

# MicroSet Computer Interface Table of Contents

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# Using the MicroSet Clock and Watch Timer with a Personal Computer

These instructions will show you how to use the MicroSet Clock and Watch Timer with your Windows computer. They'll use a sample file to illustrate the different functions of the program, so you can get started even without the timer. To work with your own timepieces, you'll need to plug the timer into a serial port on your computer.

To learn how to use the software, you should go through each item described in these instructions to see what functions are available in the program. For some suggestions of what you can do with the program, see "Using the computer interface" at the end of these instructions. To find something in these instructions, always start with the Table of Contents.

These instructions will teach you what the program does and how it works. At the present time there is not a section on which function in the program you would use to diagnose particular flaws in a clock or watch, or what specific flaws look like on the computer. Such a book would be very useful and might be even larger than these instructions. We would like to produce such a book when we're able to collaborate with someone who has worked for many years in the repair trade and knows MicroSet.

For the time being, this is the guidance I can give you --- the software interface will let you see how a clock or watch performs over time. This is very different from taking a single reading with the timer. A single reading is a snapshot of a moving target. The rate of your clocks and watches is always changing. The changes are caused by irregularities in the gear train, dirt, dried oil, inconsistency in the drive force, flaws in the escapement, changes in the pendulum, and many other factors. Being able to record these changes over a few minutes or several hours will not only let you get a more accurate reading of the average running rate of the timepiece, it will reveal anomalies that are caused by the flaws just mentioned. MicroSet is a tool that you can use to see flaws and imperfections. But it will be up to your skill and knowledge as a clock or watchmaker to interpret the graphs and connect them to the flaws in the mechanism.

The current versions of MicroSet go beyond the measurement and display of rate information. They can also compare the rate with the amplitude of swing and with a variety of environmental factors like temperature and barometric pressure to reveal how these issues effect clocks and watches. In addition, there are specialized functions for the watchmaker that emulate the traditional paper tape timer, display oscillograms of the component sounds within an individual tick, and calculate balance wheel amplitude. The only way to learn what this program can do for you is to go through these instructions slowly, as you're able, to see each function decribed.

## Installing the software

This version of MicroSet will work with versions of Windows from 95 to XP. Put the MicroSet CD in your CD-ROM drive. Open a window for the CD-ROM drive and double-click on the file "SETUP.EXE" in the Install Folder. Follow the instructions to install the program on your computer. After installation there should be a file called "MICROSET2x.EXE" or "MICROSET3x.EXE" on your hard disk and in your list of Programs under the Start Menu.

## Connecting the MicroSet timer to the computer

These instructions will work with a sample file, but you'll need to connect the MicroSet timer to your computer to work with your own clocks and watches. The software came with a data cable for this purpose. One end of the cable has a stereo mini-plug that goes into the jack in the timer that's labeled "Data Out". The other end of the data cable has a female DB-9 connector for a serial port in your computer. You will need to determine where the serial ports are in your computer, and confirm that you have one available.

Windows computers can have several serial ports, and they're given names like COM1 or COM2. Sometimes a serial port is disabled because it's used by a modem. If you don't have a free serial port you'll have to get one. You can tell MicroSet which COM port to use under the CONFIGURE menu, but we'll get to this later.

If your computer has USB ports and no old-style serial ports, you can use a USB to Serial Converter. We have these available for a modest cost or you can buy one locally or from a mail order catalog. Contact Mumford Micro Systems for details.

## Startup

Select MicroSet from the Programs list in the Menu. The first time you run MicroSet it will try to connect with the timer on the serial port known as "COM1". If you will be using the timer with serial port COM1, no adjustment will be necessary. But if COM1 is not available a message will appear that asks you to select the COM port you'll be using instead. You should select the COM port you'll be using by clicking on the proper button. You can now click on "OK" and the program will run with that serial port. If you click on a port that's not available, you're get a warning message. To see what COM ports are available in your computer, you can use the Device Manager window. To see the Device Manager in Windows XP, right click on "My Computer" and select "Properties". Click on the "Hardware" tab and then the "Device manager" button. In the list of devices that appears, click on the "+" next to "Ports (COM and LPT)". You should now see any COM ports that are available.

After you confirm that MicroSet works with the COM port you selected, you can save that configuration so MicroSet will come up configured correctly the next time you use it. To save the configuration, go to the Setup item under the Configure Menu in the MicroSet program and click on "Save Settings".

If you want to run the program even though you can't connect to a COM port, click on the CANCEL button and the program will run, but you won't be able to capture any new data.

## Capturing your first data

To capture rate information from your own clocks and watches, set up the MicroSet timer to take readings in the Time Mode. The LED on the timer should blink with each beat, and new readings should be appearing on the LCD screen. Near the top left corner of the computer screen is an area labeled "Plot" with two settings: On and Off. Click on the "Plot: On" button.



The computer should now capture every new reading that appears on the MicroSet LCD screen, and the area on the computer screen labeled “# of samples” should start counting up.

You may not see the readings in the graph area if the scale is not correct for the rate of the timepiece you’re measuring. Wait until there are at least three readings in the “# of samples” and then click on the “Autoscale” icon. This will reset the Y axis to the proper scale so the samples will fit the display area.



Each new reading of the timer should now appear on the screen of the computer. There are many controls with which to manipulate the way the data is displayed. You can change the type of graph and the scale of readings. You can compute averages and show trends. But the most important use of the program is what you’re now seeing -- a history of the rate over time. You will no doubt see that the rate readings from the timer are not all the same, that the clock or watch speeds up and slows down. Now that you can record these changes over time, you can see when these changes have order, and this order will tell you about what the timepiece is doing. Are the changes random? Then the timepiece may need cleaning or pivot work. Does the clock continually speed up and slow down? Then any one rate reading will not be accurate, and you should find the average to know how the clock runs over time. You will now be able to observe the operation of your clocks and watches with much greater detail.

## **Learning to use the software**

We have provided a sample file for you to use as we describe all of the functions in the program. You could also use live data captured from your own clocks or watches, but the sample file will make some explanations easier. Our explanation of the program will be a step-by-step explanation of each command. If you have questions, don’t hesitate to call or send us an email.

## **Open the sample file**

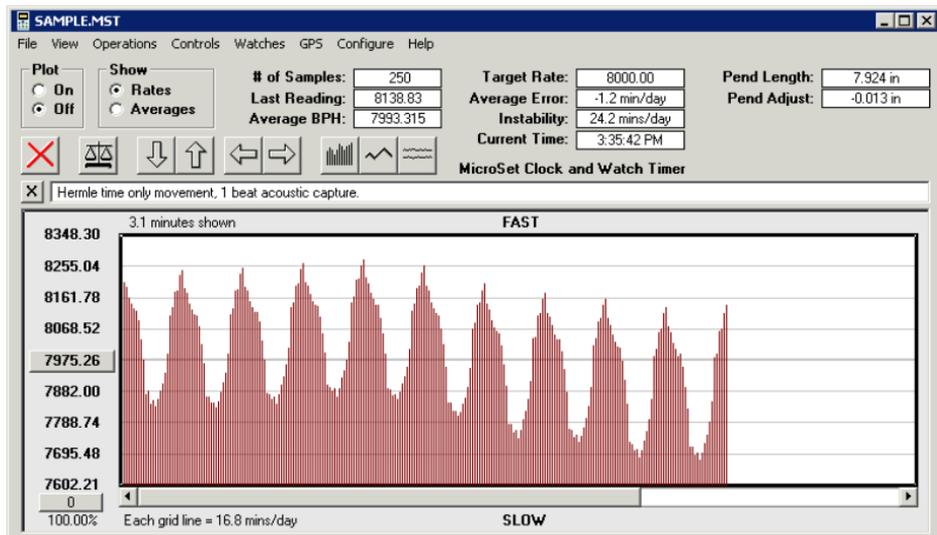
When the program starts up you will see the main screen of the program. An example of this is shown in Figure 1. For the purpose of illustration we’ll open a sample data file. Use the FILE menu to open the file “SAMPLE.MST” which was provided with the installation. The extension “MST” stands for “MicroSet Timer”.

## **Basic display**

The sample data should appear in the graph on your screen (your screen may not be exactly identical to Figure 1 because of differences in screen sizes and types). The sample file contains 250 readings from a simple Hermle time-only clock movement. (Though this description will use a clock, the same operations would be used with watches. There are, however, several watch-specific operations described later under the Watches Menu.)

These beat readings were captured with the clip-on acoustic sensor. Each reading represents a single beat in the clock. But we skipped every other beat. This causes the timer to read only one pallet of the escape wheel, ticking on each tooth one after another. To do this the timer was set to “Time: 1 (skip)”. At the left of the graph you will see labels indicating the beat times. In Figure 1 these times are shown as “Beats per hour”, but you

can also work with “Seconds per beat”. The MIDPOINT of the graph is set at 7996.31 BPH. This number appears in a button in the middle of the Y axis, at the left side of the screen



**Figure 1 - The MicroSet Screen**

At the top of the screen you will see that the program currently holds 250 “Samples”. This means it stores 250 different readings from the MicroSet timer. You can also see that the last reading it received was 8138.83 BPH, and the accumulated average rate of this clock over the entire 250 samples was 7993.315 BPH. This number is very significant. Though the clock rate is always changing (just look at this graph), the clock hands really show the accumulated average rate.

### Set the midpoint

Look again at the button in the middle of the Y axis. This shows you the MIDPOINT of the graph is at 7975.26 BPH. If you look near the top right corner of the screen, you'll see that the “Target Rate” for this clock has been specified as “8000”. The target rate is the correct rate for the clock. To see how the data in the graph relates to the correct rate for this clock, click on the button in the middle of the Y axis. A dialog will appear on the screen and let you manually enter new values for the graph parameters. You will be able to specify a new MIDPOINT for the graph, automatically set the midpoint to the current average, or set the midpoint to the “target” rate for this clock. You will also be able to specify a “step size” for the grid lines. If the step size is made smaller you will, in effect, “zoom in” on more subtle rate changes. If the step size is made larger you will “zoom out” on rate changes. You can also zoom in and out with the up and down arrow icon controls or with the up and down arrow keys. For now, click on “Lock midpoint to target rate”. The graph will be redrawn with the target rate at the midpoint.

In the graph, each vertical line represents one beat reading. The beat times change dramatically in this graph because they're single beats recorded from the escape wheel.

Single beats on a clock escape wheel almost always look like this. The rate increases and then decreases with each revolution of the wheel because the escape wheel is never perfect. You will find that watches are much more stable.

At the lower left corner of the graph you'll see a label that tells you how much rate change is represented by each horizontal grid line. In Figure 1 this value is 11.3 minutes per day. This is a very large number. What this graph is showing you is that, with each revolution of the escape wheel, this clock speeds up and slows down by an amount equal to more than an hour per day! (The range spans about 7 grid lines and each line represents 11.3 minutes per day.) Note that the shapes of the cycles are nearly identical. This is because the irregularities that change the rate are the same on each rotation of the wheel. Though the rate is changing a lot, it changes the same way with each rotation of the escape wheel and the average rate ends up being consistent.

At the top left corner of the graph you'll see the message "3.1 minutes shown". This tells you that the data visible in this graph required 3.1 minutes to gather.



### The Comment line

Directly above the graph is a framed rectangle with text in it. In the sample file this text says "Hermle time only movement, 1 beat acoustic capture". You can use this area to record your notes about what the data in this file represents. To enter text in this area, just point at it with the mouse and click. You can then enter your text. On new data files the program automatically puts today's date in this field. You can then add the name of the clock that was studied or any other conditions you might want to remember (like the type of sensor, the number of beats per reading, or the particular issue you were looking at). Any information you enter in this rectangle will be recorded on disk with the data so you can see it any time you open this file.

There's a small box with an "X" in it to the left of the comment line. You can delete the current contents of the comment line by clicking on the "X".

You can make the comment area larger by selecting "Large Comment Window" from the View Menu.



### The Icon Controls

Above the comment line is a row of icons. These are shortcut commands to manipulate the graph and the data it shows. Each icon is an active button that will change the graph in some way.



### Reset

The first icon has a red "X" in it. This is to RESET the graph. If you click on this icon all the data will be erased. If you want to try this, go ahead. Then load the file again from the FILE menu.

## Autoscale



The second icon looks like a “balance” or “scale”. This is used to automatically scale the Y axis values so the current beat times fit nicely in the window. If you click on this icon now it won’t change because the graph is already scaled for this data.

## Vertical scale



Next to the autoscale icon are two icons that look like up and down arrows. The down arrow reduces the vertical resolution of the graph and allows bigger (taller) values to fit. This has the effect of “zooming out”. The up arrow increases the vertical resolution to reveal more subtle changes in rate times. This has the effect of “zooming in”. Click on the UP icon. The beat times seem to get bigger. This is because the step size between grid lines has become smaller and we are more sensitive to rate changes. You can also select these functions by typing the up or down arrow keys on the keyboard.

Click on the AUTOSCALE icon to re-scale the data to fit the screen. Now click the DOWN icon a couple of times, until it looks like the rate doesn’t change very much in this clock. When viewed this way, this clock looks pretty good -- even though the rate is changing by over an hour per day with each revolution of the escape wheel! To get a frame of reference for what kind of scale the graph represents, look at the bottom left corner of the graph where the scale of each grid line is shown. With the data “zoomed out” so it looks like the clock is more accurate, you’ll find that each grid line might represent a rate change of more than an hour per day.

Hit the UP ARROW icon a few times to zoom in on the data. Watch the message at the lower left corner of the graph, and zoom in until you get just a few seconds per day in rate change for each grid line. In this clock, the graph will then be completely off scale. If the clock were accurate, the rate readings would all fit on screen with each line equal to a few seconds per day.

**When you look at a graph, you must pay attention to the scale. Any clock will look good viewed at a coarse scale, and any clock will look terrible when viewed on a very fine scale.**

## Horizontal scale



The next two icons look like left and right arrows. They’re used to expand or compress the data graph horizontally. At the very lower left corner of the screen you will see a scale factor. Normally this is “100%”. If you click on the LEFT ARROW icon, the horizontal scale will compress and this number will get smaller, indicating that not every data point is displayed. If you click on the RIGHT ARROW icon the horizontal scale will expand to show the entire data set. If you expand beyond 100% the data lines will get fatter. This can make it easier to see individual items. You can also select these functions by typing the left or right arrow keys on the keyboard.

In addition to these controls, there are commands under the View Menu to quickly compress the horizontal scale so all data points fit on the screen or expand the scale to

100% so every sample is visible (even though they may not all fit on the screen).

### Graph type



The next icons let you select which type of graph is used to display the data. (The third graph type is only available in version 3). You can use whatever style you prefer. The first type uses vertical bars to represent each sample. The advantage of the vertical bars is that they make it easy to see how many readings occurred between different peaks or troughs in the data. The second graph type shows one wandering line that follows the rate. The third graph type is used for a simulation of paper tape style watch timing machines. You must have purchased Version 3 to get this choice. Instructions for using the paper tape simulation will be given under the Watch Menu section.

### Plot On/Off



Above the icon controls, at the left side of the screen, is an area labeled "Plot" with two buttons under it: "On" and "Off". This is how you tell the program to start collecting new data from YOUR clock timer. You must plug the data cable that came with your timer into the jack labeled "Data Out" at the top of the timer unit. Plug the other end into a serial port of your computer. You must know which serial port you are plugged into. You must use the Configure Menu of the MicroSet program to tell the program which serial port you're using.

As you may know, the MicroSet timer can be configured to read out in either "Seconds Per Beat" or "Beats Per Hour". No matter how you have MicroSet configured, it will always send data to the computer as Seconds Per Beat. If you prefer to use Beats Per Hour, you can tell the Windows program to convert the Seconds readings from the timer into Beats Per Hour (look under the View Menu for this command).

If your clock is far from your computer you can use extension cables for stereo headphones to extend the reach of either your data cable or the optical sensor cable. They both use 1/8" stereo phone plugs. You may not be able to reliably extend the sensor cable if you're using the acoustic sensor.

Before you start recording new data, hit the RESET icon to clear out any previous data. Be sure the horizontal scale is set to 100%. Otherwise, you might be fooled because not all new readings will be displayed in the compressed modes. You may even want to "fatten up" the plot lines with the RIGHT ARROW icon to make the first few data points easier to see.

Set the timer to the Time Mode. You may set it to any number of readings you like, from 1 to 254. Smaller numbers will give you results more quickly, larger numbers will give you more accurate readings. But don't use an odd number unless you have a specific reason to. Odd numbers of beats will appear jumpy because of beat error or imperfect placement of the optical sensor. So use "Time: 10" or "Time: 30" and don't use "Time: 15" or "Time: 31".

Hit the BEGIN button on the timer to start sampling. Click the “On” button in the “Plot” area of the computer screen. As each new rate value appears on the LCD screen of the timer, it should also appear in the data graph on the computer. The “# of samples” at the top of the screen should increase with each reading. To stop capturing data you can either click on the “Off” button on the computer screen or hit the “MODE” button on the timer itself.

The computer interface will make it easy to see that the timer readings are more accurate when the timer is set to measure more beats (Time: 60 will be more accurate than Time: 4). If you set the timer to measure 4 beats, the graph will be jumpy. If you set the timer to measure 60 beats, the graph will be more consistent.

The program will currently store 90,000 samples before it gets full. When it gets full, the “Plot: On” setting will change to “Plot: Off”. If you take a reading from a one second pendulum every minute, you will be able to capture data for more than two months before the program fills up. If you capture a reading every hour, it will hold ten years worth of data.



### Show averages or rates

To the right of the “Plot On/Off” area is an area labeled “Show” with buttons for “Rates” and “Averages”. It’s possible to calculate and display two different kinds of averages and several other manipulations on the data set. )These calculations are available under the Operations Menu and will be described in more detail when the MENU commands are covered.)

Storage for the alternate calculations is kept separate from the main data, and you can switch back and forth between AVERAGE results and actual RATES by clicking on one of the “Show” buttons. When original Rate times are displayed the graph will be in dark red. When Averages are displayed the graph will be in blue. You can select which data set is displayed (actual rates or averages) with the buttons in the Show area. Note that, when a file is saved on disk, only the RATES data (the red data) is saved.

If “Averages” are selected while new data is coming in from the timer, the current average type will be displayed for each new reading. For example, if you have selected “Running Average”, the software will display the running average rate of a clock over long periods of time. If you have selected “Boxcar Average”, the boxcar value will be calculated for each new reading.

<b># of Samples:</b>	250	<b>Target Rate:</b>	9000.00	<b>Pend Length:</b>	7.924 in
<b>Last Reading:</b>	8138.83	<b>Average Error:</b>	-1.2 mins/day	<b>Pend Adjust:</b>	-0.013 in
<b>Average BPH:</b>	7993.315	<b>Instability:</b>	24.2 mins/day		
		<b>Current Time:</b>	3:35:42 PM		

### File Statistics

To the right of the “Show: Rates/Averages” area are several statistics about the data currently captured in the computer. First shown is the “# of Samples”. In the sample file provided (see Figure 1) these are 250 samples. This means that the timer completed 250 separate readings and reported them to the computer. In this file each reading was a single beat, but if the timer had been set to average 60 beats, the 250 samples would represent 250 readings of 60 beats each.

The **“Last Reading”** shows the last value that was returned from the timer unit.

The **“Average BPH”** shows the total accumulated average rate of the clock or watch over the study period. This value is calculated by adding all of the rate times together and dividing by the number of samples. This reading tells you actual accumulated rate of the clock — which is what the hands show you.

The **“Target Rate”** is the correct rate for the clock under study. The program does not calculate this value — you must enter it yourself. If you know what the correct rate for the clock is, you can enter it here by clicking on the value shown for the **“Target Rate”**. A dialog will appear to let you enter a new value. Once the program knows what the correct rate for the clock is, it can calculate the average error of the clock.

Below the **“Target Rate”** is another box called **“Average Error”**. It will display the amount of error in the current data set by comparing the current average rate with the target rate you have entered. This will show you how many seconds of error per day there are in the current data set. A positive number indicates the clock is fast, a negative number that it is slow. If the Target Rate is not known you should set it to zero, and the Average Error will not be calculated.

Below the Average Error display is a box labeled **“Instability”**. This is a calculation we have created that reflects the general stability of the clock under study. To calculate the **“Instability”**, each individual reading is compared to the accumulated average rate at the time that it comes in. The **“Instability”** value is the average difference between each individual reading and the average rate when the reading was taken.

If the clock is very consistent, each new rate reading will be close to the current average, and the Instability rating will be low. If the clock is erratic, the beat times will jump around a lot, each one will vary more from the average, and the Instability rating will be high. Experience will teach you what to expect. On very accurate clocks the Instability will be zero. In the sample file the Instability is rather huge, at 24 minutes per day. This means that each individual reading is likely to vary from the average by 24 minutes per day. This is an unfair test, however, because we are reading single beats on the escape wheel, and we know that these are very erratic.

Below the Instability rating is the **“Current time”** of day. It's handy to have this reminder on screen because the system clock in the computer is often wrong and needs correction. The MicroSet program records the time of day when each sample comes in. This information is useful because you might want to correlate rate changes to things that happen at specific times. For example, you'll find that some clocks speed up as the minute hand falls from 12 to 6, and slow down as the minute hand climbs from 6 to 12. If the times recorded from the computer's system clock do not match the hands of the clock, this correlation won't be evident. Keep an eye on the time of day shown and, when it's wrong, correct the system clock in your computer.

At the right side of the statistics display area is a box labeled **“Pend. Length”**. If you have entered a Target Rate, MicroSet will calculate the theoretical correct pendulum length for the target rate you specified. Below this is a box labeled **“Pend. Adjust”**. If you entered a Target Rate, this box will show you how far the pendulum bob must move for the clock to achieve the Target Rate you've specified.

## Manipulations on the data points

### Seeing individual data points

It's possible to display the values associated with individual data points. When the mouse pointer is over the graph window, it takes on the shape of a cross hair. If you position this cross hair over a particular data line and click the left mouse button, a line of text will appear at the top left corner of the graph which identifies that sample number, the value of that sample, and the time and date that sample was acquired. You can drag the crosshair through the data and see different data points.

### Changing individual values

If you click on the right mouse button you will be given an opportunity to change the value stored for that sample. This allows you to correct erroneous readings. You can either enter a new value manually, let the program automatically calculate the average of the two adjoining points, or delete the sample.

### Measuring a range

If you hold down the left mouse button, then drag from one data point to another and release the mouse button, the text display will show you the number of samples that were spanned by your selection, the amount of change from beginning to end, the average value of the samples you spanned, and the time difference between them. This allows you to identify the time intervals that produce visual effects in the data graph. For example, in the sample file, you can see that the period of the peaks is 25 samples. This means (with this setup) that the escape wheel has 25 teeth.

As you drag over the data, the screen will show you the information about each individual sample you pass over. If you wish to see the summary of the range as you drag the mouse, hold down the SHIFT key while you drag.

### Delete a sample

Once you have specified a single data point by clicking on it with the left mouse button, or a range of points by dragging over them, you can delete them from the data set by hitting the DELETE key.

### Arrow keys

The arrow keys on the keyboard have the same effect as the arrow icons to expand or compress the horizontal and vertical scales of the graph.

If you hold down the **CONTROL** key when you press the up or down arrow keys, the midpoint of the graph will change rather than the vertical scale. This has the effect of letting you see data that's above or below the top and bottom edges of the graph.

Normally, when you press the left or right arrow keys, the horizontal scale of the graph will expand or compress by a factor of two. If you hold down the **SHIFT** key when you press the right or left arrow keys, you can expand or compress the horizontal scale of the graph in smaller increments.

If you hold down the **CONTROL** key when you press the right or left arrow keys, the display will scroll right or left by the size of one screen width. This has the effect of letting you see what's beyond the right or left edges of the graph.

If the screen is in a compressed horizontal scale, the indicator at the bottom left corner will say something less than 100%. You can automatically expand the scale to 100%

and set the left border by holding the **CONTROL** key down and clicking on any data point. That data point will be placed at the left border of the graph.

### **Setting the left viewing margin**

There is a small button in the lower left corner of the screen, just below the labels on the Y axis. This button normally has the number "0" in it. This is the left margin of the samples you can view. MicroSet can capture up to 90,000 samples, but Windows will not let a scroll bar manipulate more than 32,767 samples. If you capture a huge data file (larger than 32,767 samples) you can click on this Left Margin Button and set the left margin to an offset. For example, if you set the left margin to 10,000, you'll be able to view and scroll through samples 10,000 to 42,767.

### **Redraw the screen**

You can redraw the current data by clicking on the text box which shows the current number of samples.

# The MENU Commands

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## The FILE Menu

The File Menu lets you store and retrieve data sets.

**Open** lets you open a data file that has been previously saved on disk.

**Save** lets you save current data file on disk.

**Save As** lets you save current data file on disk with a new name.

### Save A Subset As

This command lets you save a subset of the current data file on disk with a new name. The purpose of this command is to reduce the size of a data file. For example, suppose you captured a data file with a new sample every minute for a week. At the end of the week, you would have over 10,000 data points. Let's further suppose that, when you examine the data, you find that one sample each hour would have been adequate. This command will let you save a file with only one sample per hour.

When you select Save A Subset As you will be asked to enter the number of samples you wish to skip for every sample saved. For example, to save one sample every hour from a file of one sample every minute, you would enter 59 -- for every 60 samples, one will be saved. To save one sample every ten minutes, enter 9. The smaller file is saved under the name you give it. The file in memory is not changed. If you wish to see the smaller file, you must open it with the OPEN command.

**Print** lets you print an image of the current graph on your printer.

**Exit** terminates the program and returns to Windows.

## The View Menu

The View Menu gives you several commands that manipulate the graph.

### Fit in window

This will compress the horizontal scale as necessary so that the entire duration of the current file will fit on the screen. This lets you step back and look at the overall result of the entire sample period.

### Expand to 100%

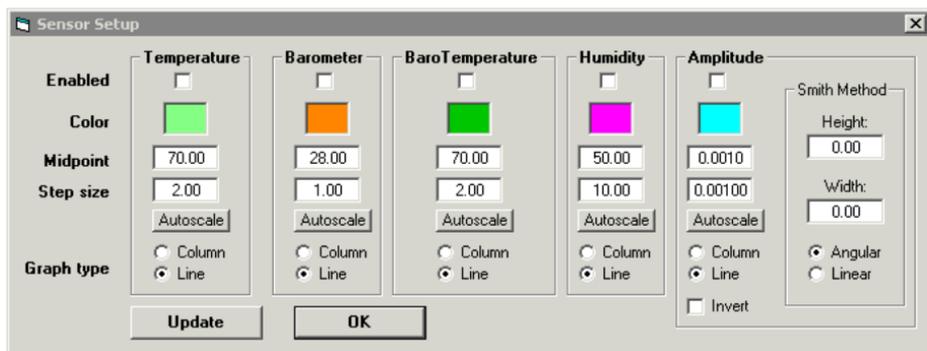
This will expand the horizontal scale to 100% and lets you see every data point that will fit within the screen width.

### Setup Sensors and Amplitude

This selection will allow you to display pendulum amplitude and rate simultaneously if you have a MicroSet 3 with this feature. This feature was not available before October of 2004, but if you have an earlier timer it can be upgraded.

If you bought an optional temperature or atmospheric sensor for MicroSet, This function will allow you to configure and display the readings for these sensors on the computer screen.

When you click on Setup Sensors and Amplitude, the dialog shown in Figure 2 will open. This dialog is used to configure all of the optional display settings.



**Figure 2 – The Sensor Settings**

There are controls areas for four sensors and one for the pendulum amplitude. The “Temperature” sensor is the single temperature sensor sold for MicroSet. The “Barometer”, “BaroTemperature”, and “Humidity” are provided by the MicroSet Atmospheric Sensor. These are both optional sensors that can be ordered from Mumford Micro Systems.

There are several settings every sensor has in common. At the top is a check box where you can set whether the display for that item is enabled or not. An item must be enabled to be visible in the graph.

Below this is a “Color” box. If you click here, you can change the color that’s assigned to that item. You will use different colors to differentiate the different elements in the data graph.

You can also set the midpoint and step size for each item, just as you can for the clock rate data. If you aren’t sure what values are appropriate, you can click on “Autoscale” button to automatically scale the display to fit in the graph window.

Finally, each item can be displayed as a line graph or bar graph, like the main rate data.

After you have configured the settings you can click on the “Apply” button and preview the selections you have made in case you want to make further adjustments before you put the Sensor Setup dialog away. Or, you can just click on “OK” and the graph will be updated with the new settings.

### **Displaying the amplitude of swing**

Beginning in October of 2004, MicroSet 3 is able to display the amplitude of a pendulum at the same time as it displays the rate of the pendulum. It does this by measuring the amount of time the sensor is triggered at the end of each reading. It works with optical or magnetic sensors, but not with the acoustic sensor. To see this data, you must enable the Amplitude section of the Sensor Setup dialog shown in Figure 2.

Usually, when measuring a pendulum, you put the sensor at the center of swing. In this configuration, if the pendulum swings wider, it will pass through the center of swing

more quickly. This is indicated by a shorter length of time that the sensor is triggered. If you enable the amplitude display, the timer will measure the relative speed of the pendulum as it passes through the center of swing. As the pendulum swings wider, the reading will get smaller. This is confusing when it's plotted on the graph because we tend to associate larger values with greater amplitude. There is a check box in the Amplitude section of the Sensor Setup dialog labeled "Invert". If you click on "Invert," smaller values will be plotted at the top of the graph to better represent larger amplitude.

When measuring the amplitude with a sensor at the center of swing, the readings are relative and not absolute. You will easily see when the amplitude gets larger or smaller, but you have no way to calibrate these changes or associate them with any absolute amount of swing.

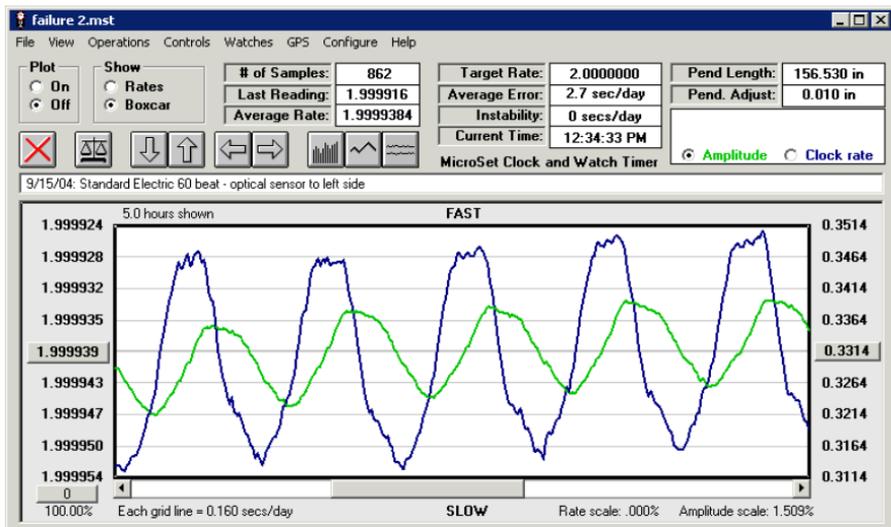
The amplitude can also be measured by placing the sensor at one side of the swing. The sensor must be located very near the maximum amplitude of the pendulum, and it must be arranged so that the sensor will be triggered every time the pendulum reaches it. But the pendulum must not swing beyond it, so the sensor becomes untriggered for an instant before the pendulum swings back. If you're using an optical sensor, it may help to add a bit of opaque tape to the pendulum tip to make it wider and be sure the sensor stays blocked the whole time. Or, you might arrange the optical sensor to trigger on the edge of a disc-shaped bob. If you're using a magnetic sensor, a larger magnet will have a larger field to trigger the sensor.

Keep in mind that, with the sensor at the side of swing, the rate measured by MicroSet will be the period of the pendulum (two swings) rather than the beat time. So a one second pendulum will have a rate reading of two seconds.

In this configuration, when the pendulum swings wider, it spends more time at the end of the swing. A larger reading corresponds to a larger amplitude, so you should not check the boxed marked "Invert" in the Sensor Setup dialog.

Figure 3 shows a graph with both rate and amplitude. The taller wave is the rate, the smaller wave is the amplitude. In this clock the change in rate is caused by the minute hand, which speeds up the clock as it falls from twelve to six. As it speeds up the rate, the amplitude begins to increase as well, though it lags the rate. When the minute hand reaches the six and must be hauled back up to twelve, it takes more energy from the clock, the rate slows down and, after a while, the amplitude declines too.

You can also convert these readings to a good approximation of the actual amount of swing. At the right side of the Amplitude section of the Sensor Setup dialog is a box labeled "Smith Method". The Smith Method was devised by Dr. David Smith at the University of Auckland in New Zealand. It uses trigonometry to convert the timing information to actual degrees of half swing. It relies on the assumption that the pendulum swings in a sinusoidal motion. Any divergence from this shape will distort the readings. The results of the Smith Method may not be correct to very small decimal places or in clocks whose motion is disturbed at the side of swing where the measurement takes place (like a gravity escapement). But in most cases you will be unable to distinguish any difference between the calculated amplitude and any value you can manage to read directly.



**Figure 3 – Pendulum rate and amplitude**

To apply the Smith Method you must enter two parameters. You must enter the “Height”, which is the vertical distance from the pivot point of the suspension to the sensor. If you wish to be precise, and you’re using a magnetic sensor, the distance is from the pivot point of the suspension to the point at which the magnetic field triggers the sensor. Such small distinctions are probably insignificant. Even if your measurements are not high precision, the results will be approximately correct.

You must also enter the “Width”, which is the horizontal distance the pendulum must travel from its at-rest position to the trip point of the sensor. When you have entered these two values, MicroSet will have what it needs to perform the Smith calculations and new amplitude readings will be stored as degrees of swing.

There is also a radio button that lets you choose “Angular” or “Linear”. If the Angular button is selected, the stored readings will be degrees of half swing. If the Linear button is selected, the readings will be converted to horizontal offset from the center of swing in whatever units you used to enter the Height and Width. (You can use either inches or metric units.)

When you have entered this information and MicroSet calculates the amplitude, the readings are stored as calculated. If you enable the Smith Method and calculate degrees of half swing, you can’t go back later and view the amplitude as inches of offset or as raw time values. So be sure to configure the amplitude display for the way you want to view it in the beginning, before you collect the data.

### **Manipulating the display of sensors and amplitude**

Once you have turned on the sensors or amplitude display, the main graph window will have some new controls in the top right area. These can be seen in Figure 4. Additionally, the right side of the graph will become annotated with values for the sensor or amplitude readings.

Pend Length:	39.132 in	Temperature:	0.00
Pend. Adjust:	0.001 in	Barometer:	29.63
<input checked="" type="radio"/> Barometer	<input type="radio"/> BaroTemp	Baro Temp:	69.85
<input type="radio"/> Amplitude	<input type="radio"/> Clock rate	Humidity:	55%
		+	-
		Up	Down

**Figure 4**

At the top right corner of the screen you will see current settings for the sensors. If you don't have a sensor, the reading will be zero. In Figure 4, there is no Temperature sensor.

To the left of this is a rectangle with radio buttons for each sensor or the amplitude that you have enabled. The color of the label indicates the color of the data in the graph. The radio button selects which sensor is currently "active". In Figure 4, the Barometer is "active". When a sensor is active, the labels on the right side of the graph reflect the readings for this sensor. The reading at the middle of the graph is a button you can click on. If you click on this button, you can reconfigure the settings for this sensor.

Under the current sensor readings at the top of the screen are four small buttons labeled "+", "-", "Up" and "Down". These are used to arrange the data in the graph. If you're plotting several parameters simultaneously, it's important to be able to rearrange the scale and location of each element to make a readable graph. These four buttons simplify that task. They will effect whichever sensor is currently active, as determined by the radio buttons. To zoom in on a sensor (or amplitude) reading, click the "+" button. To zoom out, click the "-" button. To move the data set higher in the graph, click "Up". To move it lower, click "Down". There's also a radio button for the "Clock Rate", so you can manipulate its scale and position too. Use these buttons to arrange the data so it's more legible in the graph.

If you hold down the Shift key when you click on one of these four buttons, the action of the button will be reduced to a finer scale.

### **Show/Hide gridlines**

This selection under the View Menu is "Show/Hide gridlines". You may find that, when you have data on the screen for the rate, the amplitude, and a few sensors, the gray gridlines become distracting. You can turn the gridlines on or off with this menu item.

### **Large comment window**

This selection under the View Menu will enlarge the size of the comment area, so you can enter a longer description of the data you are viewing.

### **Display custom legend**

This selection under the View Menu will display a special message you might want to appear on each graph. The message that appears can be specified with the Setup command of the Configure menu. For example, you might want to display the name of your business if you give printouts of the graphs to your customers.

### **Show seconds per beat**

This command will configure the graph to display rate data in the form of Seconds Per Beat. This is the default format for the graph. For example, a one second pendulum would have a beat time of 1.000000 seconds per beat. The Y axis is labeled to six decimal places.

### **Show beats per hour**

This command will convert the beat times from "Seconds Per Beat" to "Beats Per Hour" if you are more comfortable using these values. A one second pendulum has a rate of 3600.00 Beats Per Hour.

### **Show error per day**

This command will label the Y axis in terms of error in seconds per day. To perform this calculation you must have entered a "Target Rate" at the top right corner of the screen. When this mode is selected, the midpoint will be set to the target rate and displayed as Seconds Per Beat or as Beats Per Hour, whichever is the current mode. Each grid line will be labeled as error in seconds per day from the specified target rate. If the error is too great to be reasonable, the program will not enter this mode.

### **Show microseconds**

This command is similar to "Show seconds per beat", except that the values on the Y axis are shown as microseconds of offset from the midpoint. In other words, instead of showing "1.000010" (seconds), the Y axis shows "10.00" (microseconds). This makes it easier to understand the Y axis labels when the increments are small. The midpoint is still shown as seconds per beat to six decimal places. If the vertical step size is too large, the program will not enter this mode.

### **Show milliseconds**

This command is similar to "Show microseconds", except that the values on the Y axis are shown as milliseconds of offset from the midpoint. In other words, instead of showing "1.010000" (seconds), the Y axis shows "10.00" (milliseconds). This makes it easier to understand the Y axis labels when the increments are in this range. The midpoint is still shown as seconds per beat to six decimal places. If the vertical step size is too large, the program will not enter this mode.

### **Show pendulum amplitude**

This command will allow you to set up the timer to measure and display the amplitude of a pendulum rather than its rate. Changes in pendulum amplitude suggest changes in driving power of the escapement, or changes in power losses within the movement.

This function predates the newer ability to show amplitude and rate at the same time, which was described under "Setup Sensors and Amplitude". We leave this function in the software because not everyone can use the newer feature.

Note there is a separate function to show the amplitude of watch balance wheels. This will be described under the Watches Menu.

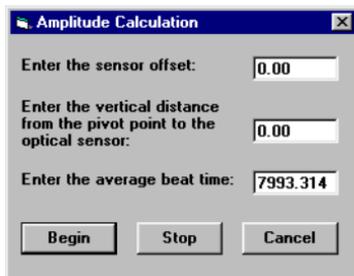
The setup and calculations for this function were devised by David Smith, professor of mathematics at the University of Auckland in New Zealand. There is a specific procedure that must be followed to produce this information. The computer needs a couple of measurements to make the calculations, and these are entered in a dialog box which appears when you select "Show Amplitude" from the View Menu. If you don't bother to

enter these measurements, you can still capture changes in amplitude, but they won't be calibrated in degrees.

First you must position the optical detector to one side of the exact center of swing. Try to locate the sensor about 80% of the way from the center of swing to the maximum amplitude of swing. This proportion is not critical, but don't get too close the point of maximum amplitude. Also, the measurements will be more accurate if the "flag" which triggers the optical sensor is as thin as possible. You may wish to apply a very thin strip of opaque tape to the bob, which will trigger the sensor. This strip can be as narrow as .05". Now you must measure the horizontal distance from the center of swing to the center of the sensor. This value is called "sensor offset", and you can measure in either inches or millimeters. For now, just write this number on a slip of paper for reference.

You must also enter the vertical distance from the optical sensor to the effective center of rotation (or point of suspension) of the pendulum. This value should be in the same units (inches or millimeters) as the sensor offset. This value is called the "vertical offset". Make this measurement and write it on a slip of paper for reference.

You must also enter the actual rate of the pendulum. This is not necessarily the correct rate for the pendulum, but rather the current average rate. In other words, if you're working with a one second pendulum and the current rate is 1.000014 seconds, this is the number you should enter. The first time you configure the "Show amplitude" mode, MicroSet will automatically put the current "average rate" into the correct location. You can let MicroSet determine the current average rate by logging conventional rate readings on the clock for a while. You can do this with the sensor in the off-center position if you like. Just be sure the timer is set to measure a relatively large number of even beats ("Time: 30" or "Time: 60").



**Figure 5 – The Show Amplitude Window**

Once you get a pretty stable average rate, select the "Show amplitude" function from the View Menu. A dialog box will appear in which you must enter your measurements. Enter the horizontal sensor offset as well as the vertical sensor distance. If the correct beat time is not entered automatically, and you know what it is, you can enter it manually. When all three values are correct, click on the BEGIN button. It's a good idea to record the sensor offset, the vertical offset, and the average rate in the comment box above the graph. These values must be entered again if you wish to view the data at a later time. The software stores the raw time values, not the calculated result. A good place to record these values is in the comment line of graph. Then they will always be stored with the data itself.

You must now set MicroSet to read single beats, but skip every other one. In other

words, set the timer to show “Time 1 (skip)...” on the LCD screen. This setting is below “Time 1...”. If your timer does not have a “Time 1 (skip)...” setting, the setting of “Time 1...” is correct.

Watch the pendulum, and press the BEGIN button on the timer when the pendulum is swinging towards the sensor from the long side. For example, let’s say you moved the sensor to the left of center. The left half of the swing will now be short, the right half will be long. Start the timer when the pendulum is swinging to the left, before it reaches the sensor. You want the single beat that the timer measures to be the short portion of the off-center measurement. MicroSet will begin to display the amplitude of the pendulum swing in degrees. The display will not show degrees and minutes, it will show degrees in fractions to 6 decimal places.

You will probably need to click on the “Autoscale” icon to get the data to present itself in proper scale on the screen. Since the timer is set to read out single beats, you’ll get a lot of data (one reading every two beats). This is probably more than you need, but you can use the “Skip samples” or “Pre-average new data” functions (see the OPERATIONS menu) to reduce the volume of data.

While in the “Show amplitude” mode the data will be displayed in light blue color. The “Show averages” message on the screen will change to “Show amplitude”. The raw rate readings that the timer returns are stored in the red primary data area (“Show rates”) of the program. The amplitude calculations are stored in the alternate data area (“Show amplitude”) of the program.

If this setup is done with only very rough measurements, the resulting data will still give a very accurate indication of the way the amplitude is varying, even though the scale of the readings may not be exact. You can easily see changes in amplitude of just a few seconds of arc. For comparison, the angle that the hour hand of a clock turns in one second is 30 seconds of arc.

To turn off the amplitude calculations, select “Show amplitude” from the View Menu and click on the STOP button.

### **Show Rate Finder**

This command is used to display the results of the optional Rate Finder. The Rate Finder is a way of automatically counting the correct BPH of a running pendulum clock. The Rate Finder will count the number of pendulum swings in one rotation of the minute hand. This, by definition, is the correct Beats Per Hour of the movement. If you purchased the Rate Finder, you can capture each hour’s beat count on the computer screen. The Show Rate Finder Mode sets the Y axis to display whole numbers in ascending order.

### **Show Raw Data**

There may be times when you want to display data that isn’t clock rate information. For example, you might want to record the “Width” function, which records the amount of time a sensor is triggered. “Show Raw Data” will format the scale of the graph for data values in several formats. The data can be displayed with no decimal places, with three decimal places, or with six decimal places. Furthermore, the data will be displayed with large values at the top. (When displaying clock rate as seconds per beat, MicroSet puts smaller numbers at the top because these are faster than large numbers. In the “raw” format, large numbers are always at the top.)

## The OPERATIONS Menu

This menu provides several commands to alter either the data stored in memory or the way the data is gathered.

### Running average

The Running Average is the accumulated average rate of the clock or watch at each sample point. This is, in effect, what the clock or watch hands show you. When you select this command, the program will go through the data and add each value together. At each position it will divide the current sum by the number of samples in that sum. The average results are stored in the “alternate” (blue) data area. You can switch between the Running Average and actual Rates by clicking on the “Show Rates” or “Show Averages” buttons at the top left corner of the screen. When the average values are shown the color of the graph changes from red to blue and the “Averages” button in the “Show” area at the top left corner of the screen is selected.

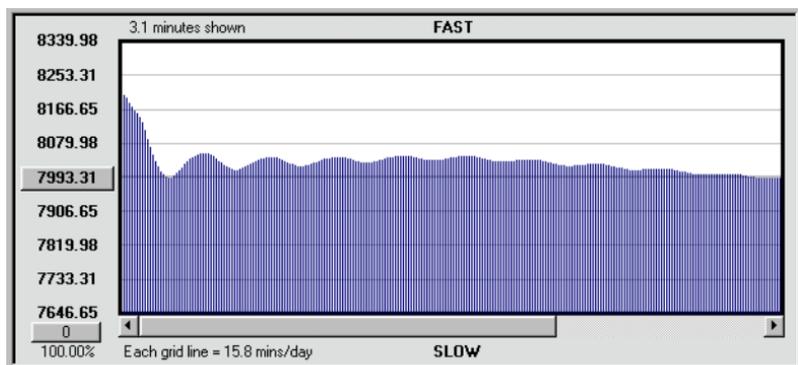


Figure 6 - Running average

The hands of a clock show the accumulated average rate. We have seen that individual samples from a clock will vary over time, and that higher settings of the MicroSet Time Mode produce more consistent readings (you get more accurate results if you set MicroSet to “Time: 60” than if you set it to “Time: 2”). For similar reasons, if you let a timepiece run in the average mode for half an hour you’ll get a much better idea of what the rate of that clock or watch really is, because the fluctuations of rate that occur over shorter periods are averaged out.

For a demonstration of this, load the sample file SAMPLE.MST. Select “Fit in window” from the View Menu to get the entire data set on the screen. Click on the SCALE icon to set the vertical scale for good viewing. Once again you see the strong cycles of the escape wheel. Now select “Running Average” from the OPERATIONS menu. You will see that the strong wavy shape of the data is quickly dampened to a gradual slope that reaches an average rate. This is really how this clock runs. Each reading is very different from its neighbors, but over time these changes average out to a “flat” rate. But the rate is never truly flat. There are always changes happening in the movement to produce irregularities.

Once you set the software to show the running average you can leave it alone, and all new readings will automatically be averaged before they are plotted. In this way you can

just let a clock run for as long as you like and you'll be able to easily see when the average rate has become stable.

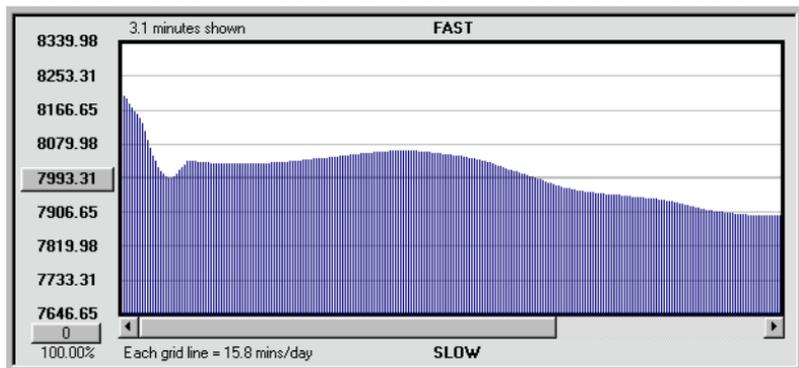
### Boxcar average

This is also known as a “moving” average. When you select this command, a window will appear and ask you for the “boxcar” size. Enter a number, and after you click on OK, the program will go through the data and average the last “boxcar” number of samples and store the average of those samples at the last position. It will then average the previous “boxcar” number of samples and store the average at the next-to-last position.

**Example:** Imagine a data file with 100 samples. If you enter a boxcar size of 10, the value of sample 100 will be set to the average of samples 91 through 100. The value of sample 99 will be set to the average of samples 90 through 99, and so on. The average results are stored in the “alternate” (blue) data area and the original readings are preserved in the main (red) data area, so you can perform the boxcar calculation over and over with a different boxcar size to see different results.

You can view either Rates or Boxcar Averages by clicking on the “Show Rates” or “Show Boxcar” buttons at the top left corner of the screen. When the Boxcar Average values are shown the color of the graph changes from red to blue, the label “Averages” changes to “Boxcar”, and the “Averages” button in the “Show” area at the top left corner of the screen is selected.

The effect of the Boxcar Average is to reduce short term fluctuations of rate. This is also called a “low pass filter”. The Boxcar Average will smooth out the jumpiness of each reading, but will allow you to see when the rate is generally speeding up or slowing down. By choosing increasingly large boxcar sizes, you increasingly reduce the effect of short term fluctuations and increasingly reveal longer term fluctuations that might otherwise be hidden in the data.



**Figure 7 - Boxcar average**

To see for yourself, open the SAMPLE.MST file. Select “Fit in window” from the View Menu to get the entire data set on the screen. Click on the SCALE icon to set the vertical scale for good viewing. The dominant effect you see are 10 cycles of the rotation of the escape wheel. We want to remove (average out) these strong cycles. First we need to know how many samples are in each cycle. Move the crosshair over the tip of one wave and press the left mouse button. Drag the crosshair to the tip of the next wave and

release the mouse button. The text at the top of the graph will tell you that you have selected 26 samples. But this includes the tip of both cycles -- one complete cycle is one sample less, or 25 samples.

Now choose "Boxcar average" from the OPERATIONS menu and enter a boxcar size of 25. This will completely average out the escape wheel cycles because they have a period of 25 cycles. Click on "OK". You're left with a slowly sloping wave that represents more accurately the average rate of the clock. It's now evident that there is some other major rate change going on in this clock that's unrelated to the rotation of the escape wheel. This is evidenced by the hump near the middle of the graph. In the 3.1 minute interval of this short sample the rate changed by about 30 minutes per day due to this other, as yet unknown, effect.

### Difference / Rate of change

This command will examine the data and show you the difference between each subsequent reading. It gives you a way of analyzing how a timepiece is changing as opposed to what it's absolute rate is.

When you select this function the data graph will turn blue to indicate that you're looking at the "alternate" data area. The raw rate information is undisturbed in the red (main) data area. The midpoint of the graph is set to zero, and each reading is displayed as the difference between it and the preceding sample. Values are shown as seconds to six decimal places.

An example of use for this function would be to reveal damaged escape wheel teeth. When a tooth is flawed, it is likely to produce an abnormal beat time. By displaying the differences between single beats, such effects are easy to spot. In our sample file, one tooth stands significantly taller than the others. This bit of information was not evident in the other display modes.

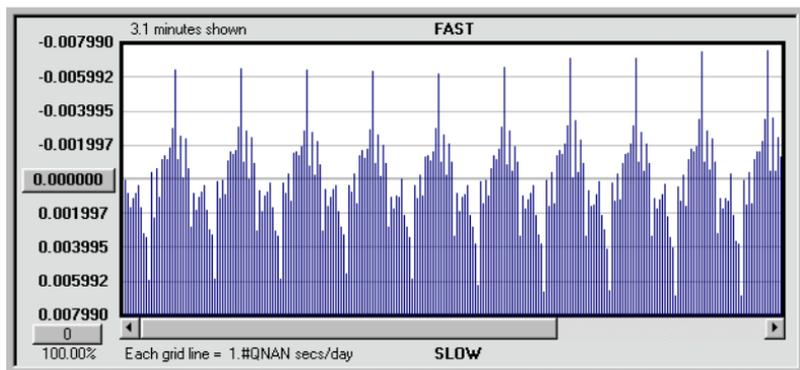


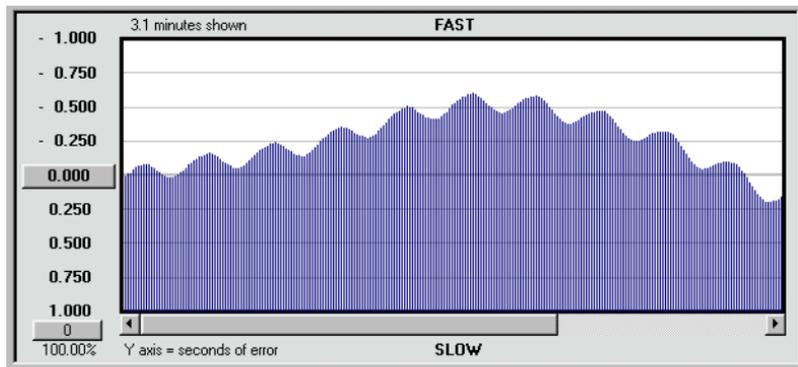
Figure 8 - Difference / Rate of change

### Percentage change

This command is very similar to the previous one, but it shows you the readings as a percentage of change from the previous value rather than as absolute fractions of a second.

## Gain/Loss

This command will convert the rate of a clock into the absolute gain or loss in seconds of time. Up to now we've been viewing the data in terms of how fast or slow each beat is. This command shows us how fast or slow the whole clock is over time. The midpoint of the graph is set to zero, and each reading is displayed as how fast or slow the clock is at that instant. In other words, if the clock has lost a second by reading 150, sample 150 will have a value of 1.0. Positive numbers indicate loss, negative numbers indicate gain.



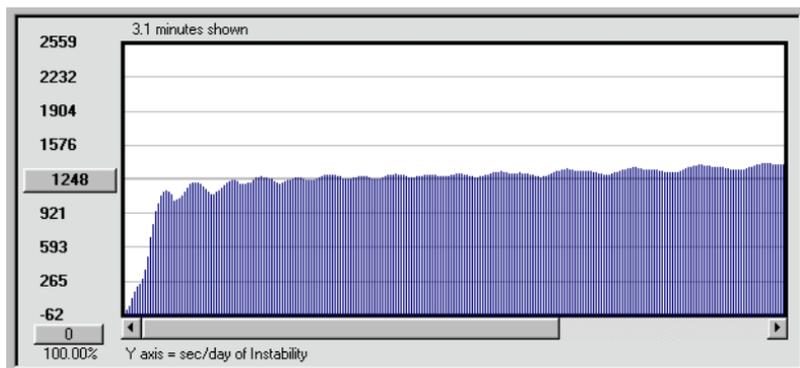
**Figure 9 – Gain/Loss**

In our sample file, the Gain/Loss function shows that the clock is generally gaining, but the gaining rate is moderated by the fact that the escape wheel speeds up and slows down with each rotation. By the end of our 3 minute interval, the clock has lost about a quarter of a second.

One way in which this function could be useful is as follows. Suppose you have a clock that doesn't keep time. Suppose you've used MicroSet to adjust the rate, but the clock still loses time. The problem could be that the hands are slipping even though the clock is beating correctly. If you set the clock to the correct time and let it run for a few hours or longer, you can compare the amount of time the hands show have been gained or lost with the amount of time that the computer tells you have been gained or lost. The computer will give you the answer according to the beating of the clock. The clock will give you an answer according to the motion of the whole clock. If the results are not the same, there may be a problem in the motionwork.

## Instability history

This command will show the history of "Instability" readings throughout the measurement period. You will recall that the "Instability" parameter (shown near the top right of the screen) gives some indication as to how consistent a movement is. The "Instability" figure usually shows the final, total Instability value for the movement. The Instability History will calculate the Instability value for each sample in the file and display them in the alternate (blue) data area. This command was added at the request of a customer, who thought it would be useful in finding cycles within a movement when the rate was disturbed by some flaw. No such irregularity appears in our sample file; the Instability reaches a consistent value and stays there.



**Figure 10 - Instability History**

### **Remove noise**

This command will eliminate samples that are so far out of scale with the other readings that they can only be attributed to “noise” -- either actual acoustic noise that disturbed the acoustic sensor, or a data error with the optical sensor that can't be right. To use this command, scale the data on screen so all the legitimate samples easily fit between the top and bottom boundaries of the screen, and the flawed data points extend off the screen. When you select “Remove noise”, any data point that is outside the range of the maximum and minimum values on the Y axis are set to the average of the two neighboring points.

Use this function with care. Don't be too quick to judge that a data point just CAN'T be legitimate. Sometimes these outliers are real, and evidence of unexpected behavior.

### **Pre-average new data**

This command will average several readings internally before it plots a new value on the screen. It was added to facilitate certain kinds of experimental work. It's basic operation allows you to take readings for much longer periods of time. When you select this command, a dialog will appear and ask you to enter the number of samples you want to pre-average. Let's say you enter 60. The software will then take 60 readings from the timer, average them together, and plot the result. If the timer had been set to “Time: 60”, you would get one data point in the graph for every 3600 beats of the clock or watch. In this way you can multiply the Time Mode setting of MicroSet and get readings over intervals much longer than the usual limit of “Time: 254”. This lets you capture data for very long periods of time without collecting a large number of samples. It's easy to forget that the pre-average is on, however, so try to remember when you use it. To disable pre-averaging, set the value to zero.

### **Skip samples**

This command is similar to “Pre-average new data”, except that it simply skips a specified number of samples rather than averaging them together before they're recorded. In most cases, you'll want to “pre-average” readings rather than skip them because you care about what the clock is doing between readings. Sometimes, only the reading you take matters, and the ones in between should be ignored.

This command is primarily for use with the GPS interface. The GPS interface gathers a new data sample every ten seconds. This is probably too much data to store, so you can skip readings you don't need. You don't want to average the skipped readings from the GPS interface, however. Maximum accuracy is achieved with a simple reading of immediate GPS offset. If you skip five readings you'll get every sixth one, or one reading every 60 seconds. If you skip 359 readings you'll get one reading every hour.

This command is also used with the "Show Amplitude" function. When measuring the amplitude of a pendulum, each reading stands on its own. You don't want to average the amplitude between readings, you probably want the amplitude at the instant it is recorded. However, if you want the average amplitude over an interval, use the "Pre-average" function rather than the "Skip samples" function.

### Modify datasets

This command will allow you to modify the data stored in the program. There are a couple of uses for this function. For example, let's suppose you have gathered several days worth of rate data on a very accurate clock and the clock is running fast by 10 microseconds per beat. Perhaps you'd like to evaluate variations in the clock performance as if it were running exactly to rate. You can simulate this adjustment to the pendulum by adding 10 microseconds (.000010) to every rate reading. The result will represent how the clock rate would look if it were possible to correct the average rate without disturbing the clock whatsoever. The inherent fluctuations will still occur, we simply raise or lower the bob "mathematically" as opposed to actually.

If you're using the GPS interface, you're collecting drift in the clock rather than rate values. If the clock is running slow, it will continue to drift farther and farther from the GPS reference. Perhaps you'd like to evaluate your data as if the clock were not drifting. This can be simulated by subtracting an accumulating amount from each drift reading. As above, this will produce a "mathematical" adjustment to the pendulum length without disturbing the characteristics of behavior.

There are two data areas in MicroSet -- the "main" data area and the "alternate" data area. The main data area appears red, the alternate data area appears blue. When new data is captured it is stored in the main data area. When you save a file, it is the main data area that gets saved. The alternate data area is used for some of the calculations, like "Boxcar average" or "Running average". The alternate data area also stores the results of the "Modify datasets" command.

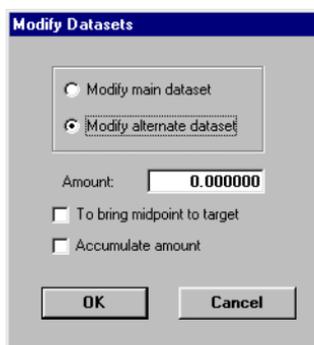


Figure 11 - Modify datasets dialog

The "Modify datasets" command brings up a dialog where you can select several options. Two buttons let you choose to modify the **main dataset** or the **alternate dataset**. Which dataset you modify depends on what you want to do. If you modify the main dataset, the results of your modification will be stored in the alternate data area so your original data will not be lost. If you modify the alternate dataset, the results will be stored back into the alternate data area and overwrite the data you operated on.

A text box lets you enter the **Amount** by which to adjust the dataset. The number you enter will be added to every value in the dataset. To subtract a value, enter a negative number.

A check box lets you choose to have the program automatically enter the amount of correction needed to **bring the current midpoint of the graph to the specified target rate**. This is useful if you have rate data captured for a watch or clock that's not running exactly on time. Set the midpoint of the graph to the current average rate. Be sure the correct rate of the watch or clock has been entered in the "Target Rate" area. If you check the box "To bring midpoint to target", the value needed to bring the **average rate** to the **target rate** will be calculated and entered in the AMOUNT field.

A check box lets you choose whether or not to have the AMOUNT "accumulate". If you click on "Accumulate amount", the amount you enter will be added to the first data element, twice that amount will be added to the second data element, three times that amount will be added to the third data element, and so on. This function is used with offset times from the GPS interface to remove drift.

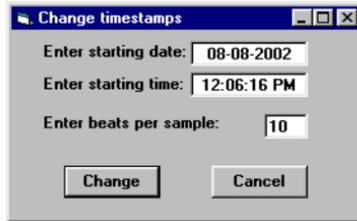
When you have the MODIFY DATASETS dialog configured the way you want, click on "OK". The operation will be performed and the results will be shown to you in the alternate data area (the blue dataset). If you modified the main dataset, you can do it again, as many times as you like with different values, because the main data area is left unchanged. If you modified the alternate dataset, you will have overwritten the previous values in the alternate data area.

### **Exchange data sets**

This command will let you exchange the normal (red) data set with the alternate (blue) data set. When you save a file in MicroSet, only the normal (red) data area is saved. If you want to store the result of some operation that has put data in the blue data area, you will need to exchange the data sets to get the values in the red data area before you save the file. Keep in mind that, if you exchange data sets and then save the file, your raw original data will not be stored on disk. If you wish to preserve the original data, be sure to save it on disk before you exchange it for the result of some calculation.

### **Change time stamps**

Every time a reading is captured by the Windows interface program and stored, the time of day is recorded for that sample. This allows you to go back later and correlate changes in the data with motion of the clock or watch hands, the temperature in the room, etc. If the clock in your computer is set correctly, the time stamp will usually be correct. If you notice that your computer clock was wrong after you've collected some data, this command will let you correct the time stamps in your data file. Or, if you have purchased the optional Data Capture memory for MicroSet (which allows you to capture readings while you're away from a computer), you will need to reset the time stamps of the captured readings.



**Figure 12 - Change timestamps**

When you select this function, a dialog will appear that lets you enter the conditions for time stamp calculation. You must enter the date of the first sample, the time of day of the first sample, and the number of beats between each sample. This last number may require a little thought.

If you had MicroSet to "Time: 30" then there would be 30 beats between each sample **unless** you also had the Windows Interface Program set to pre-average or skip some samples. If you had MicroSet configured to "Time: 30" beats and the Windows program set to Skip 29 beats, there would be 900 beats per sample. This is because there were 30 beats that you got a reading from, and "29 times 30" more that were skipped.

If you're using the MicroSet Data Capture memory, you may also need to think about how many beats per sample there are. If you had MicroSet configured to "Time: 30" beats and had the Data Capture set to "10", you would capture one reading after 30 beats and you would not capture the next "9 times 30" beats. In other words, there were 300 beats per sample.

After entering the correct parameters, click on the "Change" button and the timestamps in the file will be changed. You will see no outward effect, but the time stamps can be viewed by clicking the left mouse button when the cursor is over a data sample.

## **The Controls Menu**

This menu makes many of the commands that are usually accessed with mouse clicks available as menu items. This is a convenience for people who prefer to use the keyboard rather than the mouse.

### **Plot On**

Starts capturing readings from the timer.

### **Plot Off**

Stops capturing readings from the timer.

### **Show Rates**

Displays the main data area (the red data).

### **Show Averages**

Displays the alternate data area (the blue data).

### **Refresh display**

Redraws the graph

### **Recalculate average**

Recalculates the Average Rate value

### **Delete all data**

Empties the graph. Same as clicking on the red "X" icon.

### **Autoscale**

Scales the data to fit on the screen. Same as clicking on the red autoscale icon.

### **Reduce vertical scale**

Compresses the vertical scale. Same as clicking on the down arrow icon.

### **Move down**

Moves the data lower on the vertical scale.

### **Increase vertical scale**

Expands the vertical scale. Same as clicking on the up arrow icon.

### **Move up**

Moves the data higher on the vertical scale.

### **Halve horizontal scale**

Compresses the horizontal scale by half. Same as clicking on the left arrow icon.

### **Reduce horizontal scale**

Compresses the horizontal scale by a small amount.

### **Double horizontal scale**

Doubles the horizontal scale. Same as clicking on the right arrow icon.

### **Expand horizontal scale**

Expands the horizontal scale by a small amount.

### **Bar graph**

Displays the data in column format. Same as clicking on the bar graph icon.

### **Line graph**

Displays the data in line format. Same as clicking on the line graph icon.

## The Watches Menu

This menu has a set of features especially for watch work. You will not have this menu unless you purchased version 3 of the Windows Interface Software.

### Paper tape simulation

This remarkable features allows MicroSet to simulate an early paper tape style of watch timing machine, like Vibrograph and Tickoprint. These machines printed a dot on a paper tape for each beat of the watch. You could tell if the watch was fast or slow, and many other things, by analyzing the pattern of dots. Many people have become skilled in the use of these machines. MicroSet will allow you to perform the same kinds of analyses on the computer screen but with much greater accuracy, flexibility, and more quietly.

To use the paper tape simulation, put MicroSet in the mode to read a single beat: "Time: 1". Do not use "Time 1 (skip)". On the LCD screen you will see individual beat times changing very quickly with each beat of the watch.

At the computer, under the Watches Menu, choose "Paper tape simulation". MicroSet will ask you for the correct rate of the watch in Beats Per Hour. Enter this value and MicroSet will switch to the "double-dot" style of graph display. It will set the graph to display zero beat error at the center of the screen with a spacing of two milliseconds per grid line. Tell the program to begin taking readings by clicking on "Plot: On" at the top left corner of the screen. MicroSet will now show you each beat of the watch as a dot on the screen. If the watch is running close to rate and with little beat error, these settings will allow you to see the watch performance easily. You should see two nearly parallel lines similar to Figure 13.



Figure 13 - Paper tape simulation

You may need to adjust the Level control on MicroSet to get the best result. I have found that a setting near 2 o'clock is sufficient on most watches, but you may wish to turn it all the way up. You may wish to adjust the Level control while you watch the computer screen. There are three primary components to a watch tick. If the Level is not high enough you may trigger on the second or third sound rather than the first. You want to find a setting where the two rows of dots are closest together and most stable.

Each row of dots is one side of the beat. The distance between the rows is the beat error. In Figure 13 we can measure this at the Y axis to be .002 seconds (2 milliseconds). If the watch is very fast or very slow, the slope of the lines may be so extreme that you don't see them as simple, nearly parallel lines. In this case, click on the "down arrow" icon to reduce the vertical scale of the display until you can see two lines at some slope.

If the two lines are very close together you can easily "zoom in" on them to more accurately measure the beat error. Just click on the "up arrow" icon to increase the vertical resolution until you can easily measure the separation between the two lines.

With conventional paper tape timers you would use a protractor to measure the slope of the lines to derive the amount of error per day. With MicroSet we can view this value much more easily by simply looking at the top right corner of the screen where the Average Error is displayed. As long as the Target Rate was entered correctly, the Average Error will correctly show you the error per day of the watch.

As with a paper tape timer, if the data lines wander off the edge of the "tape", they will wrap back on at the other side. This makes it difficult to evaluate fluctuations in the rate because they can be "swamped" by the slope of a rate error. The computer makes it easy for us to eliminate this problem. If you click on the "autoscale" icon, MicroSet will automatically change the Target Rate to be equal to the current Average Rate. The effect of this is to remove the slope of the lines caused by rate error, because there is now, at least theoretically, no rate error at all. The lines will lose their slope and become roughly horizontal, and you can see irregularities in them much more easily.

Paper tape machines had no choice but to display single dots for each beat. With the MicroSet software, when a watch is erratic and the dots are not arranged in nice parallel lines, you may be able to view the data more easily by clicking on the "vertical lines" graph style icon. The information displayed is still the same, but you can more easily see how an "outlying dot" relates to the dots around it. To return to the conventional paper tape display, click on the "double-dot" graph style icon.

If you wish to leave the paper tape mode, click on the "Show: Rates" button at the top left corner of the screen. This will revert to a vertical line graph of each beat.

This display mode is actually a very good way of being sure you have the Level control adjusted properly. Every other line should be higher or lower than it's neighbor in a perfectly regular pattern. In Figure 14 you can see an example of this display. The first half of the data was captured with the Level control set too low. The beat readings are erratic. The second half shows the same watch with the level control turned fully clockwise. Now the beat readings are perfectly regular and much more closely spaced. You should use this display with the column graph to set the Level control before you bother trying to use the paper tape display.



**Figure 14 - Adjusting the Level control**

### **Accutron Rate**

The second item under the Watches Menu allows you to capture the rate of Accutron and other tuning fork watches on the computer. This function will not work on MicroSet 2. You must be using MicroSet 3, which has an Accutron Mode. Plug the optional Accutron sensor into the timer's Sensor In jack. Set a tuning fork watch on the sensor so the 12 o'clock position is near the center of the sensor. Press the MODE button on the timer until the LCD screen says "Accutron..." and press BEGIN. The LED on the front of the timer should come on to indicate that it's getting a signal.

When the timer is set up and measuring a watch, select "Accutron rate" from the Watches Menu. MicroSet will change it's display mode to show numbers with three decimal places, which is the resolution of frequency readings from the timer. If you have clicked "Plot: On" to begin taking readings, you should see the "# of Samples" increasing, but you may not see any data on the computer screen. This is because the values are very high and are usually off scale. Click on the "Autoscale" icon to set the Y axis values so the Accutron frequency rate will be on the screen. You should now see a new reading from the timer about once every second.

If you wish to have the program show you the error per day, simply set the Target Rate to the correct frequency for the watch. The most common value is 360 (cycles per second).

You will find that the fork frequency of Accutron watches varies with temperature and position. There's even a little wobble to the rate as the minute hand passes the 12 each hour.

### **Analyze tick sound**

This function is not available in MicroSet 2 and requires MicroSet 3. It will show you a graphical representation of a watch tick, including the component sounds and a calculation of the balance wheel amplitude. It's a little complicated to describe. Please read the following explanation patiently!

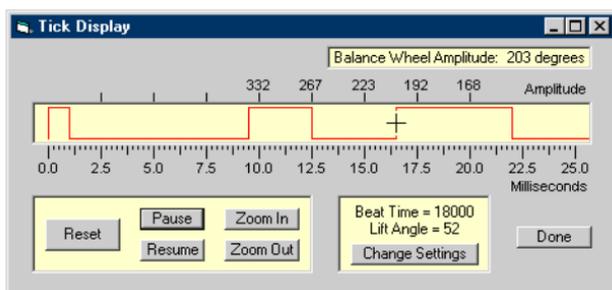
Note that we have now created an improved version of this function. It's called Balance Wheel Amplitude and will be described next. It requires additional hardware in your timer to use it.

Before you use the Tick display function you should understand what it shows you. When we hear a watch tick, we hear it as a single sound. But when examined

“microscopically”, there are actually several sounds happening one after another. The primary sounds are the unlocking, the impulse, and the drop. If you’d like more information on these sounds and what causes them, you can refer to a book on watch escapements. Such an education is beyond the scope of these instructions.

The primary use of the relationship between these sounds is to divine the amplitude of the balance wheel. But we can also learn to identify watches that have “clean” and clear component sounds and those that have noisy escapements.

To use the Tick Display function, set MicroSet 3 to the Tick Mode and press BEGIN. Put a watch on the sensor and set the Level control to about the 12 o’clock position. On the computer, choose “Analyze tick sound” from the Watches Menu. You will see a new window similar to the one shown in Figure 15.



**Figure 15 - Analyzing the tick**

The wide rectangular yellow area is the graph area where the tick sounds are displayed. The sounds are displayed as a single red line. If there is sound at a particular instant, the red line will be at the top of the graphing area. If there is no sound, the red line will be at the bottom of the area.

At the bottom of this window is a scale of milliseconds. The range starts at zero to 100 milliseconds. Some slow ticks might take as long as 70 or 80 milliseconds, but mostly the total tick duration will be closer to ten milliseconds. In order to see the sounds of your watch more accurately, there is a “Zoom In” button. Every time you click on this, the horizontal scale will be expanded. In Figure 15, I have “Zoomed In” until the total graph shows 25 milliseconds of time. There is also a “Zoom Out” button.

As the watch ticks, the sound signal is analyzed and transmitted to the computer at intervals of half a millisecond. The raw watch tick is a very messy signal, and this method cleans it up and simplifies it for viewing. Even so, the setting of the Level control is critical. You almost certainly do not want the Level set fully clockwise. This will amplify the tick so much that all you’ll see is a big burst of noise. Start with the Level control near the 12 o’clock position. You want to find a setting where you get three or four distinct sound pulses, similar to what you see in Figure 15.

But the watch is ticking much faster than the software can transmit and display it. The sound information is “buffered up” in the computer so every tick can be seen. But this means that, after a short while, the ticks you are looking at happened some time ago. When you make an adjustment to the Level control, it will affect ticks that you may not see for several seconds. Every time you make an adjustment to the Level control, click

on the "Reset" button to clear the memory and make the new ticks visible immediately.

If you wish to stop the display for a while and examine a single tick, you can click on the "Pause" button. You can restart the display by clicking on "Resume" or "Reset".

A good quality watch that is running well will have distinct sound pulses. You will find that they often alternate -- the even ones will all be similar and the odd ones will be similar but different. That's because the balance wheel changes directions. The Tick Display will allow you to evaluate subtleties of operation of the watch escapement after you have become familiar with it. Some watches will have three clean sounds, others will reveal four or more distinct sounds. Refer to a book on watch escapements for more information on these sounds.

The most significant information to be gathered from the Tick Display is the amplitude of the balance wheel. This can be predicted from the position of the sounds within the tick. Simply put, the distance of the third sound (the drop) from the beginning of the first sound (the unlocking) indicates the amplitude. The top of the Tick Display window is labeled in degrees of amplitude. These values are calculated with the aid of certain parameters for the particular watch. Specifically, we must know the Beat Time and the Lift Angle. The default values are a Beat Time of 18000 BPH and a Lift Angle of 52 degrees. You can change these settings by clicking on the "Change Settings" button. It's easy to know the correct Beat Time of a watch. You must also know the Lift Angle to get an accurate prediction of balance wheel amplitude. This value is commonly 52 degrees for wrist watches and 36 degrees for pocket watches.

Referring to Figure 15, you can see that the beginning of the third sound happens between the marks for 223 and 192 degrees at the top of the tick display window. To get the exact value of the amplitude, move the mouse pointer over the tick display window. The pointer will turn into a crosshair. Position the crosshair over the rising edge of the third sound. The value of the balance wheel amplitude for this point will be displayed in the smaller window above the tick display graph. The amplitude of this balance wheel is 203 degrees.

When you have finished with the Tick Display function, click on the "Done" button.

You can get a much more accurate reading of the watch tick and the balance wheel amplitude by upgrading your timer to have the additional hardware required for the "Balance Wheel Amplitude" function, described next.

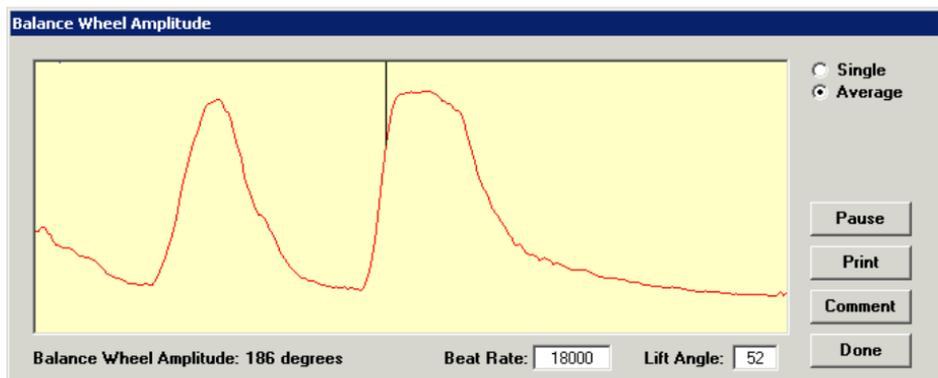
### **Balance wheel amplitude**

This function is in improved version of the Tick Mode. It's an extra-cost option because it requires additional parts to be installed in the timer. Working in conjunction with the Windows Interface software version 3, it will show you a high resolution graphical representation (an "oscillogram") of a watch tick and automatically calculate the balance wheel amplitude.

When we hear a watch tick, we hear it as a single sound. But when examined "microscopically", there are actually several sounds happening one after another. The primary sounds are the unlocking, the impulse, and the drop. The primary use of the relationship between these sounds is to divine the amplitude of the balance wheel.

To use the Balance Wheel Amplitude function, set MicroSet 3 to "BW Amplitude" and press BEGIN. Put a watch on the sensor and set the Level control to about the 10

o'clock position. On the computer, choose "Balance Wheel Amplitude" from the Watches Menu. You will see a new window similar to the one shown below.



**Figure 16 - Balance Wheel Amplitude**

The wide rectangular yellow area is the graph area where the tick sounds are displayed. The sounds are displayed as a red line. If the sound is loud, the red line will move towards the top of the graphing area. If the sound is quiet, the red line will move towards the bottom of the area. Turn up the Level control slowly until you can see three main bursts of sound. The first burst begins the wave at the left edge of the graph. The second burst will be a smaller hump in the signal. The third burst will be the tallest hump. The highest burst should go to the top of the yellow graphing area and flatten out.

The setting of the Level control will be lower for this function than you usually use with MicroSet. If the Level is not high enough, the tall burst will appear to jump left and right and not hold position. Raise the Level control a little farther so the display is generally stable. There will always be a little fluctuation from one beat to the next.

If you raise the Level control too far you won't get any display at all. Turn it back down to 9 o'clock and start up again slowly.

A good quality watch that is running well will have at least three distinct sound pulses. The Balance Wheel Amplitude display will allow you to evaluate subtleties of operation of the watch escapement after you have become familiar with it. Some watches will have three clean sounds, others will reveal four or more distinct sounds. Refer to a book on watch escapements for more information on these sounds.

### **Reading the balance wheel amplitude**

MicroSet calculates the amplitude of the balance wheel from the position of the sounds within the tick. Simply put, the distance of the third sound (the drop) from the beginning of the first sound (the unlocking) indicates the amplitude. A thin black line is drawn from the top of the amplitude window to the red trace at the point where the amplitude is read. Sometimes there will be an earlier sound that's louder than the drop, and MicroSet will read a false amplitude. If this happens you can turn down the Level control on the timer so the third main sound is the loudest one. The calculated reading of balance wheel amplitude is shown at the bottom of the window.

There is an averaging function that will extract the “Drop” sound from a noisy escapement. On the right side of the Balance Wheel Amplitude display are buttons labeled “Single” and “Average”. When the Balance Wheel Amplitude function starts up, it displays and average of several ticks. If you click on the “Single” button, MicroSet will display the sound of single ticks as they come in. Such readings will be more individualized but more coarse and less accurate. With the average function, the important sounds of the escapement will become enhanced and the background noise will be reduced.

The balance wheel amplitude calculation depends on the geometry of the watch. Specifically, we must know the Beat Time and the Lift Angle. The default values are a Beat Time of 18000 BPH and a Lift Angle of 52 degrees. You can change these if your watch is different. It’s easy to know the correct Beat Time of a watch. You should also know the Lift Angle of your movement to get an accurate prediction of balance wheel amplitude. This value is commonly 52 degrees for wrist watches and 36 degrees for pocket watches.

A “Pause” button will allow you to freeze the display so you can take a more leisurely look at the display.

A “Print” button will print a copy of the amplitude window on your printer.

A “Comment” button will insert the current value of the amplitude in the comment line at the top of the graph area.

When you have finished with the “Balance Wheel Amplitude” function, click on the “Done” button.

## The GPS Menu

This menu contains commands that are primarily used with the optional GPS Interface hardware. This hardware lets you synchronize your readings to a source of precision seconds pulses. This is usually a GPS receiver, but an "atomic clock" (rubidium reference oscillator) or other source of precision seconds pulses will work just as well. Instructions for hooking up the GPS Interface come with it.

The general idea with these interfaces is to provide a reference signal that is more accurate than the oscillator that's inside of MicroSet, so you can measure precision clocks more accurately. They can also be used for very accurate measurements of temperature effects on clocks. This is because the timebase in MicroSet can be slightly effected by temperature changes. The precision reference will not be.

When MicroSet is used with one of these interfaces, the readings you get are the drift of your clock relative to the precision reference, not the rate of the clock which MicroSet normally gives you. The GPS interface is designed to work on clocks with a one second pendulum, but it can also be used with half second clocks if they are configured to trigger the timer once per period rather than once per beat.

### Show drift

This command will automatically remove any value jumps that happen when the reference pulse and the clock "tick" come into phase. The resulting data set will be stored in the alternate (blue) data area. Also, when this command is issued, the first offset value is set to zero and all other values are adjusted by the same amount. Since the actual offset amount is immaterial, this results in a data file that shows absolute drift in the clock, from a starting point of zero. The original data, with the value jumps still in it, is kept in the normal (red) data area.

### Convert to rate

This function will calculate the actual rate of the clock by dividing the total amount of time by the total amount of change. When you select this command, a dialog box will ask you for the sample range. Enter the number of samples over which you wish to perform this calculation. For example, if you enter "10", the total time spanned by samples one to ten will be divided by the total drift over these ten samples to give a rate value. Data point ten will be set to this rate value. Then, the total time spanned by samples two to eleven will be processed the same way, and data point eleven will be set to this rate. The rate values will be stored in the alternate (blue) data area. The original raw offset values will still be stored in the primary (red) data area.

Calculations made with a small span of samples will have less precision than calculations made with a longer span. On the other hand, shorter spans will reveal rate changes of shorter duration than longer averages. The resolution of the GPS Interface in this application may be about 5 microseconds per sample. If you convert to rate with a span of 6 samples (60 seconds) you get an average rate over 60 seconds with a precision of 5 microseconds per minute (one part in 12 million). If you convert to rate with a span of 360 samples (one hour) you get an average rate per hour with a precision of 5 microseconds per hour (one part in 720 million). You can perform this calculation over and over, with different sample ranges, without disturbing the raw data.

### **Monitor receiver status**

This command will allow you to monitor the number of satellites the optional GPS Reference Receiver is able to identify. When you use the GPS Reference Receiver to measure a precision clock, you need to know if you have located the GPS antenna in a good location. A good location is one where the receiver can always see at least three satellites. The Monitor Receiver Status function will plot out the number of satellites the receiver is able to see every second. If you let this function run for a few hours you can see if your receiver is always able to communicate with enough satellites.

To use this command, unplug the MicroSet timer from the computer and plug in the GPS Reference Receiver's serial output instead. A new reading will be generated every second. You probably don't need a reading every second, so tell the computer to "Skip" a number of samples under the Operation Menu. Select Monitor Receiver Status from the GPS Menu and click on "Plot: On" to begin capturing satellite status.

## The CONFIGURE Menu

### Autosave

This command will allow you to automatically save the current data at specified times. This will help insure that you will not loose a lot of data if the power goes off or the computer crashes when you aren't around.

When you select "Autosave" a dialog will allow you to enter the "number of samples to wait before saving the data. After you enter the number of samples, click on "Start Auto Save" and you will be able to enter the name of the file to save under. To turn off Autosave, click on "Stop auto save".

If you're using the "Pre-average" or "Skip" functions, the number you enter refers to the number of readings actually stored in the graph, not any of the readings that are skipped or averaged.

Let's suppose you were gathering data with 60 beat average on a one second pendulum with a pre-average of 10. This means that a new value would come out of the timer every minute, but that these values would be averaged by the software ten times before a value was saved in the program. If you tell the "Autosave" dialog to save after three samples, you will write the current data to disk every 30 minutes.

### Setup

This selection let's you configure the software for several settings that you wish to preserve. All of these settings can be memorized by the program so it will always use your configuration.

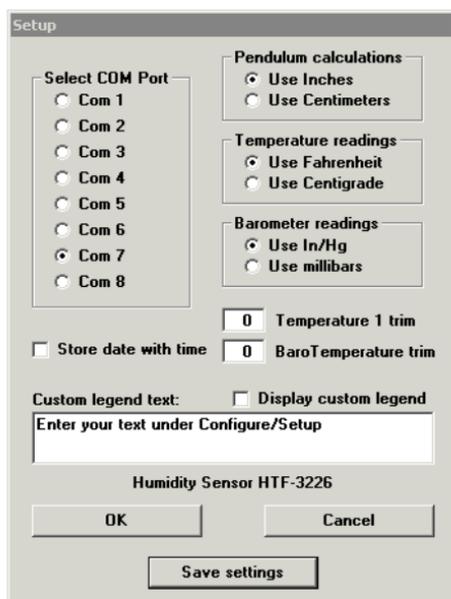


Figure 17 - Setup

To select a serial port, click on the radio button that corresponds to that port. MicroSet only works through serial ports. If your computer has no serial ports and only has USB ports, you can use a USB to serial converter to create a virtual serial port. To see which serial ports are available on your machine, use the Device Manager to display them.

You can choose to have the program display pendulum lengths as inches or centimeters. You can choose to have temperatures displayed as Centigrade or Fahrenheit. You can have the barometric sensor display readings as millibars or inches of mercury.

There's a check box to "Store date with time." If you set this, the time stamps saved in the computer files will record the date as well as the time of day. This will make the file a little larger, but it can be useful if your data runs over many days.

There are text boxes where you can enter a trim value for "Temperature 1" or for "Baro Temperature". The two temperature sensors are not perfect. They have an absolute accuracy of about half a degree Centigrade. If you wish to calibrate the sensors, or make sure they match each other, you can enter a trim value that will be applied to every reading. In this way you can characterize the two sensors you have and make them more accurate.

You can also choose whether or not to always show the custom text above the graph area, and what that text will be. You might want to enter your business name to identify who worked on the clock or watch and who produced the graph when you print them out.

There is also a comment about which humidity sensor the program is calibrated to work with. This is necessary because there are a couple of different sensors in use. If you don't have the optional atmospheric sensor, this message does not matter to you.

Once you've made your selections, click on the OK button. The program will try to accept your selections and go back to work. If the serial port you selected is non-existent or already in use by some other program, you'll get a warning message. Otherwise, the program will resume operation with the new settings.

If you want the program to remember the settings you've selected, you must click on "Save settings". This will save the selections on your hard disk for the next time you run the program.

### **Window size**

This command will let you specify the size of the program's window as a specific number of pixels. You can always re-size the window in the usual way, by dragging a corner or side. But it is sometimes helpful to have the window be a specific, known size. We often do this before capturing an image of the program window for printing or posting on the Internet.

To capture an image of the program screen, press the PRT SCR key on the computer's keyboard. This will place a copy of what's on the computer screen in the computer's "scratchpad". You can now paste this image into an image editing program like Paint or PhotoShop.

## Using the MicroSet Computer Interface

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There are probably two categories of users: those whose work with clocks and watches in the repair trade, and those whose interest is more theoretical and experimental. The computer interface has value to both of you.

### The repair trade

Several repairmen have told me that they find the graphs very useful as a sales tool. You can prepare a graph of the clock before cleaning and after cleaning to show improvement. Such improvement might be very noticeable in the “Instability” factor. If you don’t wish to provide a “before and after” comparison (or if the clock didn’t run when it came to you), a formal looking graph of the clock’s performance after service can make you seem like a very sophisticated and accomplished technician. You can add a description of the data and your shop name in the Comment Window at the top of the graph.

In your shop, you will probably find that it’s much more useful to evaluate a clock’s rate after it’s run for half an hour or more on the computer. You already know that individual readings are somewhat erratic. When you see the half hour history of these changes you’ll be in a good position to evaluate how the clock is performing. Experience will teach you what to expect and what to look for.

Pay attention to the position of the clock hands. When you capture the rate for an hour, you will see that many clocks speed up as the minute hand falls from 12 to 6, and slow down as it is raised up again. Be sure that the clock hands match the computer’s system clock.

You can get a very precise reading of whether or not a clock or watch is “in beat” by capturing every beat on the computer (set MicroSet to “Time: 1”). Every other reading will be bigger or smaller than it’s neighbor, and the difference between them is the amount of beat error in that clock or watch. MicroSet will show you this error to a millionth of a second.

Some clocks respond to rate changes pretty quickly, others take many minutes. I have clocks that can take more than an hour to settle down after an adjustment is made. If the computer is logging the rate while you adjust it, you will be able to see from the “rate curve” when a clock has stabilized and it’s worth taking another look, or if the clock is still “coming to speed” after an adjustment.

Another situation not everyone is aware of is that, if a heavy pendulum has not been hung for a while, a clock can take really a long time (overnight) to “settle in” and stabilize it’s rate. I have a rate graph of a clock with a five pound bob that continued to slow down for more than 24 hours after it was reassembled. The shape of the rate change over time clearly shows if the rate has flattened out or if more change is yet to come.

You will also benefit from considering how the rate changes. If there are specific periods of increase or decrease, try to understand what caused those changes. The duration of any cycles reflect the mechanism that caused them. We have seen that a 25 beat cycle reveals the rotation of the escape wheel. Other wheels in the clock or watch also have natural periods of rotation, and rate cycles can be traced to individual wheels.

Flaws in the escape wheel can be dramatically revealed by plotting every other beat

with the acoustic sensor. The rate will always change in cycles, but if there is any extraordinary pulse to each cycle it will be due to a particular tooth. You will want to use the acoustic sensor for these readings because they measure from the sound of the pallet striking the wheel. You will not be able to study the escape wheel in a clock by watching the pendulum with the optical detector.

To get a general idea of how a clock performs I like to look at the "Instability" factor. Some clocks will naturally have a higher rating than others, but experience will teach you what range of values to expect for a certain type of movement. When a clock comes in with a very sloppy Instability it's time to look closely at it.

You can record the strike counts from the Strike Mode on the computer. This will not only record the number of times the clock strikes, but also the time of day that the strikes occur. This can help you diagnose clocks that strike the correct number of times but at the wrong time.

You can record the individual counts from the Rate Finder on the computer. This can make it easy to identify a bad reading that might throw off the average.

## **Experimental applications**

The horological experimenter will no doubt have his own agenda of issues to look at, but I have found several issues that I think are rather interesting.

The ability to log changes in amplitude of very fine scale is incredibly useful. In my own work, making clocks with electromagnetic impulse, the amplitude measurement makes it easy and fast to evaluate changes in the efficiency of impulse. This would also work with conventional escapements. In the case of my electromagnetic clocks, if a change in the position or duration of the impulse improves the efficiency, the amplitude will begin to increase on the very next stroke. The computer reveals this long before it would be visible to the naked eye. If a change disturbs the impulse, the amplitude immediately begins to decline. With conventional escapements you might not be able to get the same instantaneous feedback, but you could certainly measure the amplitude from one run to the next in fine degrees and observe changes.

I have also found that, though you would expect the rate of a free swinging pendulum to speed up with decreasing arc (due to circular error), it sometimes slows down instead. I have personally seen this effect to be caused by residual magnetic fields acting on the pendulum, by some sort of interference to the pendulum at larger arcs (the pendulum colliding with a soft obstruction), and by loose clamps on the suspension spring. The latter condition also caused extremely long settling times after a rate change was made. Being able to plot rate and amplitude at the same time makes it much easier to investigate these issues.

I have found it interesting to log the rate of spring driven clocks for an entire week to see how they change under conditions of declining spring tension. This will also let you evaluate the performance of a fusee.

Logging a clock rate over time as the temperature and barometric pressure change are obvious cases for the experimenter. These measurements allow you to evaluate different pendulum and bob materials and different mechanisms for environmental compensation. Fabricating and calibrating compensators is made much easier with the MicroSet sensors.

On clocks with very high precision, the accuracy of the timer itself can become a limitation because it can vary by a couple parts per million over several degrees of temperature change. You can buy an optional Temperature Compensated Crystal Oscillator for MicroSet, or the GPS Interface allows “absolute” accuracy of readings over months at a time, regardless of temperature changes. These accessories allow us to observe thermal compensation in the pendulum, barometric pressure response, and even tidal effects in pendulums of adequate precision.

## **Technical Support**

If you run into difficulty there are several ways to contact us listed on the back cover of these instructions. Feel free to give us a call or send an email if you need help.

From time to time there may be enhancements to this software or new versions. Feel free to give me a call and inquire. I would be happy to receive any comments or suggestions you may have about what this software does or how it performs. It continues to evolve based on the feedback of the people who use it and my own ongoing experiments.

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