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Learning to Use the MicroSet Timer

How this booklet is organized

The Quick Start section will provide very simplified step-by-step instructions for the basic operations of the MicroSet timer to help you get started.

Using MicroSet with Watches provides some important considerations if you will be timing watches.

After this, a description of each function with more detail about some of the background issues will be presented. We strongly recommend that you read this section, at least a little at a time, to understand the full features of the timer.

Following this a Technical Reference section will explain some of the fine points to consider if you're interested.

A short summary of each command will be found inside the back cover. A flow chart of operations will be found on the back cover.

If you have a question about some aspect of MicroSet, first look to the Table of Contents. You should also feel free to call or email us at Mumford Micro Systems to ask questions about issues that are not clear to you.

Features

MicroSet incorporates many unique features which have never been available in a clock or watch timer before. MicroSet's powerful features include:

- An optical sensor as standard equipment.
- Resolution of one part per million.
- The ability to display rate as Error Per Day for **any** clock or watch (Model 3)
- The ability to tell you how far to adjust the bob to reach the correct rate (Model 3)
- A running average function to show the accumulated rate over time (Model 3)
- Three methods of finding the correct rate of any running clock.
- A special function to capture a history of strike errors for analysis.
- The ability to capture rate data in memory for later analysis on a personal computer (extra cost option)
- Direct output to a paper tape printer for watch timing (Model 3).
- An interface to personal computers for analyzing performance over time.
- A special mode to analyze the component sounds within watch ticks on a personal computer (Model 3).
- A simulation of paper tape watch timers when used with the optional personal computer interface software (Model 3)
- Many optional sensors and accessories.

These instructions are for the latest revision of the MicroSet timer, called **MicroSet 2** and **MicroSet 3**. The features in your timer will depend on which model and options you purchased. The following list summarizes the features you can look for in your timer:

- A small, hand-held unit that runs on a 9 volt battery or an AC wall adaptor.
- 16 character alphanumeric LCD screen.
- A clip-on acoustic sensor that can hear clock and watch ticks.
- An optical sensor that can measure beat times from the swing of a pendulum. It's immune to noise and much more accurate than an acoustic sensor.
- A wide variety of optional sensors are available for clocks and watches.

- MicroSet will measure the rate of clocks and watches for 1 to 254 beats
- It will display beat times in “Beats Per Hour” or “Seconds Per Beat” and can resolve rate as accurately as one second per week.
- MicroSet 3 can also display rates as seconds of error per day for any clock or watch and is not limited to a programmed set of train times.
- MicroSet 3 can also display rates as the amount of adjustment needed to move the pendulum to reach the correct rate.
- MicroSet 3 has a special Running Average feature that will display the total accumulated rate of a clock or watch for as long as you let it run. This produces rate readings that are remarkably stable and much more accurate.
- An LED will blink on each beat to indicate proper triggering.
- You can configure MicroSet to produce an audible beep when each new reading is complete.
- A “Blanking Window” can be set that allows MicroSet to ignore sounds that occur at intervals other than the expected beat time. This greatly reduces false readings when using the acoustic sensor.
- The Beat Error Mode will help you put clocks or watches “in beat” by measuring the difference between even and odd ticks.
- The Count Mode allows you to determine the correct rate of any running clock without counting wheel teeth or referring to tables of train times.
- The optional Rate Finder Mode will automate the process of counting the train to find the correct rate of any running pendulum clock.
- The Strike Mode will listen to the sound of a striking clock for up to two days, and record the number of strikes it hears at every 15 minute interval. You can then “play back” this strike history to discover any mistakes or intermittent errors.
- MicroSet 3 includes a an Accutron Mode to measure the rate of tuning fork watches.
- MicroSet 3 will produce paper tape charts of watch performance when used with an inexpensive label printer available from Mumford Micro Systems.
- MicroSet 3 includes a Tick Mode that sends detailed information about watch ticks to a personal computer. A special program that runs under Windows will display a graphical representation of the component sounds of the watch tick (unlocking, impulse, and drop), and display a calculation of the balance wheel amplitude.
- A “Balance Wheel Amplitude Mode” can be optionally added that displays an oscillogram of each tick on the computer screen and calculates the balance wheel amplitude more accurately.
- Both versions of MicroSet can be plugged into a personal computer to capture beat times for later analysis and study. This allows you to see how a clock’s rate varies over time, and to evaluate trends in these fluctuations that can help you diagnose problems and understand erratic behavior. You can also use the computer to create graphs of rate changes, or collect many periods and calculate an average rate over hours or days.
- MicroSet 3 includes the ability to measure the amplitude and rate of a pendulum at the same time and plot them together on the screen of a personal computer.
- Optional features include a built-in beat amplifier, Data Capture memory, Rate Finder, Balance Wheel Amplitude modification, and temperature and barometric sensors so you can analyze compensation in clocks and watches.
- Several “technical functions” are included (like a tachometer) to extend the usefulness of the tool.

You can upgrade MicroSet 2 to become MicroSet 3. Call, write, or send an email for details.

Quick Start

For people who want to get started, and don't want to bother with explanations or background, we will start with a "bare bones" description of how to use MicroSet. These instructions will describe measuring a clock. Similar procedures can be used with watches.

First, put the clock "in beat"

The **Beat Error Mode** is used to get the clock adjusted so both halves of the beat are of equal duration. You should adjust the crutch until MicroSet tells you the clock is in beat.

Plug the acoustic sensor into the jack labeled "Sensor In" at the top end of the timer. The acoustic sensor is the black tube with an alligator clip on the end.

Clip the alligator clip onto the winding arbor of the clock. If you're working with a watch, you can clip onto the winding stem or bow of a pocket watch. Or you may have an optional watch sensor to use.

Turn MicroSet on with the LEVEL control. The LCD screen will say:

== MicroSet 2 == or **== MicroSet 3 ==**

Press the MODE button once. It says "**Time 10...**"

Press the MODE button again. It says "**Beat Error...**"

Adjust the LEVEL control until the LED blinks once on each beat. This is likely to be when the level control is near the 1 o'clock position.

Press the BEGIN button.

MicroSet now says "**Error:**"

After a few moments MicroSet will say "**Error: +24 %**" or something similar. The number after the word "Error" indicates whether or not the timepiece is in beat. For a clock or watch to be in beat, the even and odd (or left and right) beats must be of equal duration. The Beat Error Mode shows you the difference between the even and odd beats of a clock as a percentage. The clock is perfectly in beat when MicroSet says "**Error: 0 %**". You may not be able to get to zero because MicroSet is so accurate that it can see very small differences. Also, the numbers will change as the escape wheel rotates. Try to get it adjusted so the numbers change from positive to negative with each rotation of the escape wheel. Anything less than 5% is good. Beat Error readings on watches are shown as milliseconds of beat error rather than a percentage, and are likely to be much more stable.

When measuring watches, the beat error is shown as a number of milliseconds, not as a percentage.

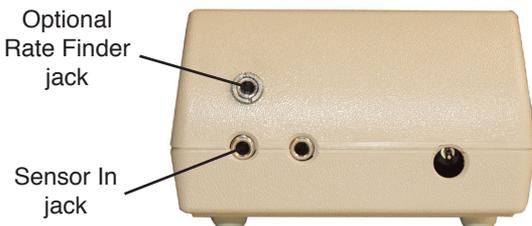
Measure the rate

Once you have the clock in beat, use the **Time Mode** to get the timepiece running at the correct rate. It will measure a number of beats, then tell you the average rate for each beat. You must adjust the length of the pendulum (or the balance spring) until the average beat time is correct for the movement.

Plug the acoustic sensor into the jack labeled "Sensor In" at the top end of the timer. The acoustic sensor is a black tube with an alligator clip on the end.

Clip the alligator clip onto the winding arbor of the clock (or the stem of a watch).

Turn MicroSet on. It says **== MicroSet 2 ==** or **== MicroSet 3 ==**



Hit the MODE button once. It says “**Time 10...**”

Adjust the LEVEL control until the LED blinks once on each beat.

You are now going to choose how many beats of the clock or watch to average before you get an answer. The default setting is 10 beats. To change this, press the PLUS button, or hold it down, until the number of beats you want to average is shown on the LCD screen. A typical value to use would be 30. The best number to use is twice the number of teeth on the escape wheel.

The timer now says “**Time 30...**” (or the number you set)

Press the BEGIN button.

The timer says “**Rate:**” and the LED blinks each time the timepiece ticks. MicroSet will measure the clock for 30 beats. At the end of this time, MicroSet will give you the average rate of the timepiece. If you’re measuring a tall clock, it might say “**Rate: 3600.10**”. This means the average rate was 3600.10 Beats Per Hour. It might also say something like “**Rate: 1.000127**”. This means the average rate was 1.000127 Seconds Per Beat. You can set MicroSet to display answers in either Beats Per Hour or Seconds Per Beat. Refer to the section titled “**Configuration - Display mode**” for more details on these two choices.

Now that you know the current rate of the clock, you can make adjustments until it runs at the correct rate.

Using the optical sensor

The optical sensor is much more accurate than an acoustic sensor. It is used on clocks to “see” the pendulum swing rather than “listen” to the tick.

Plug the optical sensor into the jack labeled “Sensor In” at the top of the timer.

The optical sensor has two posts on it. A beam of invisible light goes between these two posts. You need to position the sensor so some part of the pendulum will pass between these two posts on each swing. If the pendulum is too big, put a thin sliver of opaque tape on the bob to trigger the sensor. You will probably want to use a “3rd hand” with alligator clips to hold the sensor in place. For more details, see “**Technical Reference - Input Sensors.**”

Should I use the optical sensor or the acoustic sensor?

The acoustic sensor is easier to use, but is not as precise. The optical sensor is much more accurate and won’t give you false answers when the clock strikes or there are noises in the room.

Should I measure with Beats Per Hour or Seconds Per Beat?

Clock and watch repairmen are often used to thinking of rates as Beats Per Hour. A one second pendulum is 3600 Beats Per Hour. A typical pocket watch is 18,000 BPH. MicroSet can also be configured to display rates as Seconds Per Beat. A one second pendulum has a rate of 1.000000 Seconds Per Beat. A typical pocket watch is .200000 Seconds Per Beat. You can use whichever format you prefer.

How do I know what the correct rate is?

There are three special functions in MicroSet to help you find the correct rate of any running clock. This is a feature no other timer has ever offered. One of them is the **Count** mode, which will count the actual beats per hour from the pendulum. It will also count the correct rate of any running watch. See “**Using MicroSet - The Count Mode**” for details. The second method is an optional elaboration of the Count Mode, called the **Rate Finder**. It works with two sensors to automatically count beats of the pendulum and rotations of the minute hand to give you a continually refined count of the Beats Per Hour. See “**Using MicroSet - The Rate Finder**” for details. The final method works by measuring the time it takes the

minute hand to go around once. See “**Using MicroSet - Measuring the Minute Hand.**” All of these functions take a little while to get an answer, but you don’t have to do anything while they work, and they’re both a lot easier than disassembling a movement just to count wheel teeth.

The correct rate is stamped in the back plate of modern Hermle movements. The number they give is the Beats Per Minute. For example 200.78 Beats Per Minute is the same as 12,046.8 Beats Per Hour (multiply Beats Per Minute times 60 to get Beats Per Hour). But watch out -- we have seen some movements with the wrong rate stamped on them!

You can look your timepiece up in **The Clockmaker’s Beat Book**, which is included with MicroSet. Unfortunately, it’s not possible for all clocks to be in the book. There were just too many different clocks made over time.

You can calculate the correct rate by counting teeth in the gear train. See “**Using MicroSet - Regulating a movement.**”

With watches, there is a limited number of rates that have been used. If you don’t know the correct rate for the watch you’re working on, you will probably find that it is close to one of the standard rates. The most common standard rates are:

- 18000 BPH
- 19800 BPH
- 21600 BPH
- 25200 BPH
- 28800 BPH
- 36000 BPH

Using MicroSet with Watches

There are a few things to consider when using MicroSet with watches. First of all, there are optional watch sensors that may work better than the standard “clip-on” sensor. The clip-on sensor is included with every MicroSet. It’s used on clocks as well as watches. It attaches to the watch with an alligator clip. This sensor will work fine on pocket watches (clip to the bow), but it may not be the best choice for wrist watches, especially quiet ones. It’s not as sensitive as the other watch sensors, and it might scratch the case of an expensive watch.

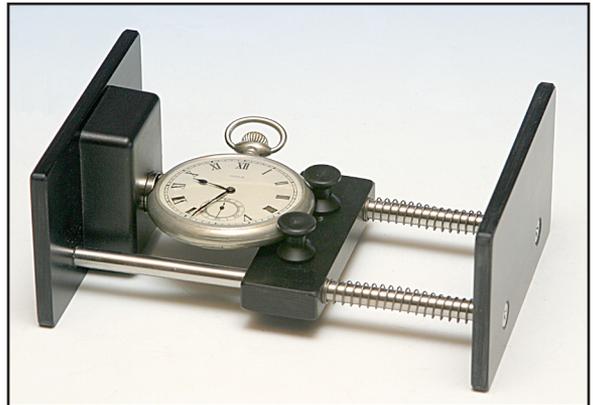
The “simple watch sensor” is more sensitive than the clip-on. It is a small plastic box with a brass tube sticking out of the top. Set the watch on top of this tube. It will be better able to hear the component sounds of a tick for the Tick Mode or reading balance wheel amplitude. It’s very modestly priced and is a good economical watch sensor.



Simple Watch Sensor

The “clamping watch sensor” is the best watch sensor we make. Its spring-loaded arm will hold the watch in place against the sensor insuring good contact for tick transmission. Also, it’s made to have six flat sides so you can set the watch down in the different positions. This sensor is the best choice for serious watchmakers.

The watch sensor made by Witschi in Switzerland has the advantage that you can rotate the watch to various positions without picking it up. It has the disadvantage of being very expensive. If you wish to use the Witschi watch holder we can get them for you and provide an interface to MicroSet.



Clamping Watch Sensor

The Blanking Window

The blanking window is a feature of MicroSet that helps it to disregard noise. The Blanking Window makes the timer “deaf” between valid tick sounds. The duration of the Blanking Window must not be too long for fast beat watches. If the value is too long, MicroSet will read the watch as having a beat rate only half as fast as the watch really has. For example, a watch with a beat time of 28,800 will measure as 14,400 BPH.

The default value for the Blanking Window is “8”. This value is set in the Configuration

Mode of MicroSet. A value of “8” is fine for watches with a rate of 18,000 BPH. But for faster watches you will need to set the Blanking Window to a smaller value. For 21,600 BPH use a setting of “6” or “7”. For 28,800 and faster use a value of “4”.

You can read how to change the default value of “Blanking” in the MicroSet instructions. Look up “Configuration” in the Table of Contents.

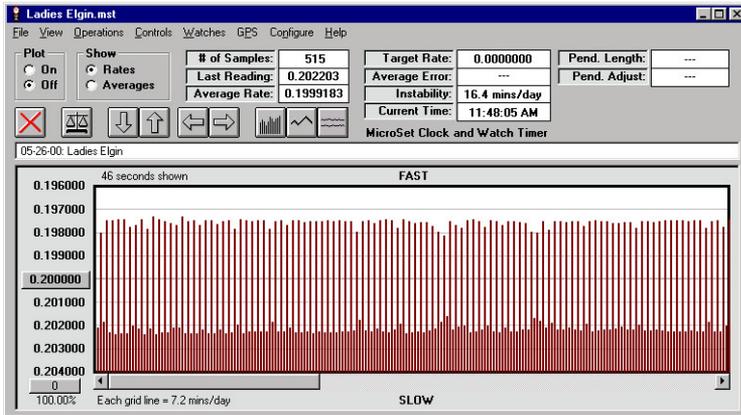
Setting the Level control

You will get better results with MicroSet if you take care to get the Level control set to the best position for each watch. Setting the Level with watches takes more care than with clocks because a watch tick is made up of several sounds. The most important sounds are the unlocking, the impulse, and the drop. You will get the most accurate measurements if MicroSet triggers on the unlocking or the drop. If you don't get the setting right, the readings will appear jumpy and inaccurate.

An easy way to get the best setting for the Level control is to use the Beat Error Mode. If you're getting clean tick signals, the beat error readings will be regular. If the readings are not clean, the beat error will seem to jump around. Adjust the Level control to find where the readings are stable and do not change by more than one or two milliseconds. If you're using the clip-on sensor, you might try moving it to different places on the watch.

Setting the Level control with the Windows Interface Software

The computer software will allow you to display the tick on the computer screen and clearly see when the readings are “clean”. There is a special setup that will make this possible. You should set MicroSet to read every beat. In other words, set MicroSet to “Time: 1”. The graph that results should alternate between one high reading and one low reading. All the high readings should be similar in height and all the low readings should be similar. If they're not, adjust the Level control until they are. The distance between the high and low readings is the beat error.



Using MicroSet

The following instructions document the operations of the MicroSet timer in greater detail. We strongly encourage you to read these descriptions to learn the details of each function.

The keypad

In general, you use the MODE button to select the various functions of MicroSet. If you press the MODE button over and over, MicroSet will cycle through the various functions that are available in your timer. If you go past the function you want, keep pressing MODE and you'll come back to it.

When the mode you want is displayed on the LCD screen, press the BEGIN button to enter that mode. After you enter a function you can usually press the MODE button again to get out of it.

The PLUS and MINUS keys are used to enter numbers and make other choices. One press will advance the count by one. If you hold down the PLUS or MINUS buttons they will "repeat" after a short while and make entries very quickly. In places where there are "Yes/No" questions, use PLUS for "Yes" and MINUS for "No".

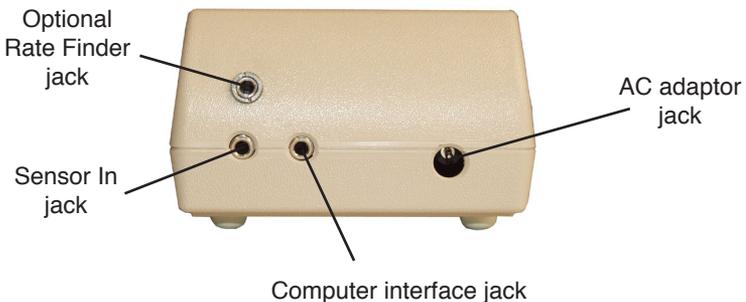
A flow chart of the MicroSet functions can be found on the back cover of this instruction book.

Power source

MicroSet will operate on a 9 volt battery or an AC wall adaptor. The battery is contained inside a door on the bottom of the unit. The AC adaptor plugs into a jack on the top end. AC operation is recommended when you have easy access to it. You can leave the battery in when the unit is plugged in to the AC adaptor and, if the AC goes off, MicroSet will keep running on the battery. If you lose your AC adaptor you can use any one that provides 7 to 15 volts DC with at least 50 milliamps (more current may be needed for some options). The plug is a 2.1 mm barrel plug, with center positive.

Turning it on

The round knob in the center of the keypad is the power switch and sensitivity control. Turn it clockwise to turn it on. MicroSet should beep twice to indicate it is waking up. It will then display "**-= MicroSet 2 =-**" or "**-= MicroSet 3 =-**" on the LCD screen. If this does not happen as expected (or any time you want to re-initialize MicroSet) press the red RESET button.



The Time Mode

Assuming that the MicroSet name is displayed on the LCD screen, press the MODE button once to enter the Time Mode. The screen will say:

Time 10...

This means MicroSet is in the mode to measure beat times, and is set to measure 10 beats.

Attach the sensor to the clock or watch

We'll start with the acoustic sensor because it's quick and easy (but it's less accurate than the optical sensor). The standard acoustic sensor has an alligator clip on the end of a black tube. Insert the plug of the acoustic sensor into the "Sensor In" jack on the top end of the timer. The Sensor In jack is the one closest to the right side of the case.

Clip the sensor to some metal part of the clock movement. You may use a winding arbor or some part of the plates or a pillar. If you're measuring a watch, you may clip the acoustic sensor to the winding stem or the bow of a pocket watch. You may also have one of the optional watch sensors.

Set the level

Notice the LED on the front of the timer just below the LEVEL control. It should blink every time a clock or watch tick is heard. Adjust the LEVEL control so this light blinks reliably at every tick. Don't set the level higher than it needs to be to get reliable triggers, because this will make the timer more sensitive to false noises. Note that movement of the cord that connects the acoustic sensor to the timer can register as false ticks, so arrange the cord where it can lie still.

When measuring watches, you may be better off to set the level control fully clockwise. Watch operation is usually quiet enough to allow full volume, and this will help insure that the tick will register at the unlocking phase. (There are several phases to a watch tick. Erratic measurements can result if some ticks register at different phases. MicroSet 3 has a function that will allow you to view and measure these phases on a personal computer. See "**Using MicroSet - The Tick Mode**".)

Select the beat count

When the sensor and level controls are arranged to produce reliable blinks on the LED, you can set the number of beats MicroSet will measure before giving you the rate. Press the PLUS button to increase the beat count. Press the MINUS button to decrease the beat count. The beat count is displayed on the LCD screen. For example, when set to measure 20 beats, the display will show:

Time 20...

If you hold the PLUS or MINUS buttons down continuously, the beat count will increase or decrease rapidly. When the display shows the number of beats you want to average, press the BEGIN button.

Unless you have a specific reason to do so, don't measure an odd number of beats. Since clocks and watches are almost never in perfect beat, an odd number of beats will give you misleading results because it reads an extra beat that's either longer or shorter than the average. Also, the most accurate results will be obtained with readings of several seconds. Measuring single beats can be useful in diagnosing escapement errors, but to rate a clock or watch accurately, use at least 20 beats. Best results will be obtained with a beat count equal to twice the number of teeth on the escape wheel. This is because the escape wheel is typically not perfectly round, and the rate will speed

up and slow down with each rotation of the escape wheel. When you measure one full rotation of the escape wheel, this change in rate no longer matters.

There are a couple of special settings in the Time Mode. When you press the MINUS button enough times to go below a count of one beat, the LCD screen will say:

Time: 1 (skip)...

This setting will measure one beat and skip the next. Skipping every other beat can be very useful. It makes it possible for MicroSet to calculate and record on a personal computer the amplitude of a pendulum rather than the rate. Instructions for doing this are included with the optional Windows Interface Program. Another feature of measuring every other beat is that it allows you to observe individual teeth on the escape wheel. Since every other beat is the same pallet striking each subsequent tooth, any repeating abnormality indicates a flawed tooth.

When you're setting up the Time Mode, if you press MINUS enough times to go below the "Time 1 (skip)" message, you will see:

Time Hours...

This is a special mode that works with the optical sensor to measure the time it takes the minute hand to go around once. This can be used to estimate the correct rate for a clock whose rate you don't know. See "**Using MicroSet - Measuring the minute hand**" for details.

You can program a default value for the Time Mode count. You might prefer to start with a low count like 2 or 4, which gives you an inaccurate answer very quickly. Or you may prefer to start out with a count of 20 or 30 to get a more accurate answer. You can configure your MicroSet to start the Time Mode with a value that suits your work style. See "**Configuration - Time count**" for details.

Reading the results

When you have the Time Mode configured with the beat count you want to use, press the BEGIN button to start measuring the clock or watch. MicroSet will say:

Rate:

as it measures the first period. The beat LED should blink and, after the selected number of beats have occurred, MicroSet will divide the total amount of time that has elapsed by the number of beats you selected and display the average length of each beat in one of two possible formats: Beats Per Hour or Seconds Per Beat. The format shown depends on how your timer is presently configured. For example, a one second pendulum might show **one** (not both) of the following displays:

Rate: 1.000023

Rate: 3599.92

The first line is the average beat time displayed in Seconds Per Beat. The second line is the rate of the clock displayed in Beats Per Hour. You can select which format MicroSet will use. See the "**Configuration - Display mode**" section in these instructions to change the current setting and for an explanation of the differences.

If you have MicroSet 3 you can also display rates as seconds of error per day or as the amount of adjustment needed to the bob to bring the clock to the correct rate. These features are explained under "**Time Mode Options**".

To restart the Time Mode you can press the MODE button, or press the RESET button to reset the timer.

Beep on completion

If the total period being measured is longer than about 10 seconds, you can instruct MicroSet to produce an audible beep whenever a reading is complete. This way the display doesn't need to be watched constantly to see when a new reading is ready. See the "**Configuration - Beep tone**" section in these instructions to turn the beep on or off.

Blanking Window

This is a very important feature of MicroSet, and you should understand how to use it. You can adjust MicroSet to ignore any sounds that occur at a time that is outside a narrow "window" of when the correct tick is likely to occur. This greatly reduces false triggering when using an acoustic sensor on noisy clocks and watches. It will also prevent a false reading if you drop a screwdriver on the table or the sensor cable gets bumped. The Blanking Window will greatly reduce these sources of inaccurate readings and is an especially important feature that you should become familiar with.

The Blanking Window has some default value that's specified in the Configuration Mode. You can, however, "maximize" the default setting to be as close as possible to the current beat time. To maximize the Blanking Window, put MicroSet in the Time Mode and press the BEGIN button. Confirm that the LED is blinking reliably on each tick and that new rate values are being displayed on the LCD screen. Then, carefully (so as not to introduce any noise by your action), hold down the PLUS button. After a moment the LED should come on and stay on. This is confirmation that the Blanking Window has been set. You can now release the PLUS button.

The blinking pattern of the LED will now be different. It will stay on for longer at each tick. When the LED is on, the Blanking Window is active and MicroSet is "deaf". When the LED goes off, MicroSet starts listening for the next tick. If things are set correctly, the LED will go off for a very short time before it comes on again. This indicates that MicroSet is ignoring sound most of the time, then listens for a very short time before the next tick arrives.

Possible problems with the Blanking Window

If a clock is out of beat, it's possible to set the Blanking Window for the long tick. This would be too late for the short tick, and the short tick would be missed. It's best to put the clock in beat before measuring the rate (see instructions for the Beat Error Mode). If the expanded blanking window isn't working out, just minimize it.

Minimizing the Blanking Window

To minimize the blanking window, have MicroSet in the Time mode (with the LED blinking and timing values appearing on the screen), and hold down the MINUS button. After a moment the LED should come on and stay on. This indicates that the blanking window has been minimized, or set to the value specified in the Configuration Mode. You can release the MINUS button and the LED should blink briefly every time a tick is heard.

You can also press the RESET button to clear the Blanking Window and start everything over with the default minimum value.

You can program a default value for the minimum Blanking time. This time needs to be very short if you're working with fast beat (36,000 BPH) watches. But with slow clocks, or watches with low balance wheel amplitudes, the tick may not be finished by the time a short Blanking Window ends. You can set the minimum Blanking Window to a value that is slightly shorter than the slowest timepiece you work with. See "**Configuration - Minimum blanking**" for details.

Using the optical sensor

One of the most important innovations of MicroSet is the ability to measure clocks with an optical sensor. It gives much more accurate results than an acoustic sensor for several reasons. For one, it measures the movement of the pendulum, and the momentum of the pendulum helps average out short term fluctuations that occur at the escape wheel. Also, the movement of the pendulum is a more precise and regular event than the relatively sloppy “tick sound” of the pallets. Finally, the optical sensor is immune to other noises. You can measure right through the strike of a Westminster chime. Try THAT with an acoustic pickup!

To use the optical sensor, plug it into the “Sensor In” jack on the end of MicroSet. The optical sensor has two short “posts” that stick up from a tiny circuit board. One of these posts is an invisible (infrared) light source. The other post is a light sensor that “sees” the light source. Position the sensor so some part of the pendulum (like the threaded rod on which the rating nut turns) will pass between the two posts and break the beam. In small mantel clocks you can hold the sensor sideways so the sensor arms are horizontal and the wire pendulum rod itself will break the beam. If no part of the pendulum will easily fit between the sensor posts, you can stick a tiny strip of opaque tape to the pendulum bob or rod which will trigger the sensor. This will add no measurable weight to the pendulum.

You may find it helpful to use a “third hand” to hold the optical sensor. Radio Shack sells “extra hands with magnifier” (catalog number 64-2063) for \$9.99. This gizmo has two alligator clips on an adjustable arm and a heavy metal base. It will allow you to position the optical detector at any angle to the pendulum. When holding the optical detector with an alligator clip, try to avoid damage to the sensor by the teeth of the clip. For example, you may wish to hold the cable at the very back of the alligator clip opening, where there are no teeth. Or you may wish to grind down the teeth on the alligator clip, or slip some shrink tubing over the jaws.

It’s usually best if the optical sensor can be located near the center of travel of the pendulum, where the beam will be broken once per beat. Otherwise, the even and odd beats will be of unequal length and can contribute to misleading results. You can also position the sensor at one side of travel where it will be broken only once for every two beats. This may actually produce more stable results, but the beat time measured will be TWICE the expected value. For example, a tall clock would show a beat time of 1800.00 Beats Per Hour rather than 3600.00 (or 2.000000 Seconds Per Beat instead of 1.000000 Seconds Per Beat).

Also, take care to keep the optical sensor out of bright light. Bright light (like the sun or a bright work lamp) will not damage the sensor, but it can overwhelm it and prevent it from working.

When the optical sensor is properly set to “see” the pendulum, put MicroSet in the Time Mode. You should see the LED blink every time the sensor is blocked by the pendulum. If it doesn’t blink, turn the level control all the way up or shade the sensor from direct light. If you want to get the sensor in the EXACT center of swing, you can do this with the Beat Error Mode of MicroSet (this function is described later).

Once the sensor is in position, measurements are taken just the same as with the acoustic sensor, except they will be more accurate and it won’t matter if the clock strikes or chimes.

Regulating a movement

Now that you are able to measure the rate of a clock or watch, you need to know what the correct rate is. There are several ways to acquire this information. For example, on modern Hermle clock movements, the plates are stamped with the correct rate in Beats Per Minute. Multiply this number by 60 to get the number of Beats Per Hour.

MicroSet comes with The Clockmaker's Beat Book of clock train tables. This booklet contains rate data for many historical clocks. But every movement can not be in the book. There were simply too many different clocks made.

There are a relatively small number of rates commonly used for watches. If you don't know the correct rate for the watch you're working on, you will probably find that it is close to one of the standard rates. The following list includes some common rates for watches in Beats Per Hour and Seconds Per Beat:

18000 BPH	.200000 SPB
19800 BPH	.187500 SPB
21600 BPH	.166667 SPB
25200 BPH	.142857 SPB
28800 BPH	.125000 SPB
36000 BPH	.100000 SPB

MicroSet has a special setting of the Time Mode to measure the time it takes the minute hand to go around. This information can be used to calculate the correct rate for any running clock. See "**Using MicroSet - Measuring the minute hand**" later in these instructions.

MicroSet has a Count Mode that will count the actual number of beats per hour of any running clock. See "**Using MicroSet - The Count Mode**" later in these instructions.

An optional elaboration of the Count Mode, called the Rate Finder, will automatically count the beat of a clock while monitoring the minute hand as well. See "**Using MicroSet - The Rate Finder**" later in these instructions.

It's also possible to calculate the correct rate by counting teeth on the clock gears. This requires disassembly of the movement. The basic procedure is to multiply the tooth counts of all wheels between (including) the escape wheel and the hour wheel. Next, multiply the tooth count (leaves) of all pinions that are associated with those wheels. Now divide the wheel product by the pinion product. Finally, multiply this number by two. The result is the correct rate in Beats Per Hour. To convert Beats Per Hour to the beat time in Seconds Per Beat, divide 3600 by the Beat Per Hour count.

As an example, let's say you have a clock with 36 teeth on the center wheel, 78 teeth on the third wheel, and 42 teeth on the escape wheel. Multiply these together and you get 117,936. The third wheel pinion has 6 leaves and the escape pinion has 6 leaves. Multiply these together to get 36. Now divide the first number by the second and you get 3,276. Multiply this by two and you get the correct Beat Per Hour count of 6552. To get the beat time in seconds, divide 3600 by 6552 to get .549450 Seconds Per Beat. See the Clockmaker's Beat Book that came with MicroSet for more details about this method.

Few clocks can be regulated to exactly the correct rate. You may want to know how fast or slow a clock is based on the range of rate readings you get. The easiest way to get this information is to use MicroSet 3. It can be programmed to display Error Per Day (see

“**Time Mode Options - Error per day**”). MicroSet 3 has another remarkable feature. It can tell you how far to move the bob to make the clock run on time. See “**Time Mode Options - Pendulum Adjustment**”.

There is also a special table in the Clockmaker’s Beat Book that came with MicroSet that will give you error per day values for different clock rates. See “**Figuring Error Per Day**” in the table of contents. Also, the MicroSet computer interface software will automatically calculate the error per day and other parameters.

The error per day can also be calculated by hand. An error of 1 minute per week is an error of .000099 parts. Multiply .000099 times the beat time to get the approximate beat error of 1 minute per week. As an example, take a Seth Thomas #1 regulator with a beat time of 4800 Beats Per Hour. Multiply 4800 times .000099 to get 0.4752. This is the amount of variance in rate that will account for 1 minute per week. In other words, if the clock were to have a beat time of 4800.47 Beats Per Hour, it would be fast by 1 minute per week.

Measuring the minute hand

This procedure allows you to determine the correct beat time for any running clock without dismantling the movement to count wheel teeth. The basic procedure is to measure the time (in hours) it takes the minute hand to go around once. Then you multiply the current beat time by this number. The result is the correct beat time.

This function is not as accurate as the **Count Mode** or the **Rate Finder**. You should probably use one of these functions instead. Instructions for the minute hand calculation will be preserved for those who want to use it.

For an example of measuring the minute hand, let’s say MicroSet told you it took .999167 hours for the minute hand to go around once. The correct time for any clock is 1.000000 hours, so this clock is running fast. Next, let’s say you measure the current beat time to be 4804 Beats Per Hour. We multiply 4804 times .999167 and get 4800. This is the correct beat time for this clock.

To perform this measurement, leave the clock movement in the normal upright position. You probably don’t have to remove the movement or dial from the clock case. Position the optical detector so that the minute hand will pass between the two posts. Place the detector near the 8 o’clock position if possible. You want the detector to be located where gravity will keep the minute hand stable, and away from any of the chiming 1/4 hour positions. It must also be located so the minute hand will pass unobstructed between the two posts of the detector. You can bend the wires going to the detectors a little if this helps. You may want to use a “third hand” to hold the sensor in place. Be sure the sensor will sit still for the full hour measurement period. Any movement of the sensor will reduce the accuracy of the measurement.

Note: The Radio Shack “extra hands with magnifier” may be useful here. This gizmo has two alligator clips on an adjustable arm on a heavy metal base and will allow you to position the optical detector at any angle to the face of the clock. You may need to tip the detector at an angle to the face, so one leg of the detector reaches behind the minute hand. The detector need not be parallel to the minute hand. You can also use the optional magnetic sensor.

Once you have managed to get the detector in position, set MicroSet to the Time Mode,

and press the MINUS button until the Time count goes below one to the value "Hours". In this mode, MicroSet expects to measure an interval about an hour long. Move the minute hand of the clock into the sensor to be sure the LED on MicroSet will come on when it passes through the sensor. Back the minute hand away from the sensor and start the Time Mode by pressing the BEGIN button. When the minute hand moves through the detector, the LED will come on and the LCD screen will say:

Rate: (waiting)

This lets you know that MicroSet saw the minute hand go by and is now waiting to see it again in about an hour. Be sure the clock can sit undisturbed for a full hour. You can now go about your business and come back in an hour to get your results.

You can let MicroSet run in HOUR mode for many hours. Each hour a new reading will be displayed. If you have the optional personal computer software, each reading will be stored on the computer. You can increase the accuracy of this method by capturing several hours of readings, then averaging them together. If you do this, be sure to record a reading EVERY hour. Often, one hour will be fast and the next one will be slow. For best results, don't skip any hours.

When MicroSet has finished measuring the minute hand, it will display the result in fractions of an hour. In other words, if the clock is a little fast, MicroSet might show ".999012." This is how many hours it took the minute hand to go around. This number is less than one and means that it took less than one hour for the minute hand to make one revolution.

As was stated earlier, to make use of the hourly reading, multiply the HOUR measurement times the CURRENT beat time to get the CORRECT beat time. So, after you've taken an HOURLY reading (or beforehand) you must also take a CURRENT beat reading of at least 30 beats (set MicroSet to TIME: 30 or more and measure the pendulum with the optical detector). The formula is:

$$(\text{CORRECT BPH}) = (\text{HOUR RATE}) \times (\text{CURRENT BPH})$$

If you have MicroSet to display rates as Seconds Per Beat rather than Beats Per Hour, you must DIVIDE the current rate by the hourly rate:

$$(\text{CORRECT SPB}) = (\text{CURRENT SPB}) / (\text{HOUR RATE})$$

The accuracy of this measurement will depend on the accuracy of your readings. The hourly mode depends on stability and a smooth running minute hand. The current beat time depends on the stability of the clock and the number of beats that you average. My experiments suggest that the correct rate can be determined to within a minute or two a week if you average three or four readings. Better quality clocks give better results, sloppy clocks may give inferior results.

Time Mode Options

Once MicroSet is running in the Time Mode you can access the Time Mode Options. These are additional functions that are related to the measurement of rate. Some of them are extra cost options, and some are only available in MicroSet 3. If you wish to add an option you don't have, give us a call.

To access any Time Mode Options in your timer, press the BEGIN button while the Time Mode is running. You can step through the different Time Mode Options that may be in your timer by pressing BEGIN several times.

Speaker On/Off

The first Time Mode option is to turn the internal beat amplifier on or off. If you didn't buy the internal beat amplifier this option will not appear in your timer. If you have the amplifier, you can access it by pressing BEGIN while the Time Mode is running. The LCD screen will say:

Speaker: Off

Press the PLUS key to turn the speaker on. If it's already on, press the MINUS key to turn it off. You can now return to the Time Mode by pressing MODE and the speaker will stay as you set it.

The volume of the speaker is controlled by the existing LEVEL control. To make it louder, turn the LEVEL control clockwise. MicroSet can continue to take readings while the speaker is on. You may notice that there is a slight additional sound when MicroSet displays a new value on the LCD screen. Also, if you have MicroSet plugged into a personal computer, you may here an extra "beep" when data is sent to the computer. Don't be fooled by these sounds and think they're coming from your clock or watch. If they bother you, reenter the Time Mode Options by pressing the BEGIN key. This will stop MicroSet from taking readings and you'll only hear the clock or watch.

The speaker is mounted to the back of MicroSet, where it faces the work table. The rubber feet on MicroSet hold the timer off the table and let the sound out. In fact, the speaker is louder when MicroSet is sitting on a work table than it is if you turn it over and face the speaker towards you. However, the speaker will be loudest when sitting on a hard, reflective surface. The sound will be muffled if you set it on a padded or carpeted surface.

Running Average

The Running Average option is one of the most useful benefits of MicroSet 3 (it's not available in MicroSet 2). When the Running Average function is turned on, MicroSet 3 will accumulate a running average of every rate reading it has taken and display the average rate of the timepiece over any length of time you wish to let it run. It will cause rate readings to settle down to very stable and accurate values that change only in small fractions after just a few minutes.

When you enter the Running Average option, the LCD screen will say:

Average: Off

To turn on the Running Average function, press the PLUS key. The LCD screen will say:

Average: On

Now hit the MODE button to return to the Time Mode. As new readings are shown on the LCD screen, they will appear in the following format:

1: 3600.00

The first digit is the number of samples that have been taken. The number after the colon is the Running Average rate. In the example shown, the rate is displayed as Beats Per Hour, but the Running Average function works if you have MicroSet configured to show Seconds Per Beat or any of the other Time Mode display modes. Each time a new reading comes in, the average rate will be refined and the difference between subsequent readings will get smaller and smaller.

To turn off the Running Average mode, enter the Time Mode Options and press BEGIN until the LCD screen says:

Average: On

Press the MINUS button to change it to "Average: Off" and then press MODE to return to the Time Mode.

If you wish to reset the running average value, enter the Time Mode Options and press BEGIN until the LCD screen says:

Average: On

Press PLUS and then MODE to return to the Time Mode, and the running average value will be reset and start over.

If you're using the Running Average mode and a bad beat comes in, it will throw off the whole running average because the bad value becomes incorporated with every reading. For this reason, take special care to get clean readings in the Running Average mode. In typical operation, the Running Average rate shown will become more and more stable over time. Commonly, it will get a little larger, then get a little smaller. This is because clock rates are cyclic. But the amount of change should get smaller and smaller with each reading. If you notice that the rate just keeps getting bigger and bigger, or smaller and smaller, it may mean you have a bad sample that has thrown off the running average. You may wish to re-enter the Running Average mode to reset the average and start over.

Normally we recommend using a relatively large number of beats for the Time Mode. For example, if you set MicroSet to "Time: 2", you'll get less accurate and more erratic answers than if you set it to TIME: 30. This seems to be much less important with the Running Average mode. In theory, there's no reason for a setting of "Time: 2" to be less accurate than a setting of "Time: 60". I have been using small numbers because I get new answers more often and the average function gradually removes the difference between each reading.

Show Error Per Day

The third Time Mode Option is only available in MicroSet 3. It allows MicroSet 3 to display rate readings as seconds of error per day rather than as Beats Per Hour or Seconds Per Beat.

To activate the Error Per Day option, enter the Time Mode Options and press BEGIN until the LCD screen says:

Show error/day?

To answer "Yes", press the PLUS key. MicroSet will then show you the last reading that it made on your watch or clock. Let's say you were working on a pocket watch, and the last reading taken in the Time Mode was 18020.00 Beats Per Hour. MicroSet would show this value on the LCD screen:

Target: 18020.00

MicroSet needs to know the CORRECT rate for your timepiece before it can calculate the error between the correct rate and the current rate. MicroSet proposes the last value measured as the "target" rate. This is not likely to be the right value, but it is likely to be very close. If it's not close, your timepiece is so far off that there's no need to see seconds per day of error ... the error is much larger than seconds!

You can adjust the proposed number with the PLUS and MINUS keys. To make the value larger, press (or hold) the PLUS key. To make it smaller, press (or hold) the MINUS key. When you press PLUS or MINUS the proposed rate will change by a small amount. If you hold the key down, the value will change rapidly. If you hold the key down even longer, the value will change even more quickly.

When the value shown gets to the correct rate (which would be 18000.00 in this example), let go of the PLUS and MINUS keys. The LCD screen will say:

Target: 18000.00

To enter this value and begin timing the watch again, press the BEGIN key. MicroSet will now show you the rate of the watch in terms of seconds per day of error rather than Beats Per Hour or Seconds Per Beat. In other words, MicroSet will now tell you how fast or slow the watch is. If the value shown is positive, the watch is fast. If the value is negative, the watch is slow.

If you want to turn off the Error Per Day display mode, press the BEGIN key to access the Time Mode Options. Press BEGIN until the LCD screen says:

Show error/day?

This time, answer “No” by pressing the MINUS key. MicroSet will return to the previous display mode, whether it was Seconds Per Beat or Beats Per Hour.

As you enter the target rate for this function, if MicroSet has been displaying Beats Per Hour, the PLUS and MINUS keys will change the proposed rate by an odd number (.09 BPH). This is normal. If you cannot get MicroSet to display the exact rate you want, choose the closest value. The rate that MicroSet gives you will still be more accurate than a tenth of a second per day.

Show Adjustment

The fourth Time Mode Option is the Pendulum Adjustment option. It causes MicroSet to display rate readings not as Seconds Per Beat or as Beats Per Hour, but as the amount of adjustment needed to the rating nut to get the clock to run on time. This unique function will make it much easier for you to know how much adjustment is needed to get the clock running correctly.

To activate the Pendulum Adjustment option, enter the Time Mode Options and press BEGIN until the LCD screen says:

Show adjustment?

To answer “Yes”, press the PLUS key. MicroSet will then show you the last reading that it made on your clock. Let’s say you were working on a tall clock, and the last reading taken in the Time Mode was 3601.15 Beats Per Hour. MicroSet would show this value on the LCD screen:

Target: 3601.15

MicroSet needs to know the correct rate for the clock before it can calculate the amount of adjustment needed. It proposes the last value measured as the correct rate (the “target” rate). This is not likely to be the right value, but it is likely to be close. If it’s not close, your clock is far from the correct rate.

You can now adjust the “target rate” with the PLUS and MINUS keys. To make the value larger, press (or hold) the PLUS key. To make it smaller, press (or hold) the MINUS key. When you press PLUS or MINUS the proposed rate will change by a small amount. If you hold the key down, the value will change rapidly. If you hold the key down even longer, the value will change even more quickly.

When the value shown gets to the correct rate (which would be 3600.00 in this example), let go of the PLUS and MINUS keys. To enter this value and begin timing the clock again, press the BEGIN key. MicroSet will now show you the rate of the clock in terms of how much adjustment, in ten-thousandths of an inch, must be made to the rating nut to get the clock to run at the target rate you entered. If the bob must be lowered, the number will be positive. If the bob must be raised, the number will be negative.

If you want to convert the measurement of ten-thousandths of an inch into the number

of turns of the rating nut, you need to know how many threads per inch are on the rating screw. If it's 30 threads per inch, each turn is one inch divided by 30, or .0333 inches per turn.

To turn off the Pendulum Adjustment display mode press the BEGIN key to access the Time Mode Options. Press BEGIN until the LCD screen says:

Show adjustment?

Answer "No" by pressing the MINUS key. MicroSet will return to the previous display mode, whether it was Seconds Per Beat or Beats Per Hour.

Data Capture

The fifth Time Mode Option is Data Capture. This is an extra cost option. If you didn't purchase Data Capture, the option will not be available. When Data Capture is turned on, rate readings taken by the timer are stored in memory within the timer as they are displayed on the LCD screen. At some later time you can connect MicroSet to a personal computer and "dump" the data that has been captured into the Windows Interface Program. This allows you to capture data for the computer even though the clock you are working on is not near a personal computer. This feature will be useful if you have a computer in your office but not in the clock shop. Repairmen may find it useful to capture detailed information about clocks on house calls, which can be examined later when they return to the shop. Or perhaps there is a clock or watch you are interested in buying at a local shop, and you'd like to examine its performance before you commit to purchase. Assuming the shop keeper will allow it, you can capture the behavior of the timepiece in the shop and examine it later on your computer. Even if you have a computer handy to use with MicroSet, you no longer need to tie it up with monitoring a clock. The computer can be free for other things and MicroSet can monitor the clock all by itself.

To use Data Capture, MicroSet must be in the Time Mode and taking readings. Press the BEGIN key to access the Time Mode Options. Press BEGIN one or more times until the LCD screen says:

Capture: Off

The default condition is for Data Capture to be off. To begin capturing your readings, you must turn it on. Do this by pressing the PLUS key. The LCD screen will then say:

Capture: 1

The number "1" means that MicroSet will capture every reading in memory. You can press the PLUS key again and the number "1" can be increased up to 250. The number that you select is the number of readings that will occur before one is stored in the Capture memory. For example, if you set the LCD screen to show:

Capture: 10

MicroSet will store one reading for every ten that occur. The reason for saving fewer than every reading is that the Capture memory can hold no more than 8,125 readings. This is quite a lot, but there may be times when you would prefer to capture over a longer period of time. By skipping some readings your Capture time is increased.

After setting the Data Capture count value, you can go back to the Time Mode and begin capturing readings. Do this by pressing the MODE key.

MicroSet will now resume taking readings from the timepiece under study. Every new reading that's displayed on the LCD screen will be followed by the letter "C", to indicate that they are being captured. The readings will be stored in memory inside the timer until the memory storage is filled. If you fill the Capture memory, the Capture function will be turned off and the letter "C" will no longer appear after each rate reading.

Here are some typical kinds of measurements and the length of time you can capture with a Capture count of "1". If you enter a number larger than "1", multiply the duration shown by the number you entered for the Capture count:

- Seconds pendulum, Time 240 (one reading every 4 minutes): capture for 22 days.
- Same measurement, but optical sensor configured to time one period rather than one beat: capture for 45 days.
- Seconds pendulum, time 30 (one reading every 30 seconds): capture for 2.8 days.
- Mantel clock, time 30 (one reading every 11 seconds): capture for 25 hours.
- Pocket watch, time 60 beats (one reading every 12 seconds): capture for 27 hours.
- Pocket watch, time 1 (capture every beat): capture for 27 minutes.

When you have captured all the data you want, you should turn off the Capture function. Press the BEGIN key to access the Time Mode Options. Press BEGIN again until the LCD screen shows:

Capture: 1 (or some other number)

Press the MINUS button until the LCD screen says:

Capture: Off

This indicates that the Capture function has been turned off and new readings will no longer be stored.

When you turn Capture off, MicroSet stores a marker in the data to indicate where the end is. This allows you to turn the timer off and still be able to Dump the data at a later date. The data is stored in nonvolatile memory, and you can leave MicroSet off for an hour, or a month, and still get the data out. However, if you turn Data Capture "On" again, it will start a new data session and any previous data will be erased.

You can capture more than one "session" of data with the Capture function. You can stop the Time Mode (or use any other function of MicroSet), or set up on a different timepiece, and then Capture more data. If you wish to do this, do NOT turn the Data Capture off. As long as Data Capture is left on, the data will go into memory and it can be dumped to a PC later. If you turn off the Capture function you cannot add any more data.

Dumping captured data

When you're ready to transfer your captured data to the PC, plug MicroSet into the serial port of your Windows computer with the cable provided. You must also run a version of the MicroSet Interface Program that's compatible with Data Capture. The data comes out of the timer really fast -- too fast for earlier versions of the interface program.

To Dump data, put MicroSet in the Time Mode and press the BEGIN button to access the Time Mode Options. Press BEGIN until the LCD screen says:

Dump?

Be sure the Windows Interface Program is ready to accept data (the "Plot: On" button is selected) and press PLUS on the timer. This will start the data dump. Every reading stored in the timer will come flying out of MicroSet. The numbers will appear on the LCD screen so fast that they will be illegible. New data points will appear on the computer screen as fast as your computer is able to display them. When the dump is complete, the timer will return to the start of the Time Mode. You can dump the data as many times as you like; it will stay in memory until you turn Data Capture "On" again, which resets the storage area and begins a new capture.

Here are some things to keep in mind about the Capture process.

- 1) You can use Data Capture whether MicroSet is configured to display Seconds Per Beat or Beats Per Hour. The data captured will always be saved as Seconds Per Beat, which is what the computer interface requires. When you dump the data to the PC, even though MicroSet may have been displaying Beats Per Hour, you will dump Seconds Per Beat.
- 2) Normally, when you capture readings from the timer on the computer, the computer stores the time of day that each reading was taken. When you examine the data on the PC screen, you can tell when each sample was taken because it has a "time stamp". When you dump data from the timer's Capture function, it all comes in very quickly, even though it may have taken days to collect it. The time stamp associated with each sample will be the instant it transferred to the computer, not the actual time it was captured. The Windows Interface Program has a command to correct the time stamps. It's called "Change timestamps" and can be found under the Operations menu. To correct the timestamps you must know the time that the first reading was captured and the number of beats between each captured reading. For example, if MicroSet was set to Time 30 beats, there were 30 beats between each reading. But if you set the Capture count to "Capture: 10", there would be 300 beats between each captured reading. If you wish to correct the timestamps, you must make a note of the start time and counter values of your capture data when you start Data Capture.
- 3) That data will be saved in the timer for as long as you like, but if you turn Capture "On", any stored data will be lost. If you wish to capture more than one clock, you must do so without turning off the timer and without turning off the Capture function between clocks.
- 4) Remember to "close" the Data Capture by turning "Off" the Capture function when you are through. If you turn off the timer without turning off the Capture function, the timer will not know where the end of the data is when you Dump it. However, as long as you do not turn off the timer, you can Dump the data without "closing" the Data Capture. The Dump command keeps track of the current end of data as long as the timer is left on. This allows you to Dump the data in the middle of a capture and then continue to capture more.

Paper tape output

The last Time Mode Option is Paper Tape. It allows MicroSet 3 to print traditional paper tape charts like a Vibrograph or Tickoprint produces on an inexpensive label printer. The paper tape printer is an optional accessory available from Mumford Micro Systems. Call or write for price and availability.

To use the paper tape printer, plug the special data cable that comes with the printer into the MicroSet Data Out jack at the end of the timer. This is the jack normally used by the computer interface. MicroSet must be in the Time Mode and generating readings. Press the BEGIN key to access the Time Mode Options, and press BEGIN as many times as necessary to reach the Paper Tape option. The LCD screen will say:

Paper tape?

Answer "Yes" by pressing the PLUS button. MicroSet will then display the last reading that was taken in the Time Mode. MicroSet must know the correct rate for the timepiece in order to calculate the paper tape data. It proposes the last value measured as the correct (or "target") rate. The value shown is not likely to be exactly correct, but it is likely to be very close. If it's not close, you may wish to exit the paper tape mode by pressing the MODE button and getting a more accurate reading in the Time Mode before you enter the Paper Tape Mode.

When you have a proposed rate that is close to correct, adjust the value with the PLUS and MINUS keys. To make the value larger, press (or hold) the PLUS key. To make it smaller, press (or hold) the MINUS key. When you press PLUS or MINUS the proposed rate will change by a small amount. If you hold the key down, the value will change rapidly. If you hold the key down even longer, the value will change even more quickly.

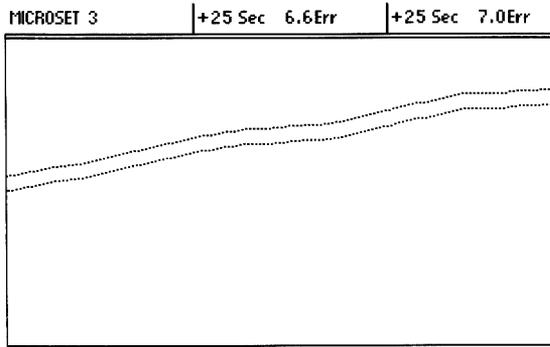
When the value shown gets to the correct rate, let go of the PLUS and MINUS keys. Depending on the rate of the watch you are using, the LCD screen might say:

Target: 18000.00

To enter this value and begin printing tape, press the BEGIN key. The LCD screen on MicroSet will then say:

Paper tape: 1x

and the printer should begin to print. To stop printing, press the MODE button. A short sample of the paper tape is shown below.



As the tape runs, a black dot will be printed on the tape for each beat of the watch. The position of the dot depends on the rate and beat error of the watch. If the watch is fast, the lines will wander off the top of the tape. If the watch is slow, the lines will wander off the bottom. If the watch is running at exactly the correct rate, the lines will be horizontal. After 100 beats, MicroSet will print the current rate of the watch at the top of the tape. In this example, it printed "+25 Sec", which means the watch is 25 seconds per day fast.

In the strip above, there are two lines. This is because the watch is not in perfect beat. In other words, the "tick" takes longer than the "tock". The difference between these two times is the "beat error". Larger beat errors appear as more separation between the two lines. Every 100 beats MicroSet prints the last beat error at the top of the tape, after the current rate. In this example, the beat error was 6.6 milliseconds.

If you do not see two clean rows of dots like the sample shown, your watch may be very dirty or the level may not be set correctly. Start with the level control of MicroSet set to maximum. Adjust it downward if you don't get clean results. It will also help to use a good watch sensor. The clip on acoustic sensor that comes with MicroSet may not work as well as one of the special watch sensors (call Mumford Micro for details).

While the tape is running you can rotate the watch to different positions to evaluate the effect. It is beyond the scope of these instructions to teach you how to read the many possible variations in the printed pattern, and what they all mean. Much has been written on this subject, and many people have learned how to read the output of Vibrograph, Tickprint, and WatchMaster timers. A listing of several common faults and the tapes they produce can be seen at the end of these instructions.

There are several controls you have over the paper tape display that exceed the abilities of the original paper tape timers. MicroSet will allow you to magnify the beat error to see finer detail. To do this, press the PLUS button while MicroSet is printing a tape. The LCD screen will say:

Paper tape: 2x

and the printed tape will be magnified two times. The beat error will appear twice as large in the pattern of dots, but the value printed at the tape edge will be correct. You can press the PLUS button again for a scale of "4x", and a third time for a scale of "8x". To return to lesser magnifications, press the MINUS key. The LCD screen will always tell you what magnification is in use.

If the rows of dots are running at the edge of the tape and you would like to center them, press the BEGIN button. This will start a new reading and re-center the dots to the middle of the tape. You can also use this button if you've moved the watch or otherwise disturbed the current reading and wish to start a clean measurement of the next 100 beats.

It's difficult to see the details of the individual beats when the overall rate is fast or slow, because the dots run off the edge of the tape. This was unavoidable with traditional paper tape timers. But because MicroSet allows you to specify any arbitrary rate as the correct rate, you can get the lines to run horizontally simply by telling MicroSet that the current rate is the correct rate. In other words, when you first enter the Paper Tape Mode, simply accept the proposed rate reading you are given without adjusting it to be the known true rate. In this case, the lines will be horizontal, the beat errors will be easy to see, and any fluctuation in rate will be easily seen as a divergence from horizontal.

The Beat Error Mode

For a clock or watch to run properly, the length of the even beats should be the same as the length of the odd beats. This is called being “in beat”. MicroSet has a special mode to help set this. Press the RESET button to initialize MicroSet. Press the MODE button twice to pass through the Time Mode and go to the Beat Error Mode. Connect an acoustic sensor to the movement as described in the previous section.

Note: You can't use the optical sensor to put a clock in beat; MicroSet must hear the pallets on the escape wheel. On the other hand, you can use the Beat Error Mode with the optical sensor to be sure the optical sensor is placed at the exact center of swing.

When the sensor is placed correctly, the level is set properly, and “**Beat Error...**” is displayed on the LCD screen, hit the BEGIN button. MicroSet will now measure the relative duration of two ticks and display the difference between them as the percentage of difference. If the clock is badly out of beat the percentage of difference will be large. If the clock is nearly in beat the percentage will be small. For example, MicroSet might say:

Error: +10 %

This means that the first beat is 10% longer than the second beat. You can probably hear a difference of 20%, but below this MicroSet will be more accurate than your ear. If the difference is 0% the clock is in perfect beat.

When measuring watches, the beat error will be displayed as the number of milliseconds of error, which is usually how this value is used by watchmakers.

There is a polarity sign in front of the numbers in the Beat Error Mode when measuring clocks. This indicates which beat is longer. The polarity will change on every beat because MicroSet is reading every beat. It's normal for the beat error readings to toggle between plus and minus. Adjust the beat so the number is as small as possible, regardless of the polarity sign.

On clocks, there are always eccentricities in the escape wheel. You will never get the Beat Error Mode to read the same number every time (this is not true of watches). In fact, the numbers are likely to vary in a regular pattern of getting larger and then smaller. Ideally, you will try to adjust a clock so the changing numbers are centered around zero. In other words, try to get the numbers to go positive and then negative by equal amounts with each rotation of the escape wheel. If you do this, you're at the center of beat and you have placed the clock as “in beat” as that clock is able to run.

To terminate the Beat Error Mode you can hold down the MODE button or press the RESET button.

The Count Mode

The Count Mode is an original and unique feature of MicroSet. It will determine the correct number of Beats Per Hour of any running clock to within a couple of seconds per day. The Count Mode simply counts the number of beats that MicroSet hears with the acoustic sensor or sees with the optical sensor.

To use the Count Mode, press the MODE button until the LCD screen says:

Count...

Then hit the BEGIN button. The display will change to:

Count: 0

which means that no beats have been counted yet. MicroSet will now increase the count on each "trigger event". A trigger event occurs when something blocks the optical sensor or when the acoustic sensor hears a sound. You can use either the acoustic sensor or the optical sensor with the Count Mode, and either one will cause the counter to increase by one. But the optical sensor will produce much more reliable results because it can't be triggered by noise. The acoustic sensor can easily get false beats.

Once the Count Mode is running there are several keys that affect the count:

- To zero the count and start over, hit the BEGIN button.
- To temporarily freeze the count display without interrupting the count, hit the MINUS button.
- To restart the count display from a frozen condition, hit the PLUS button.
- To exit the count mode, hit the MODE button.

Using the Count Mode

The primary application for this function is to provide a way to determine the correct beat time of an unknown clock. MicroSet already supports one method of doing this for clocks - by using the optical detector to measure how long it takes the minute hand to go around once. The Count Mode provides a more accurate method with less effort. Here is how it works:

A clock or watch is a gear train. It doesn't matter if the timepiece is running fast or slow, there is a specific gear train between the pendulum and the hands. It always takes the same number of pendulum swings to move the minute hand around once. It may take more or less than an hour, but it will always take the same number of pendulum swings. This is, by definition, the Beats Per Hour of the movement. We use the Count Mode to count the number of beats in one rotation of the minute hand.

Start by positioning the optical detector at the center of swing of the pendulum. You should not use the acoustic sensor because it is likely to get a false trigger before an hour is up. Put MicroSet into the Count Mode and the LCD screen will say:

Count: 0

Here is the most simple method for counting clock beats:

- With the clock running, carefully watch the minute hand approach a mark on the dial between 6 and 12 (but not at 9 if the clock strikes at 9). At these positions the hand is being raised up, and gravity will help remove any "slop" in its motion. If the clock has a seconds hand, watch it approach the 12.
- Press the BEGIN button on MicroSet as soon as the minute hand (or second hand) reaches a known position. This will start MicroSet counting. You can now go about your business for about an hour.

- Come back an hour later and closely watch as the minute (and second) hand reach the exact same position. At this point, hit the MINUS button to freeze the count. MicroSet will now show you the number of beats in one hour. You must be precise in starting and stopping the counter. If you're off by a single beat, the answer will be inaccurate.

The Count Mode can also be used on watches. Often you can guess what the correct rate for a watch is by measuring it. It's likely to be close to a standard value. If you want to be sure, you can use the Count Mode. Though you must use the acoustic sensor, watches typically run quiet enough that you aren't likely to get a false trigger. The Count Mode uses the current setting for the Blanking Window as set in the Time Mode, and this will also help eliminate false triggering. Place your watch and MicroSet where they won't be disturbed for a while. You might want to place the watch on a foam pad to be sure it's isolated from noise. Many watches have seconds hands. This is a big help. Watch closely as the minute and second hands reach a known spot on the dial, then push the BEGIN button to start the count.

If you have a second hand to use, you may not even need to wait an hour for an answer. When a half hour has passed, freeze the count when the second hand gets to the starting point. Multiply the count by two. If your count is very close to one of the standard values, you can be pretty confident that the standard value is correct. If you're still not sure, let the count continue for the rest of the hour.

It will be difficult to get a really accurate answer by watching the minute hand with clocks because it will be hard to see the exact position of the minute hand and many clocks don't have seconds hands. One improvement on this method is to let the clock run for several hours, then divide the total count by the number of hours that have elapsed. Every extra hour increases the accuracy of your reading. You might let it run overnight. This will give you a very accurate answer. If you wish, you can freeze the count at each hour and divide the count by the number of hours. When your result does not change from the previous value, you have an accurate answer. (If you freeze the count, be sure to start it up again with the PLUS button. Don't hit BEGIN or you'll zero the count.)

You can get more accurate results if you start and stop the counter with the strike instead of the minute hand. To do this, wait until the clock is about to strike the hour. Then, as soon as the first sound of the "warning" is heard, start the counter by pressing the BEGIN button. Wait until the next hour, then freeze the count as soon the next warning is heard. As in the previous method, if you let the clock run for several hours, you'll increase your accuracy. The following list shows the accuracy of readings I obtained on a Seth Thomas mantel clock using this method over several hours. As you can see, the longer it ran, the more accurate the answer became:

One hour:	70 seconds per day
Two hours:	23 seconds per day
Three hours:	11 seconds per day
Four Hours:	8 seconds per day
Five hours:	7 seconds per day

Remember -- it doesn't matter if the clock or watch is fast or slow. It only matters that the minute hand (or the strike) makes one rotation. For this reason you can shorten the time required for these measurements on clocks by removing the bob so the movement will "wig-wag" at an accelerated rate. You may need to tip the movement to get it "in beat" with the bob removed.

The Rate Finder

The Rate Finder is an optional feature that can be added to either MicroSet 2 or MicroSet 3. It is an elaboration on the Count Mode and is another original and unique feature of MicroSet. It works with two sensors to automatically count beats of the pendulum and rotations of the minute hand to produce an accurate count of the correct rate of any running pendulum clock. Each hour that goes by produces a more accurate result, and the most recently calculated Beats Per Hour of the movement is displayed on the MicroSet LCD screen. No other timer we know of has this feature.

The Rate Finder requires the addition of a second input jack in the MicroSet case. This jack is located just above the standard MicroSet sensor jack. A special magnetic sensor is provided for use with the Rate Finder, and is plugged into this extra jack.



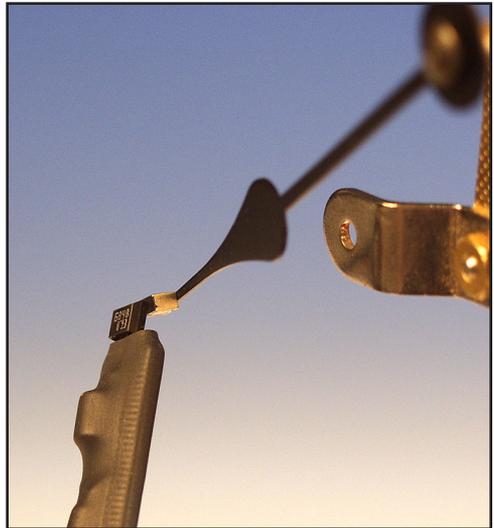
To access the Rate Finder, press the MODE button on MicroSet until the LCD screen says:

Rate Finder...

The optical sensor should be plugged into the standard sensor input jack. The special magnetic sensor should be plugged into the optional jack. The Rate Finder won't work if you plug the sensors into the wrong jacks.

Place the optical sensor at the center of swing of the pendulum tip, just as you would if you were measuring the rate of the clock. You'll need to use a "third hand" fixture to hold it in place. Adjust it so that the LED on MicroSet blinks each time the pendulum passes between the two posts.

The new magnetic sensor is used to count rotations of the minute hand. It works with a small permanent magnet which is included with the sensor. (Actually, the sensor should work with any strong magnet. The one we supply is very small, so it won't stall the movement by being too heavy.) When MicroSet is in the Rate Finder mode, the LED should come on any time the magnet is brought near the tip of the sensor. But the sensor will only work with one side of the magnet. One edge of the magnet has been marked with red paint. This edge of the magnet goes next to the sensor. Note also that the sensor has a flat side and a side with parts on it. The flat side should face the magnet. Hold the red side of the magnet at the tip of the sensor and confirm that the MicroSet LED comes on.



Stick the magnet to the tip of the minute hand so the red side faces away from the minute hand and towards the flat side of the sensor. Hold the magnetic sensor in a "third hand"

or other fixture so the magnet will pass by the tip of the sensor as it goes around. The magnet should come within about 1/8" of the sensor. Best results will be obtained if the sensor is placed near the 7 or 8 o'clock position. This will help take out slop in the minute hand as it goes around. Don't locate the sensor near a striking position or at the top or bottom of the dial. Also, **the sensor must be held perfectly still**. If it gets bumped or moves even a tiny bit, the results will be thrown off. Be sure the sensors, cables, and third hands are securely located and will not move accidentally.

If your minute hand is not steel, you can hold the magnet in place by placing a second magnet behind the minute hand so the two magnets pinch the minute hand. We have provided two of the tiny magnets. You could also hold the magnet in place with a tiny bit of double-sided tape.

When the magnet passes by the tip of the magnetic sensor, it should trigger the timer and the MicroSet LED should come on. This will only work when MicroSet is in the Rate Finder mode, because only the Rate Finder Mode looks for the extra sensor. Carefully move the minute hand around and confirm that it will cause the MicroSet LED to come on.

When you have both sensors in place, the MicroSet LED should be blinking with each beat of the clock. Press the BEGIN button. The LCD screen should say:

0: 0

The left zero means we have completed zero hours of measurements. The zero on the right is the beat count. Advance the minute hand until about 10 minutes before it will trigger the sensor. Now just let the clock run. When the minute hand reaches the magnetic sensor, the MicroSet LED should come on and stay on. MicroSet should begin counting the beat, and you should see the beat count on the LCD screen. The count will continue until the minute hand makes a full rotation and comes back to the sensor.

When the minute hand sensor is tripped a second time, the current count is the number of beats required to move the minute hand around once. By definition, this is the Beats Per Hour of that movement. The MicroSet LCD screen will then show something similar to this:

1: 9721.00 BPH

The "1" means the minute hand has gone around once. "9721.00" is the BPH of the clock being measured. This display will stay on the LCD screen while the Rate Finder keeps counting beats. This result will not be perfect. It's likely that the first count will be off by a few beats. But you can let the clock run longer, and the longer it runs, the more accurate your answer will be. When the minute hand has made another rotation, the new results will be shown.

When the minute hand has gone around a third time, the LCD screen will show something similar to this:

2: 9721.50 BPH

The "2" means two rotations are being measured and "9721.50" is the average BPH of the clock being measured. From now on, every time the minute hand goes around, the total count acquired will be divided by the number of rotations that have occurred and the newly calculated BPH will be displayed. You can let this run as long as you like. The longer it runs, the more accurate the answer will be.

(The Rate Finder shows you the results of the first two rotations before it starts to calculate an average. It has been our experience that the first count is often farther off than the later ones.)

To start a new count, press the BEGIN button. This will reset the beat count and hour count to zero and start over.

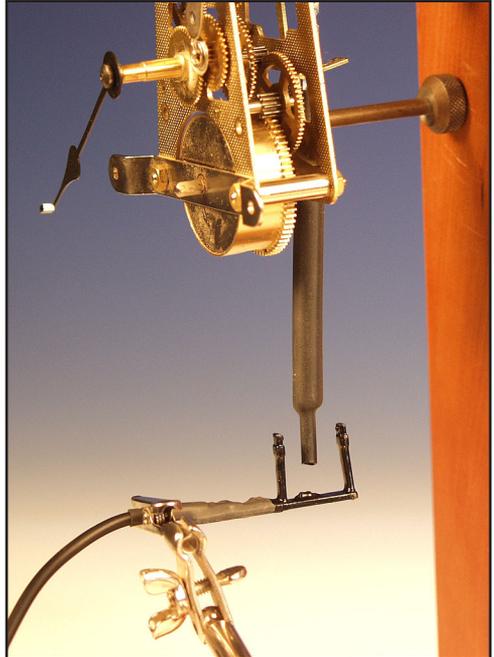
To exit the Rate Finder Mode, press the MODE button.

Speeding up the count

The setup just described takes about an hour to get each reading, because it takes about an hour for the minute hand to go around once. (It takes more or less than an hour depending on whether the clock is fast or slow.) But we can speed this up. Remember -- it doesn't matter if the clock is fast or slow. We're not measuring the rate of the clock, we're counting the beats. If you remove a heavy bob or fabricate a temporary, short pendulum, the clock will run much faster than it normally does. But it will still take the same number of beats to move the minute hand around each time.

This picture shows the optical sensor mounted under the movement, but the pendulum has been replaced with a short length of black heat shrink tubing. You can use anything that's convenient and light. With a very light or short pendulum, the clock will run much faster and the minute hand will move around faster. The setup shown here let me count the beats for one full rotation of the minute hand in 30 minutes.

You can also see the magnet on the tip of the minute hand, but the magnetic sensor has been removed to make the picture less confusing.

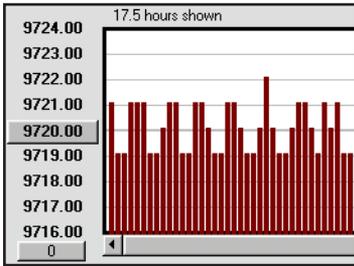


The optical sensor measuring a temporary, fast pendulum

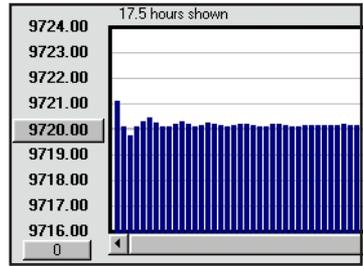
Using the Rate Finder with the computer interface

The Rate Finder is even better if you have the MicroSet computer interface software. Without the software, the MicroSet LCD screen shows you the accumulated average beat count after each hour. But the Rate Finder sends the individual hourly counts to the computer. The computer can then easily compute the average. It also allows you to see patterns in the hourly counts.

The following images shows the beat counts from a new Hermle movement. Notice that some counts are high and others are low. They follow a pattern that repeats every five hours. It turns out this movement has a ten leaf pinion on the center shaft which is driven by the first wheel. The five hour pattern is caused by eccentricity in the first wheel. Though this test ran for 17 hours and 38 rotations of the minute hand, the computer allows us to see the pattern and know the rate much more quickly. When converted to a Running Average, we can see the correct rate within two rotations of the minute hand.



Raw Rate Finder counts



Running average of
Rate Finder counts

The Strike Mode

The Strike Mode is another original and unique feature of MicroSet. The purpose of this function is to help you diagnose errors in a strike train without requiring you to sit and listen to it for hours on end. Naturally, some strike errors can be found easily enough by moving the minute hand around manually and listening. Other times, the faults are intermittent and harder to detect. The Strike Mode will listen to the clock for you, recording a history of its strike counts for many hours. The Strike Mode does not distinguish between different hammers, and it does not record the actual sound of the strike. It records the number of times the movement struck at each quarter hour.

The following comments were made by John Losch, instructor at the NAWCC School of Horology:

“There are several things to be derived from such recorded information. As is the case with “count wheel” or locking plate movements, one worn segment (French clocks particularly) or a bent tooth (American) can be elusive especially to the casual repairman. A record should show exactly where correction is needed. With rack striking, a worn rack tooth can play havoc, especially when its problem is slight, and the evidence of it is intermittent. Irregular striking without a defined pattern would confirm that the error is in the setting of levers or “timing” of train wheels improperly synchronized.”

Setup of the Strike Mode

There are actually two modes in the Strike Mode. First, you must use the **Strike Capture Mode** to record a strike history. Then, you will use a **Strike Review Mode** to read your results.

You may use either the acoustic sensor or the optical sensor with the Strike Mode. However, as always, the acoustic sensor will be vulnerable to false triggers and may not always produce a perfect result. If you use the acoustic sensor, position it so the strike hammer you’re interested in will trigger the sensor but other sounds will not. This can be difficult to achieve. You will probably want to turn the level control down pretty far. You may find it helpful to clip the acoustic sensor to a popsicle stick and position the popsicle stick so the hammer(s) will hit it. For example, with a Westminster chime, slip the popsicle stick between the hammers and the chime rods. You’ll probably want to muffle the chime rods so they don’t resonate and make noise. With such a setup it is possible to record every strike in a Westminster chime (4 strikes at 15 minutes after the hour, 8 strikes at 30 after, 12 strikes at 45 after, and 16 plus the hour count on the hour).

On simple count strike trains you will probably prefer to use the optical sensor because it will not be fooled by extraneous noise. Arrange the sensor so the strike lever breaks the optical beam just once per strike. This is easily accomplished by sticking a bit of opaque tape (electrical tape) to the strike lever. Hold the sensor with a “third hand” so that the tape will reach into the gap of the sensor and break the beam when the hammer is raised.

To put MicroSet into the Strike Capture mode, press the MODE button until the LCD screen shows “**Strike...**”. At this point the LED on the timer will light up whenever the sensor is triggered. This allows you to confirm that your sensor is adequately positioned to detect the strike reliably. Move the minute hand around to trigger the strike and confirm that the LED comes on once per strike.

Strike Capture Mode

When the setup is reliable, press the BEGIN button on the timer. The LCD screen will show:

Strike: 0=0

MicroSet is now in the Strike Capture Mode. The number on the left indicates which strike number was last recorded, and the number on the right indicates what the strike count was. Since you've just started, both values are zero.

As soon as a strike occurs, the LED on the timer will blink and MicroSet will begin to count strikes. The display will not change until the strike has finished and several seconds of quiet time have elapsed. Then the display will show the last strike recorded. For example:

Strike: 1=3

This would mean that the last strike recorded was the first one and that 3 strikes were recorded. The memory capacity in MicroSet will let it record strikes four times each hour for 2 days. If the memory in MicroSet gets full, it will automatically switch to the **Strike Review Mode**.

Strike Review Mode

When MicroSet is in the Strike Capture Mode and you've captured a strike history, you can review it by going to the Strike Review Mode. Do this by pressing the MicroSet MODE button. The LCD display will then switch from showing you the LAST strike that was recorded to showing you the FIRST strike that was recorded. For example, you might see:

Strike: 1=3

This would mean that three strikes were recorded at the first event. You can now step through the record by pressing the PLUS and MINUS buttons. PLUS will move you forward in time, MINUS will move you back in time. With these two buttons you can review the history of strikes and look for incorrect counts.

While you're in the Strike Review Mode, if you wish to begin a new Strike Capture, press the BEGIN button and the LCD screen will show:

Strike: 0=0

This indicates that the previous strike history has been erased and MicroSet is waiting to record the first strike count in a new history.

To exit the Strike Review Mode you can press the MODE button.

If you enter the Strike Mode when there is already a strike history in memory, you will not enter the Strike Capture Mode (which would erase the previous strike history) but rather you will enter the Strike Review Mode. If you wish to record a new history rather than review the previous one, simply hit BEGIN again.

If you have a strike history in memory and press the RESET button, or turn MicroSet off, the strike history will be lost and you must start over.

Using the Strike Mode with the computer interface

Though the Strike Mode works perfectly well in the stand-alone timer, it is augmented by the personal computer interface. The computer will not only record the number of strikes at each event, it will also record the time of day the strike occurred.

If you have a personal computer connected to the timer while it's in the Strike Mode, the strike count will be transmitted to the computer each time it happens. With the

MicroSet software running on the computer, you'll get a graph of the strike counts at each "event". For example, if the clock strikes 4, you'll get a data point with the value "4" in the MicroSet graph. You can tell what time each strike occurred by clicking on a data point in the graph. The program then tells you the value of that point and at what time it was captured. In this way you can confirm not only that the count is correct, but also that strike events happened when they were supposed to.

The Accutron Mode

MicroSet 3 includes a special mode for measuring tuning fork watches (like the Accutron) that use a tuning fork motor to drive the movement. These tuning forks run at a variety of frequencies, with 360 cycles per second (or “Hertz”) being the most common. MicroSet will automatically detect the correct rate of any of the following frequencies:

300
360
440
480
720

The Accutron mode requires a special, optional, inductive sensor. This sensor will also trigger on the motor impulse of quartz watches and clocks, and you can measure them with MicroSet too.

To use the Accutron mode, press the MODE button until the LCD screen says:

Accutron...

Set a watch on the inductive sensor. The tuning fork in the watch is near the 12 o'clock position. Place the watch so the tuning fork is at the center of the sensor. Turn the MicroSet level control up and the LED should come on and stay on. This means the watch is running and MicroSet can sense the tuning fork. Press the BEGIN button and MicroSet will say:

Blocks: 5...

This allows you to choose how many cycles to measure before a rate reading is returned. If you select “5 blocks” you'll get a reading about once every two seconds, depending on the frequency of the watch you are measuring. This is usually an adequate interval to get an accurate reading. If you prefer to get fewer readings over longer periods, press the PLUS button to increase the “Block” count. When ready to start measuring, press the BEGIN button. MicroSet will say:

Rate:

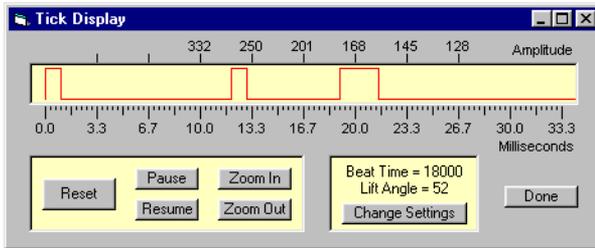
When the first reading is ready, it will also appear. MicroSet will automatically adjust to the rate of the tuning fork and read out the rate as seconds per day of error. You can also display the actual frequency of the tuning fork. To see this, press and release the MINUS button. The display will change to frequency of the fork. To return to error per day, press and release the PLUS button.

If you have the Windows Interface Program for MicroSet, you can capture Accutron watch rate over time on the computer. MicroSet must be configured to output Accutron rates as frequency. These rates will be displayed as a graph on the computer, and you can see the effect of temperature or position on the frequency of the tuning fork. Frankly, I was surprised to see that positioned affected the tuning fork rate, but it seems to.

Tick Mode

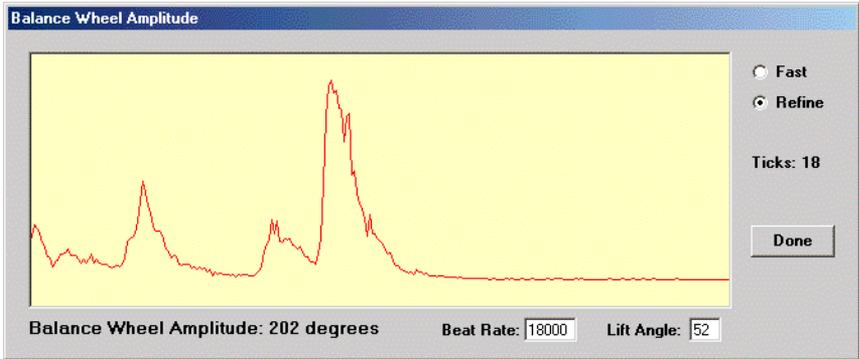
MicroSet 3 includes a unique feature for use with watches. It is a diagnostic mode that transmits very detailed information about the watch tick to the Windows Interface Program. To use the Tick Mode, you must have version 3 of the Interface Program.

A watch tick is a complex sound, composed of several shorter sounds that arise from the actions within the watch escapement. These sounds are sometimes called “the five shocks”, but there are three sounds that are the most significant. They are the unlocking, the impulse, and the drop. For the serious watch repairman it is useful to know the details of these sounds. The Tick Mode will send the raw data needed by the Windows Interface Program to produce a graphical image of the watch tick. From this graphical image you can measure the duration and placement of the component sounds. The MicroSet Interface Program also calculates the balance wheel amplitude based on the beat time and lift angle of the watch. The image below shows the Tick Mode display on a personal computer. Instructions for using the Tick Mode come with the computer interface software.



Balance Wheel Amplitude Mode

The Balance Wheel Amplitude Mode works like the Tick Mode except that it uses an additional analog to digital converter inside MicroSet to display a more accurate view of the tick sound. This more accurate view allows the Windows interface program to calculate and display the balance wheel amplitude directly. Instructions for using the Balance Wheel Amplitude Mode come with the Windows interface software.



The Computer Interface

If you purchased MicroSet with the optional Computer Interface Software, it can automatically transmit its measurements to your personal computer. This is a very powerful feature with great benefit to the repairman as well as the experimenter. Versions are available for Macintosh and Windows. To take full advantage of the features in MicroSet 3 (especially the Tick Mode, Balance Wheel Amplitude Mode, and Data Capture), the latest version of the Windows Interface Program will be needed.

You will find that, in almost all timepieces, the rate will change from one reading to the next. This happens for many reasons. The beat measurements follow cycles that are related to the rotation of the wheelwork. If you take a 50 beat average now it may be slower than a 50 beat average taken 10 minutes from now. Both readings are correct -- the rate is changing. After you've stopped a pendulum to make an adjustment, it may take a few minutes or as long as an hour to achieve a stable rate again. With a personal computer connected to MicroSet you can see how the rate changes over time and get a feeling for the range and stability of the timepiece you're working with. The computer software will also display the rate of any clock or watch in terms of error per day with either MicroSet 2 or MicroSet 3. You can capture rate data for as long as you like and plot the changes to reveal the effects of spring tension, wheel errors, temperature, barometric pressure, and many other factors that were not possible to see before. The software presents live charts and running averages of rate changes, all of which can be saved on disk or printed on paper for later reference or to give to customers.

Paper tape watch timer simulation

With MicroSet 3 and the Windows Interface Program version 3 you can display a simulation of the paper tape displays of early watch timing machines like Vibrograph and Tickoprint. If you've used one of these machines, you have learned that they can reveal subtle details about how a watch is performing. The trouble with these machines is that they're old, less accurate, expensive, and noisy! MicroSet 3 and the Windows Interface Program can produce the same kinds of displays, but with added features made possible by the computer. Rate information is displayed directly rather than interpreted from the slope of the readings, and the beat error can be read directly from a calibrated scale. The sloping lines can be "normalized" to run flat so irregularities can be more easily observed, and you can "zoom in" or out to see finer detail or longer periods. The graphs can be saved on disk or printed on paper. And the software can be set to work for any beat time, so you need not interpret the displays differently for unusual beat watches.

The computer interface is available from Mumford Micro Systems. Please call for details and availability.

Configuration

There are a several settings that are available to configure the behavior of your MicroSet timer. These settings are remembered from one day to the next, even when MicroSet is turned off. To enter the Configuration mode, do the following:

- Be sure MicroSet is turned off
- Hold down the MODE button
- Turn on the timer and wait until the words “BEEP ON” or “BEEP OFF” appear on the LCD screen.

You can cycle through the Configuration settings by pressing the MODE key.

Beep On/Off

You can configure MicroSet to beep every time a Time Mode measurement that takes longer than about 10 seconds is complete. When you first enter the Configuration mode, the display will show either “**Beep On**” or “**Beep Off**”. To turn the beep on, press the PLUS button. To turn the beep off press the MINUS button.

If you're through with configuration after turning the BEEP on or off, hit the RESET button. To continue with the next configuration setting, press the MODE button.

Time mode beats

This setting lets you store the default value of beats to be measured in the Time Mode. When you use the Time Mode, you specify the number of beats to measure before the average rate of each beat is given. This configuration setting lets you select a starting value that suits your work style. You might prefer to start with a low number, like two or four, so you can get a result quickly though it may not be highly accurate. Or you may prefer to start with a beat count of 20 or 30 to get accurate results. A value of 10 is a compromise, allowing you to go up or down for speed or accuracy.

When MicroSet is at this Configuration setting the LCD screen will say something like:

Time beats: 10

To increase the number, press the PLUS key. To decrease the number, press the MINUS key. When the number you'd like to use is showing you can hit the RESET button to exit the Configuration Mode. Or, to continue with the next configuration setting, press the MODE button.

Blanking Window size

This setting lets you store the minimum duration for the Blanking Window. The Blanking Window is the feature in the MicroSet Time Mode that allows it to ignore sounds that occur between proper ticks. Because MicroSet can measure watches as fast as 36,000 BPH and clocks as slow as 30 seconds per beat, there may be no one setting for the Blanking Window that will serve all timepieces perfectly.

When MicroSet is at this Configuration setting the LCD screen will say something like:

Blanking: 6

To increase the number, press the PLUS key. To decrease the number, press the MINUS key. If you will be measuring watches as fast as 36,000 Beats Per Hour, you should set the Blanking value to “4” or “5”. If you will be measuring nothing with a beat time faster than 18,000 Beats Per Hour, you can set the Blanking value as high as “10”.

You can evaluate the effect of your Blanking Window setting by the action of the beat LED when you are measuring timepieces. The LED will stay lit for the duration of the

Blanking time, then go off when MicroSet begins to listen for ticks again. If the LED does not go off between ticks the Blanking value is set too high. If the LED goes off long before the next tick, you can afford to increase the Blanking value.

When the number you'd like to use is showing you can hit the RESET button to exit the Configuration Mode. Or, to continue with the next configuration setting, press the MODE button.

Time Mode display format

You can configure MicroSet to display the results of its Time Mode measurements in Seconds Per Beat or in Beats Per Hour. When you enter this configuration setting the display will show either

Units: Secs

or

Units: BPH

To have MicroSet display Time Mode measurements in Seconds Per Beat, press the PLUS key and the display will show "**Units: Secs**". To have MicroSet display time measurements in Beats Per Hour press the MINUS key and the display will show "**Units: BPH**". For an explanation of why you would choose one mode or the other, see the Technical Reference section of these instructions.

MicroSet 3 can also display rate as seconds of error per day or as the amount of adjustment needed for the pendulum bob. These settings are made with the Time Mode Options.

If you're through with configuration after this setting, hit the RESET button. To continue with the next configuration setting, press the MODE button.

Pendulum length units

If you purchased MicroSet 3 you can select which units will be used -- inches or centimeters -- for the Pendulum Adjustment Mode. When you enter this configuration setting the display will show either

Length: IN

or

Length: CM

To have MicroSet use inches for length readings, press PLUS. To have MicroSet use centimeters, press MINUS.

If you're through with configuration after this setting, hit the RESET button. To set the oscillator calibration, press the MODE key.

Oscillator calibration

The final setting in the Configuration Mode allows you to enter a "trim" value that is used to correct for inherent errors in the quartz crystal time base. This unique feature allows us to recalibrate your MicroSet timer with software if the accuracy of the quartz crystal changes over time. Don't change this setting unless you know what you're doing and have a good reason to change it. You may want to record the factory setting for this value inside the back cover of this instruction manual. If anything goes wrong and the trim value gets changed, you can re-enter the original value. You (or I) can make adjustments to this setting as the unit ages, and it allows us to recalibrate MicroSet without making any changes to the hardware.

When you enter the Trim Mode, the display will show something like the following:

Trim: +1

The range of values is +99 to -99. To increase the trim value, press or hold the PLUS button. To decrease the trim value, press or hold the MINUS button. When the value you want is displayed, you must press the BEGIN button if you want MicroSet to memorize it. When you do, the LCD screen will show "OK!" and the trim value will be stored in permanent memory for future use. This extra key press helps to insure that the trim value will not be changed accidentally.

The units of Trim are "parts per million". If the Trim value is "+1", it means the crystal oscillator is accurate to one part per million, and the remaining one part per million error is corrected with the software Trim value. The final error of the timer is always zero parts per million when it's at the same temperature it was when it was calibrated.

When I made the very first MicroSet timers, this setting had values as large as 20 or 30 parts per million, which is typical for quartz crystals. Since then I have learned methods of making the crystal oscillators much more accurate, and the software Trim setting has become less important. The Trim setting is now never greater than five, and is typically one or zero.

Experience has shown that MicroSet does not lose much accuracy over time. I have gotten several units back for upgrades after more than a year, and the trim value has always been within two or three parts per million of correct. A change of 1.65 parts per million is a change of one second per week. Your timer is not likely to be off by more than this in a year's time.

To exit the calibration mode press the MODE key.

Technical Functions

There are several “technical functions” built into MicroSet that are not necessarily related to timing clocks or watches. These functions are put in as utilities to help the experimenter, or to extend the usefulness of the timer. Not all timers will have all functions. To access the technical functions, hold down the BEGIN button when you turn on the timer. To move from one technical function to the next, press the MODE key.

Temperature

If you purchased the simple temperature sensor for MicroSet, the first technical function will display the temperature once per second. This reading is also sent to the computer interface if you have it, so you can record the temperature when you aren't measuring a clock.

Barometer

If you purchased the optional Atmospheric Sensor for MicroSet, this technical function will display the barometric pressure followed by the temperature every other second. These readings are also sent to the computer interface if you have it, so you can record the barometer and temperature when you aren't measuring a clock.

Width

This function will display the amount of time a sensor is triggered. For example, if you're using an optical sensor at the center of swing, it will measure how long the sensor is blocked each time the pendulum passes. This value will get smaller when the pendulum has a wider amplitude. This reading is sent to the computer interface if you have it.

Dark / Light

This function will display the amount of time a sensor is triggered, followed by the amount of time the sensor is NOT triggered. This reading is sent to the computer interface if you have it.

Tachometer

This function will display the RPM of a spinning tool like a lathe or mill. To use it, you need to arrange an optical or magnetic sensor to trigger once on each rotation of the tool. The best way is probably to get a spare magnetic sensor from Mumford Micro and use epoxy to hold the magnet to some part of the tool where you can mount the sensor. This is an easy way to add a tachometer to your watchmaker's lathe or other tooling used in watch and clockmaking.

Technical Reference

This section contains technical details about the operation of MicroSet, and explains the limits and benefits of different settings. I'll also include comments about things I have discovered in the development of the MicroSet timer for those who may be interested in the subtleties of experimental horology.

Seconds Per Beat or Beats Per Hour

Why would you select one mode or the other? Mostly it depends on personal preference. Many people are used to Beats Per Hour. Others prefer Seconds Per Beat. In MicroSet, Seconds Per Beat is somewhat more accurate because it shows seven digits of precision (1.000000) and Beats Per Hour show just 6 digits (3600.00). Seconds Per Beat become more accurate as beat time increases, so there is an advantage in accuracy when measuring very slow clocks like Atmos and 400 day clocks (see below).

Input Sensors

Two different input sensors come standard with each MicroSet. One is an acoustic sensor. It works by hearing the "tick" sound produced by the escapement. The other is an optical detector. It works by seeing a pendulum swing back and forth. Which should you use? The acoustic sensor will probably be used when you want a quick answer. The optical sensor will be used when you want maximum accuracy or immunity to noise. Watches, of course, must use an acoustic sensor.

The acoustic sensor

The acoustic sensor is easy to set up, but it's vulnerable to noises within a clock (like chimes) and extraneous noises in the room. Even movement in the wire that connects the acoustic pickup to the timer can produce errors because the pickup must be very sensitive to hear the soft ticking of clocks and watches. You may wish to rest watches on a foam pad while you are measuring them.

The optical detector

The optical detector is much more precise than the acoustic sensor and is immune to noise. It allows you to measure right through the hourly strike of a chime clock without interruption, which is not at all possible with an acoustic pickup.

The optical detector consists of an LED emitter and a phototransistor detector mounted face to face on a small circuit board. (The LED is infrared and you won't be able to see that it's on.) If you look closely at the emitter and detector, you will see a small bump near the top of each one. This is the window where the viewing takes place, and it is this point where the invisible beam must be broken by the pendulum.

You must arrange this detector so some part of the pendulum will pass between the emitter and detector. The most likely location is the bottom of the clock, underneath the pendulum, at the center of swing. The threaded rod on which the rating nut turns may be small enough to fit between the emitter and detector. You may need to stack something under the sensor to raise it up enough to "see" the pendulum rod. You may need to rest something on the cord of the detector to keep it from sliding around. The best way to hold the optical detector is with a "third hand" which you can buy from Radio Shack.

If the post on which the rating nut turns is not suitable to trigger the sensor, you may apply a tiny strip of opaque tape to the pendulum. This is especially effective on Atmos and anniversary clocks. A tiny sliver of electrical tape, about as narrow as you can possibly cut it, is all that's needed (if the tape doesn't seem to work, try making it black with a

marking pen). You may need to be creative about how to arrange this tape to break the beam of the optical detector at the center of swing.

If you're concerned about the effect on timekeeping of adding this tiny bit of tape to the pendulum, you can measure the effect. Add two pieces and measure the rate, then remove one of them and measure the rate again. The difference will indicate any error introduced by the added material. It is not likely to be measurable.

Measuring Atmos and anniversary clocks

The optical sensor is an excellent way to measure the delicate movements of Atmos and anniversary (400 day) clocks. These clocks have very slow beat times and very soft "ticks". If you really prefer to use the acoustic sensor on 400 day clocks, be sure the spring is fully wound. This will produce a louder tick.

To measure an Atmos clock, apply a tiny sliver of electrical tape to the top of the ring of the pendulum. The tape will stick out horizontally. Be sure it isn't too long, or it will collide with the leg of the movement as it rotates. Use the Radio Shack "third hand" to hold the optical sensor vertically, so the strip of tape will trigger the detector.

Be sure the Atmos clock is placed on a solid surface so the pendulum will not be perturbed if you move around near it. The correct beat time for an Atmos is 30 seconds. MicroSet can display this as 30.000000 Seconds Per Beat or 120.00 Beats Per Hour. You'll get more accurate results with Seconds Per Beat. When using Beats Per Hour the resolution is one part in 12,000. This is an error of 50 seconds per week. When using Seconds Per Beat the resolution is one part in 30,000,000. This is an accuracy of greater than one second per week.

The optional magnetic sensor, used with the Rate Finder Mode, also works well on Atmos clocks. You can set the tiny magnet on the Atmos pendulum to trigger the sensor. The magnet we provide is so tiny that it will have no measurable effect on the rate. You can also measure Atmos clocks with the optional laser sensor. This allows you to measure the clock without even taking the cover off.

To measure an anniversary clock, apply a tiny sliver of electrical tape to the top of one of the pendulum balls, or to the rate adjusting ring. The tape should stick out horizontally. Use the Radio Shack "third hand" to hold the optical sensor vertically, so the strip of tape will trigger the detector. Be sure the clock is placed on a solid surface so the pendulum will not be perturbed if you move around near it. MicroSet can display the rate in Seconds Per Beat or Beats Per Hour, depending on how you have it configured. Most anniversary clocks have a rate of 480.00 Beats Per Hour, which is 7.5 Seconds Per Beat. If you use Beats Per Hour, the accuracy will be limited to about 13 seconds per week.

Limits in the oscillator calibration

MicroSet uses a clever trick to achieve greater accuracy than common components usually allow. Common crystal oscillators are only accurate to within about 50 "parts per million". Expensive crystal oscillators are available with much greater precision, but these oscillators are expensive. You can buy an improved oscillator for MicroSet as an option, contact us for details.

Though any common crystal may not be accurate to better than 50 parts per million, any one is very stable at the frequency it ends up having. When MicroSets are assembled, the oscillator components are hand selected to arrive at a frequency that's very close to the correct rate. Then, the oscillator is adjusted further by comparing it to a precision

reference. This gets components within a few parts per million of a perfect rate. The trim value you can enter in the MicroSet Configuration Mode adjusts the timing calculations to correct any remaining error of the crystal. This value gets factored into timing measurements more accurately if the measurements are several seconds long. If you measure a single beat, or two beats, the correction is incomplete and the rate information will not be as precise. But if you average beats for 10 or more seconds, the software correction is quite accurate. (This issue was more important when the trim value was typically 20 or 30. Now that the trim value is typically less than five, it matters much less.)

The general rule is, if you want the most accurate rate values, be sure to average at least 20 beats. Measuring more beats will also average out inherent errors in the escapement and other short term variabilities in a clock. You will find that averages of 50 or 100 beats are more stable than shorter ones. But it is best to measure twice the number of teeth on the escape wheel. If the escape wheel has 30 teeth, set MicroSet to "Time: 60".

Thermal stability

Quartz oscillators like the one in MicroSet are also susceptible to temperature changes. If you measure a watch when MicroSet is at 100 degrees the rate will appear different than if you measure it at 50 degrees. A temperature change like this is likely to have a bigger effect on the watch itself, but we would still like to have some idea about how MicroSet changes with temperature. We constructed a low temperature oven in which we placed a MicroSet unit which was connected to a reference "beat" generator. We were then able to vary the temperature of MicroSet over a wide range and measure it's response to temperature. We found that, on average (and quite linearly) MicroSet would read an increase of 0.65 parts per million per degree Fahrenheit. In other words, if the temperature of the timer were to change 5 degrees, you could expect the value of your readings to change by about 3 parts per million. This is the equivalent of 2 seconds per week in a clock.

However, it takes a couple of hours for temperature changes to penetrate to the crystal. We connected MicroSet to the same precision signal generator and measured its output on a 24 hour daily cycle when the room gets warm in the afternoon and cool at night. The rate changed by just 2 or 3 parts per million for a room temperature change of over 20 degrees. If you wish better stability than this from MicroSet, keep the temperature constant or buy the optional TCXO timebase.

If you need absolute accuracy for precision pendulum measurements, we offer a GPS Reference Receiver which includes a GPS satellite receiver and control electronics to facilitate measurement of the most precision clocks.

Conclusion

Thanks for your interest in the MicroSet timer. If you have any questions or suggestions be sure to let me know. I'm constantly thinking of new features for MicroSet and am grateful for input from those of you who use it.

Differences Between MicroSet 2 and MicroSet 3

There are several improvements offered in MicroSet 3. These are listed below. MicroSet 2 can be upgraded to MicroSet 3 for a nominal charge.

Feature	MicroSet 2	MicroSet 3
Display running average of rate	No	Yes
Display rate as seconds of error per day	No	Yes
Display rate as adjustment to bob	No	Yes
Will output amplitude reading with rate (requires Windows interface software)	No	Yes
Tick Mode (to analyze watches)	No	Yes
Accutron Watch Mode	No	Yes
Will print to paper tape (for watches)	No	Yes
Simulates a paper tape watch timer with the Windows Interface Software	No	Yes
Will measure rate and pendulum amplitude at the same time (requires Windows Interface software)	No	Yes

Accessories

There are many accessories available to extend the capabilities of the MicroSet timer. Some of these are listed below. Contact us for further details.

- A padded carrying case
- Extra sensors with different configurations
- Sensitive watch sensors
- Accutron watch sensor
- Laser sensor to measure through closed clock cases and Atmos clocks
- Temperature and barometric sensors
- GPS Reference Receiver for ultra-precise measurements
- Software interface for personal computers

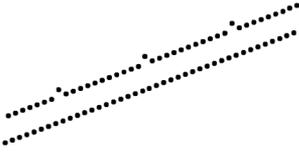
Hardware Options

There are several optional features that can be added to the MicroSet hardware. These are listed below. Contact us for further details.

- Built-in beat amplifier
- Rate Finder
- Temperature and Atmospheric sensor
- Data Capture Memory
- Balance Wheel Amplitude
- TCXO timebase

**The most current information about MicroSet features
and accessories is available on the Internet.
Go to www.WatchTimer.com**

Typical errors as revealed by paper tape printer



A damaged tooth on the escape wheel



Irregular transmission or dirty escapement



Balance is isochronous but not in poise when watch is turned



Balance is not isochronous when watch is turned



Faulty escapement or damaged pallet stone



Balance is knocking



Escape wheel is out of round



Excessive sideshake on pallet-staff or balance pivots, or defective train



Variation in balance amplitude



Variation in running of balance, poor transmission, or loss of amplitude

Summary of Operations

Time Mode - measure the rate of clocks and watches

Press PLUS or MINUS to set the number of beats to measure.

Press BEGIN to start measuring.

Blanking Window - to make the timer immune to other sounds

To turn it ON, hold PLUS until the LED stays on.

To turn it OFF, hold MINUS until the LED stays off.

You can adjust the default setting of OFF with the Configuration Mode.

Time Mode Options

Press BEGIN to access the options available in your timer.

Speaker On/Off: Press PLUS to turn it on, MINUS to turn it off

Average On/Off: Press PLUS to turn it on, MINUS to turn it off

Show error/day: Press PLUS to enter the correct rate of the timepiece. After the current rate is shown, press PLUS or MINUS to adjust it. Or press MINUS to disengage Error Per Day calculation.

Show pendulum adjustment: Press PLUS to enter the correct rate of the timepiece. After the current rate is shown, press PLUS or MINUS to adjust it. Or press MINUS to disengage Pendulum Adjustment calculation.

Data Capture: Press PLUS to begin data capture. The number shown will be the number of readings taken before one is saved. Set the number to zero to stop capture.

Dump: Press PLUS to dump the captured data to a personal computer.

Paper tape: Press PLUS to begin paper tape output. After the current rate is shown, press PLUS or MINUS to adjust it. Select the correct rate for a rate reading, or just accept the current rate for a flat tape. Press BEGIN to start printing. Press PLUS to zoom in, MINUS to zoom out. Press BEGIN to restart a reading at the center of the tape. Press MODE to terminate paper tape printing.

Beat Error - see if a clock or watch is "in beat"

Press BEGIN to start measuring. For clocks, the percentage of error will be shown. A clock is perfectly in beat when the reading is zero percent. For watches, the number of milliseconds of beat error will be shown.

Strike Mode - record strike counts and look for errors

Press BEGIN to start recording strike counts.

Press MODE to stop recording and view the counts that have been recorded.

When viewing, press PLUS to see the next count, MINUS to see the previous count.

Press BEGIN to erase all counts and start over.

Count Mode - find the correct rate of any running clock

Press BEGIN to start counting beats.

Press MINUS to freeze the count display.

Press PLUS to resume the count display.

Press BEGIN to zero the count and start over.

Rate Finder - find the correct rate of any running clock (Optional)

Set up the two sensors and press BEGIN to start counting beats.

Accutron Mode - show the rate of tuning fork watches

Press BEGIN and select the number of "blocks" to measure (the time before a reading appears).

Press BEGIN to start measuring.

Press PLUS to see the rate as Error Per Day.

Press MINUS to see the rate as frequency of the fork.

Tick Mode - send information about watch ticks to a PC

Press BEGIN to start sending tick data to the PC.

Tick 2 Mode - measure balance wheel amplitude with a PC (optional)

Press BEGIN to start sending data to the PC.

Configuration Mode - to set various parameters of operation

Hold down MODE when you turn on the timer to enter the Configuration Mode.

Beep: Press PLUS to turn the beeper ON, press MINUS to turn it OFF.

Time beats: Press PLUS or MINUS to set the default number of beats for the Time Mode.

Blanking: Press PLUS or MINUS to set the value of the Blanking Window when it is turned off. Use 8 for most cases. Use 5 if you measure fast beat watches.

Units: Press PLUS to see rates as Seconds Per Day, press MINUS to see rates as Beats Per Hour.

Length: (MicroSet 3) Press PLUS to see pendulum adjustment as inches, press MINUS to see pendulum adjustment as centimeters.