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INSTRUCTION MANUAL

for the

Sanderson
Beat-Rater™

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INTRODUCTION

The Sanderson Beat-Rater™

The Sanderson Beat-Rater™ is a tuning aid intended to help piano tuners set a fine aural temperament easily and accurately. The instrument duplicates the beat rates of the major thirds within the temperament, and gives clearly audible ticks corresponding to those beat rates. This facilitates not only learning the correct aural beat rates, but helps working tuners assess the correct beat rates for individual pianos, which may vary significantly from their theoretical beat rates.

The Sanderson Beat-Rater (SBR) has the following features:

- ◆ Four beat rates under pushbutton control that correspond to the four contiguous major thirds between C#3 and A4 (440).
- ◆ Variable slide control for the beat rates, which allows them to be sped up or slowed down to match the individual piano being tuned.
- ◆ A two-semitone tuning range to produce the beat rates of all the intermediate thirds within the temperament.
- ◆ Long battery life, small size and light weight.

We hope you enjoy using your new Beat-Rater!

Dr. A. E. Sanderson
Inventronics, Inc.

will not usually cause much trouble because inharmonicity has the effect of *improving* the fifths. If you have a bad fifth, again try to move both notes of the interval just a little rather than one note a lot.

Care and Feeding. The Beat-Rater normally requires very little maintenance, simply battery replacement every 100 hours or so, and a calibration check about once per year.

Replacing the Battery. Use a 9-volt transistor battery for the Beat-Rater, either an alkaline or an extra-life battery for longest life. To replace the battery, press down on the arrow symbol on the battery cover and slide the cover off. Remove the old battery, being careful not to pull on the battery wires. Replace the battery and reinsert it into the battery compartment, dressing the wires in such a way that they lie beside of the battery and not under it. Center the battery from side-to-side, and slide the battery compartment cover back on..

Calibration. Sanderson Beat-Raters built since 2004 have a crystal reference and don't require an annual calibration adjustment.

whole tone rising thirds progression. One way to think of this is with the "halfway" rule. Tune G3 down from B3

until its beat rate is halfway between those of F3-A3 and A3-C#4. Also tune D#4 up from B3 until the B3-D#4 third is halfway between the A3-C#4 and C#4-F4 thirds. Now the original ladder of thirds has another set of rungs halfway between the original rungs.

Now that G3 and D#4 are in their correct locations, you can backtrack and tune the fourths correctly. Retune A#3 so that the two contiguous fourths sharing that note are equal in beat rate. Do likewise with C4 and its two contiguous fourths. This automatically gives you the fourths that the piano requires to fit in with the octaves and thirds you have already tuned.

Four major thirds within the F3-F4 octave remain to be tuned, and if you look at them you will see that one note of each has already been tuned. All you need to do is tune these four notes, F#3, G#3, D4, and E4, to create a full octave of rising thirds. Each one can be tuned with the halfway rule, putting each beat rate halfway between those of two *semitone* neighbors.

The F3-F4 temperament octave has now been tuned, and the thirds should rise beautifully since all have been tuned by the halfway rule. Check the fourths, which usually cause some trouble because inharmonicity makes them beat more rapidly. If you find a bad fourth, try to move each end a little to minimize the damage to the rising thirds. The fifths

SPECIFICATIONS

Thirds: Four beat rates for the four contiguous major

thirds, C#3-F3, F3-A3, A3-C#4, C#4-F4, that span the temperament. Beat rates for all intermediate thirds available with the SEMITONE control. Pushbutton ON/OFF controls.

Accuracy: Each beat rate is within ± 0.1 of a beat, and each semitone is within ± 0.2 of a beat

Stability: No warm-up is required, drift from turn-on is less than 0.1 of a beat.

Volume Control: Clear ticking sound, continuously adjustable with slide control from soft to loud.

Thirds Control: Each major third has a pushbutton that toggles it ON or OFF. Pushing a different button changes the beat rate to the corresponding third.

Semitone Control: Slide control with center *détente* at the nominal or theoretical beat rate for each third, with a range of more than four semitones.

Battery: Alkaline 9-volt transistor battery. Battery life is about 100 hours. Low battery light.

Size and Weight: $1 \times 2\frac{3}{4} \times 4\frac{1}{2}$ in, (25x68x115 mm). 7.2 oz. (205 grams).

DESCRIPTION

The controls for the Sanderson Beat-Rater (SBR) are located on the wide or flat side of the case for convenient operation, whether the SBR is placed on the piano or in a shirt pocket. The THIRDS pushbuttons are also ON-OFF buttons, and toggle the SBR between ON and OFF. However, pushing the button for a different beat rate will change to the new beat rate *without* turning the SBR off.

The SEMITONES control is the upper slide control, with a centering détente at the F3-A3 third beat rate of 6.93 beats per second. The full range is four semitones with linear scale marks every half semitone for easy reading and best accuracy.

The VOLUME control is also a slide control, and has its centering détente at a volume that is about right for tuning a piano.

The LOW BATTERY (L) warning light is next to the volume control. To prevent unnecessary battery drain, the Beat-Rater automatically turns itself off after about one and a half minutes.

INSTRUCTIONS

Measuring the F-A Major Third. Since the Beat-Rater is tunable, measuring an unknown F3-A3 third beat rate is very easy. Play the unknown third beat

Finishing the Temperament. It is necessary to fill in the

gaps in our chain of thirds next. This requires tuning some fourths to reach the intermediate notes. (The following procedure is part of the Baldassin-Sanderson aural temperament that has been printed in the Piano Technicians Journal, Nov & Dec 1994 & Jan 1995, PACE Lesson Plans by Michael Travis.)

Tune from F3 up a fourth to A#3, and then up another fourth to D#4, keeping both fourths the same beat rate, about one bps.

Tune from F4 down a fourth to C4, and then down another fourth to G3, keeping both fourths the same beat rate as in the above step.

Now position B3 between G3 and D#4 with the major third 4:5 ratio test (as described on p. 5). This test places B3 correctly even when the fourths are not yet tuned to or correct beat rate for this piano. To determine whether the fourths are correct, compare rising third beat rates as follows.

Play a series of rising thirds spaced apart by one whole tone (two semitones) from F3-A3 through C#4-F4. Notice whether G3-B3 and B3-D#4 fit in. If they are both too fast, then the four fourths were also too fast. Conversely if they are slow, then the fourths were too slow, too.

To correct the fourths retune G3 and D#4 until the two contiguous thirds based on B3 do fit into the

Measure the beat rate of the last major third in the F3-F4 octave by comparison with the Beat-Rater set to the upper C#-F setting. Play the interval on the piano, set your foot tapping at one-quarter of the beat rate speed, and then adjust the speed of the Beat-Rater with the SEMITONES control until it matches the piano. Read this speed on the SEMITONES scale as a fraction of a semitone. If you had to move the SEMITONES control, then the theoretical beat rates are *not* correct for this piano. (If the error is quite small, you can of course ignore it.)

To readjust the notes F3, C#3 and F4 that are in error at this point, reduce the deviation of the SEMITONES scale pointer to one-third of its present value. (That is, if the measured value was -1.5 semitones, reset the pointer to -0.5 semitones.) Now press the F-A button and retune F3 down from A3. Then press A-C# and retune C#4 up from A3. Finally, press the upper C#-F button and retune F4 up from C#4. Check the F3-F4 octave and see if it is indeed as fine as you originally left it. If not, you may need to do a little minor touch-up, but you should be extremely close.

Note that resetting the SEMITONES pointer to one-third of the noted error in the C#4-F4 third gave you the correct beat rate for all the major thirds on this piano. This is because variations in inharmonicity between pianos affects the beat rates, but for a given piano, they will all slow down or speed up together, and one measurement is all you need to predict the beat rates of all of the temperament thirds.

rate and tap your foot at every fourth beat. Turn on the

Beat-Rater to F-A and adjust its speed to match that of the unknown beat rate. Now read the BEATS AT F-A scale of the Beat-Rater to find the value of the unknown beat rate in beats per second. Repeat the measurement for even better accuracy.

The F-A third is traditionally 7 beats per second, the inharmonicity of pianos can vary that up to half a beat from piano to piano. Do not be disturbed if your measured beat rate is not “theoretically correct,” but allow it to float with the needs of each piano. The most important criterion is to have three rising contiguous thirds add up to a good aural octave. If you agree that this is a good idea, then you must be ready to let the beat rates fall where the piano requires them to be. One way to accomplish this is given in the next section.

Learning the 4:5 Ratio Test for Major Thirds. One of the most useful aural tests for setting and checking major thirds is the four-to-five ratio test for contiguous thirds (those that share a note between them). The SBR reproduces this ratio correctly over a range of a major tenth, so that you can hear what the test should sound like throughout the temperament range.

To try this out, compare the speed of the lower C#-F third with that of the F-A third on the Beat-Rater. Play first one, then the other and note that F-A is faster than C#-F. Rather than trying to memorize

how many beats per second (bps) each of them is, listen for the ratio of the two beat rates to each other, which is where the 4:5 ratio comes in. To hear this clearly, tap your foot in

synchronism with every fourth beat of the C#-F beat rate. Then play the F-A beat rates *without changing the tempo of the foot tapping*. You should be able to hear five beats of the F-A third for each tap of your foot. This ratio test takes advantage of a tempo relationship between two beat rates that is always correct. The numerical beat rates vary up and down the keyboard as well as from piano to piano.

Repeat the beat rate comparison using the other pairs of contiguous thirds on the Beat-Rater. You will find that the ratio of each pair is 4:5. This fact makes the contiguous thirds test very useful. *The 4:5 ratio test does not vary from note to note, or with the level of inharmonicity from piano to piano.* Use it to set a correct ladder of thirds that matches the piano perfectly, whether the piano is a grand or a lowly spinet. The results will differ, the beat rates will vary, but the method will work just as well and just as easily on every piano.

Setting a Correct Ladder of Thirds. The first step is setting the pitch of A4 (440) to a pitch standard such as the Sanderson Accu-Fork™, which is the companion instrument to the Sanderson Beat-Rater™. It is recommended to use the note F2 as a test note, and use the interval of a seventeenth, F2-A4, as the test interval. When you have the beat rate between the Accu-Fork and F2 equal to the beat rate

between A4 and F2, the fundamental pitch of A4 is set to the pitch standard.

The next step is to set A3 down an octave from A4.

Tune A3 with F3 as a test note, setting the F3-A3 third slightly slower than the F3-A4 tenth. How much slower may depend on the piano, but usually about one-half a beat slower gives the best octave sound.

Now turn on the Beat-Rater, and set it for the F-A third. (Make sure the SEMITONES control is set to zero.) Tap your foot on every fourth beat to pick up the tempo of this beat rate. Now play the F3-A3 third and adjust its beat rate to match that of the Beat-Rater. This sets F-A to the *theoretical beat* rate of this interval (6.93 bps). To find out if that beat rate is correct for the piano you are tuning, a little trial and error is required.

Tune F4 up an octave from F3. You may use C#3 as a test note, and tune so that the C#3-F4 tenth is just a hair (half a beat) faster than the C#3-F3 third. Just how much faster the tenth must be than the third is again subjective and depends on the piano, but you try to get the best octave sound as before with the A octave.

Next tune C#4 so that the A3-C#4 third on the piano beats at the same rate as the A-C# setting of the Beat-Rater. Remember to divide by four on the beat rate to make it easy to compare beat rates. Now you are ready to see whether the theoretical beat rates will in fact fit this piano.