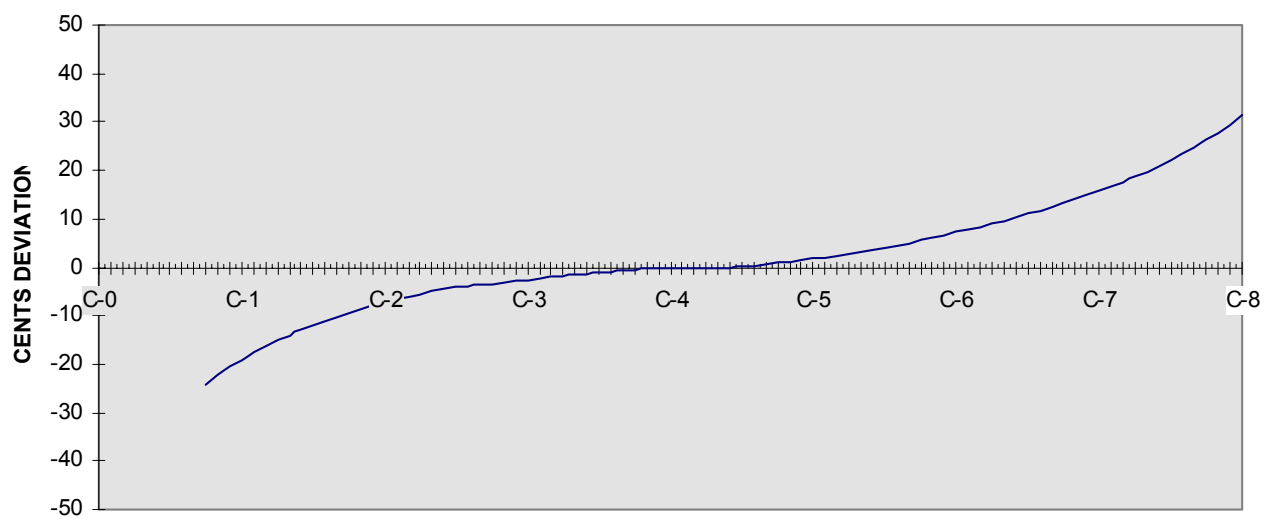
Note No.	Note Name	Cents Deviation
25	C-2	-7.2
26	C#-2	-6.6
27	D-2	-6.0
28	D#-2	-5.5
29	E-2	-5.0
30	F-2	-4.6
31	F#-2	-4.2
32	G-2	-3.8
33	G#-2	-3.5
34	A-2	-3.5
35	A#-2	-3.2
36	B-2	-2.9
37	C-3	-2.6
38	C#-3	-2.3
39	D-3	-2.0
40	D#-3	-1.8
41	E-3	-1.6
42	F-3	-1.4
43	F#-3	-1.2
44	G-3	-1.0
45	G#-3	-0.8
46	A-3	-0.6
47	A#-3	-0.4
48	B-3	-0.2

Note No.	Note Name	Cents Deviation
49	C-4	0.0
50	C#-4	0.0
51	D-4	0.0
52	D#-4	0.0
53	E-4	0.0
54	F-4	0.0
55	F#-4	0.2
56	G-4	0.4
57	G#-4	0.6
58	A-4	0.9
59	A#-4	1.2
60	B-4	1.5
61	C-5	1.8
62	C#-5	2.1
63	D-5	2.4
64	D#-5	2.8
65	E-5	3.2
66	F-5	3.6
67	F#-5	4.0
68	G-5	4.5
69	G#-5	5.0
70	A-5	5.5
71	A#-5	6.0
72	B-5	6.6

Note No.	Note Name	Cents Deviation
73	C-6	7.2
74	C#-6	7.8
75	D-6	8.4
76	D#-6	9.0
77	E-6	9.7
78	F-6	10.4
79	F#-6	11.1
80	G-6	11.8
81	G#-6	12.6
82	A-6	13.4
83	A#-6	14.2
84	B-6	15.0
85	C-7	15.9
86	C#-7	16.8
87	D-7	17.7
88	D#-7	18.7
89	E-7	19.7
90	F-7	20.8
91	F#-7	22.0
92	G-7	23.3
93	G#-7	24.7
94	A-7	26.2
95	A#-7	27.8
96	B-7	29.5



### UPRIGHT PIANO STRETCH CHART



NOTE

FILE: VERT

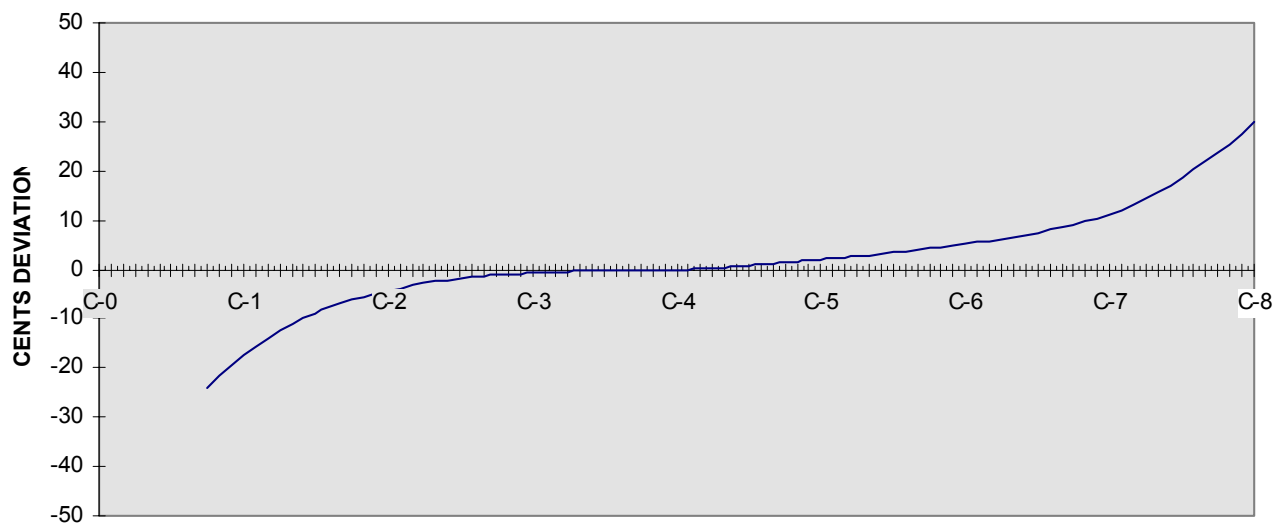
Note No.	Note Name	Cents Deviation
1	C-0	-46.5
2	C#-0	-44.0
3	D-0	-41.5
4	D#-0	-39.0
5	E-0	-36.5
6	F-0	-34.0
7	F#-0	-31.5
8	G-0	-29.0
9	G#-0	-26.5
10	A-0	-24.0
11	A#-0	-21.5
12	B-0	-19.3
13	C-1	-17.3
14	C#-1	-15.5
15	D-1	-13.9
16	D#-1	-12.5
17	E-1	-11.2
18	F-1	-10.0
19	F#-1	-8.9
20	G-1	-7.9
21	G#-1	-7.0
22	A-1	-6.2
23	A#-1	-5.5
24	B-1	-4.9

Note No.	Note Name	Cents Deviation
25	C-2	-4.3
26	C#-2	-3.8
27	D-2	-3.3
28	D#-2	-2.9
29	E-2	-2.5
30	F-2	-2.2
31	F#-2	-1.9
32	G-2	-1.6
33	G#-2	-1.4
34	A-2	-1.2
35	A#-2	-1.0
36	B-2	-0.9
37	C-3	-0.8
38	C#-3	-0.7
39	D-3	-0.6
40	D#-3	-0.5
41	E-3	-0.4
42	F-3	-0.3
43	F#-3	-0.2
44	G-3	-0.1
45	G#-3	0.0
46	A-3	0.0
47	A#-3	0.0
48	B-3	0.0

Note No.	Note Name	Cents Deviation
49	C-4	0.0
50	C#-4	0.0
51	D-4	0.1
52	D#-4	0.2
53	E-4	0.4
54	F-4	0.6
55	F#-4	0.8
56	G-4	1.0
57	G#-4	1.2
58	A-4	1.4
59	A#-4	1.6
60	B-4	1.8
61	C-5	2.0
62	C#-5	2.2
63	D-5	2.4
64	D#-5	2.6
65	E-5	2.8
66	F-5	3.1
67	F#-5	3.4
68	G-5	3.7
69	G#-5	4.0
70	A-5	4.3
71	A#-5	4.6
72	B-5	4.9

Note No.	Note Name	Cents Deviation
73	C-6	5.2
74	C#-6	5.5
75	D-6	5.8
76	D#-6	6.2
77	E-6	6.6
78	F-6	7.0
79	F#-6	7.5
80	G-6	8.0
81	G#-6	8.5
82	A-6	9.1
83	A#-6	9.7
84	B-6	10.4
85	C-7	11.2
86	C#-7	12.1
87	D-7	13.1
88	D#-7	14.3
89	E-7	15.6
90	F-7	17.0
91	F#-7	18.5
92	G-7	20.1
93	G#-7	21.8
94	A-7	23.6
95	A#-7	25.5
96	B-7	27.6

### GENERIC VERTICAL PIANO STRETCH CHART



NOTE

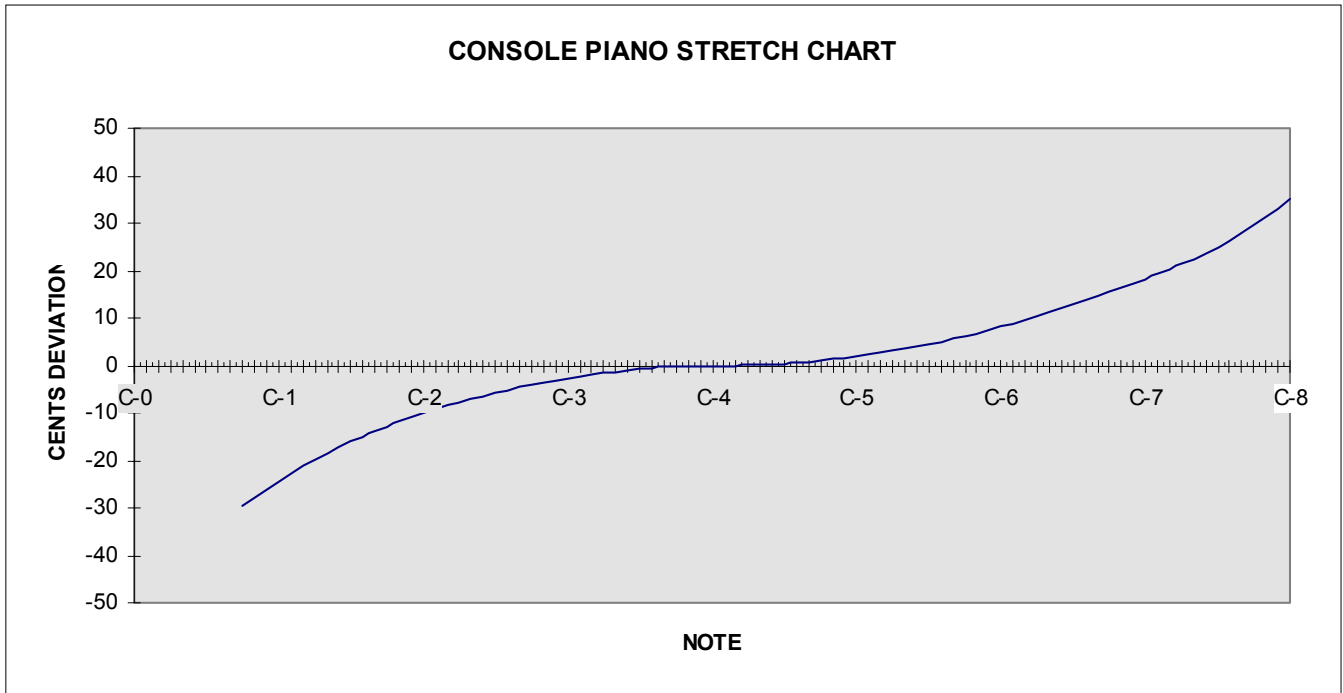
FILE: CNSL

Note No.	Note Name	Cents Deviation
1	C-0	-49.2
2	C#-0	-47.0
3	D-0	-44.8
4	D#-0	-42.6
5	E-0	-40.4
6	F-0	-38.2
7	F#-0	-36.0
8	G-0	-33.8
9	G#-0	-31.7
10	A-0	-29.7
11	A#-0	-27.8
12	B-0	-26.0
13	C-1	-24.3
14	C#-1	-22.7
15	D-1	-21.2
16	D#-1	-19.8
17	E-1	-18.5
18	F-1	-17.3
19	F#-1	-16.1
20	G-1	-15.0
21	G#-1	-13.9
22	A-1	-12.9
23	A#-1	-11.9
24	B-1	-11.0

Note No.	Note Name	Cents Deviation
25	C-2	-10.1
26	C#-2	-9.3
27	D-2	-8.5
28	D#-2	-7.8
29	E-2	-7.1
30	F-2	-6.4
31	F#-2	-5.8
32	G-2	-5.2
33	G#-2	-4.6
34	A-2	-4.1
35	A#-2	-3.6
36	B-2	-3.1
37	C-3	-2.7
38	C#-3	-2.3
39	D-3	-1.9
40	D#-3	-1.6
41	E-3	-1.3
42	F-3	-1.0
43	F#-3	-0.8
44	G-3	-0.6
45	G#-3	-0.4
46	A-3	-0.3
47	A#-3	-0.2
48	B-3	-0.1

Note No.	Note Name	Cents Deviation
49	C-4	0.0
50	C#-4	0.0
51	D-4	0.0
52	D#-4	0.1
53	E-4	0.2
54	F-4	0.3
55	F#-4	0.4
56	G-4	0.6
57	G#-4	0.8
58	A-4	1.1
59	A#-4	1.4
60	B-4	1.7
61	C-5	2.0
62	C#-5	2.4
63	D-5	2.8
64	D#-5	3.2
65	E-5	3.6
66	F-5	4.1
67	F#-5	4.6
68	G-5	5.1
69	G#-5	5.6
70	A-5	6.2
71	A#-5	6.8
72	B-5	7.5

Note No.	Note Name	Cents Deviation
73	C-6	8.2
74	C#-6	8.9
75	D-6	9.6
76	D#-6	10.4
77	E-6	11.2
78	F-6	12.0
79	F#-6	12.8
80	G-6	13.7
81	G#-6	14.6
82	A-6	15.5
83	A#-6	16.4
84	B-6	17.3
85	C-7	18.2
86	C#-7	19.2
87	D-7	20.2
88	D#-7	21.3
89	E-7	22.4
90	F-7	23.6
91	F#-7	24.9
92	G-7	26.3
93	G#-7	27.8
94	A-7	29.4
95	A#-7	31.1
96	B-7	32.9



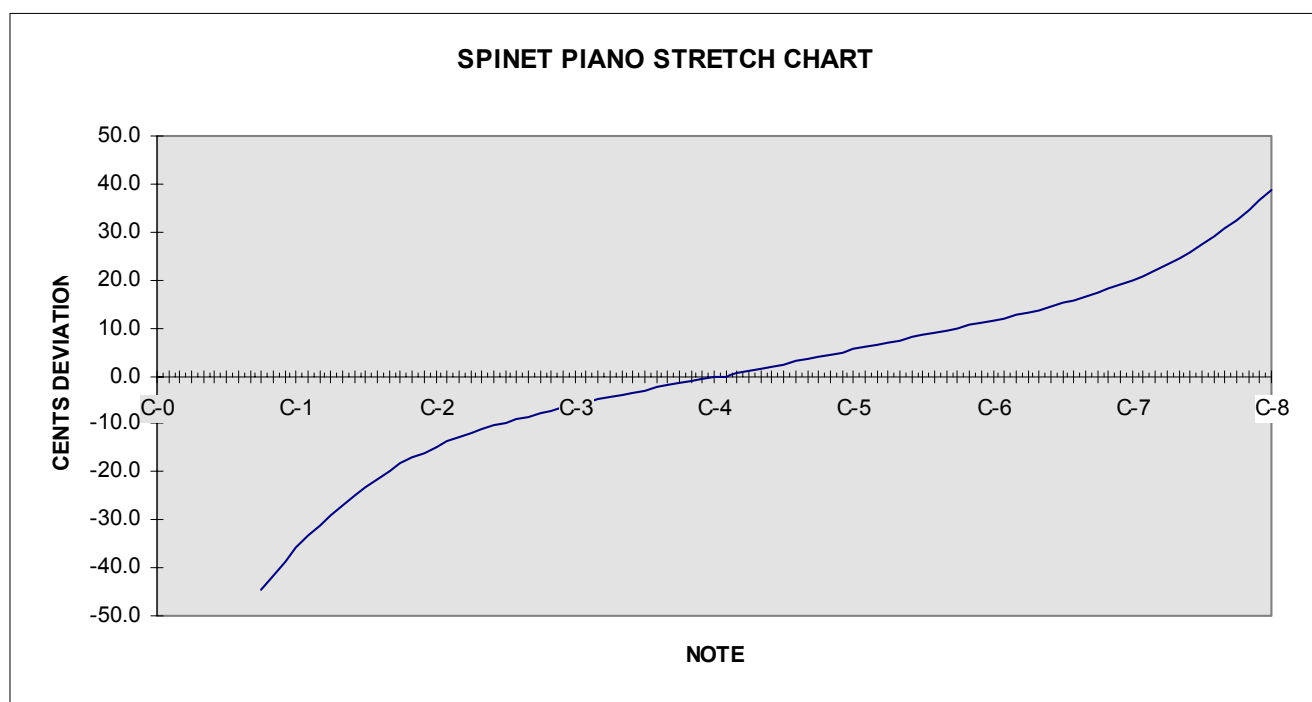
FILE: SPNT

Note No.	Note Name	Cents Deviation
1	C-0	-50.0
2	C#-0	-50.0
3	D-0	-50.0
4	D#-0	-50.0
5	E-0	-50.0
6	F-0	-50.0
7	F#-0	-50.0
8	G-0	-50.0
9	G#-0	-48.0
10	A-0	-44.7
11	A#-0	-41.5
12	B-0	-38.6
13	C-1	-35.9
14	C#-1	-33.4
15	D-1	-31.1
16	D#-1	-28.9
17	E-1	-26.9
18	F-1	-25.0
19	F#-1	-23.2
20	G-1	-21.5
21	G#-1	-19.9
22	A-1	-18.4
23	A#-1	-17.1
24	B-1	-15.9

Note No.	Note Name	Cents Deviation
25	C-2	-14.8
26	C#-2	-13.8
27	D-2	-12.9
28	D#-2	-12.0
29	E-2	-11.2
30	F-2	-10.4
31	F#-2	-9.7
32	G-2	-9.0
33	G#-2	-8.4
34	A-2	-7.8
35	A#-2	-7.2
36	B-2	-6.6
37	C-3	-6.0
38	C#-3	-5.5
39	D-3	-5.0
40	D#-3	-4.5
41	E-3	-4.0
42	F-3	-3.5
43	F#-3	-3.0
44	G-3	-2.5
45	G#-3	-2.0
46	A-3	-1.5
47	A#-3	-1.0
48	B-3	-0.5

Note No.	Note Name	Cents Deviation
49	C-4	0.0
50	C#-4	0.0
51	D-4	0.5
52	D#-4	1.0
53	E-4	1.5
54	F-4	2.0
55	F#-4	2.5
56	G-4	3.0
57	G#-4	3.5
58	A-4	4.0
59	A#-4	4.5
60	B-4	5.0
61	C-5	5.5
62	C#-5	6.0
63	D-5	6.5
64	D#-5	7.0
65	E-5	7.5
66	F-5	8.0
67	F#-5	8.5
68	G-5	9.0
69	G#-5	9.5
70	A-5	10.0
71	A#-5	10.5
72	B-5	11.0

Note No.	Note Name	Cents Deviation
73	C-6	11.5
74	C#-6	12.0
75	D-6	12.6
76	D#-6	13.2
77	E-6	13.8
78	F-6	14.4
79	F#-6	15.1
80	G-6	15.8
81	G#-6	16.5
82	A-6	17.3
83	A#-6	18.1
84	B-6	19.0
85	C-7	19.9
86	C#-7	20.9
87	D-7	22.0
88	D#-7	23.2
89	E-7	24.5
90	F-7	25.9
91	F#-7	27.4
92	G-7	29.0
93	G#-7	30.7
94	A-7	32.5
95	A#-7	34.4
96	B-7	36.5



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