CI - 203

Handheld Laser Leaf Area Meter

Instruction Manual
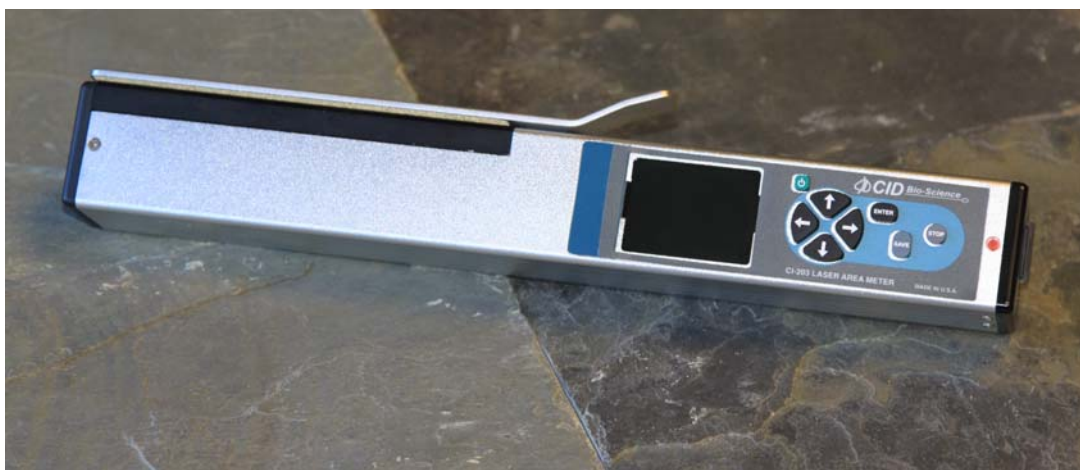
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INTRODUCTION

Congratulations on the purchase of your new CI-203 Portable Laser Area Meter. Making leaf measurements, in the field or laboratory, is now very easy with the CI-203 Portable Laser Area Meter. This state-of-the-art instrument has been designed to be the most portable leaf area measurement system available. Although you may be anxious to use your new meter, please take the time to read this manual first.

Specifications

Maximum Capacities:
- Thickness: 25 mm
- Width: 150 mm
- Length: 1-2 m
- Area: 1 m^2

Resolution: 0.1 mm (width) by 0.1 mm (length)
Computer Interface: Full speed USB interface 12MBit/s
Area Units: cm^2
RAM Memory Size: 64k Bytes
Storage: HD SD card 4GB
File System: Fat32
Display: TFT LCD 320x240
Scanning Speed: 400 mm/sec
Battery: 7.2 V rechargeable Nickel Cadmium (NiCd)
Operating Temperature: $0{\sim}50^{\circ}\text{C}$
Operating Time: to a minimum of 500 leaves
Dimensions: 355L x 45W x 50H mm
Weight: 1Kg

Features

- Non-destructive measurements
- Measures area, length, width and perimeter, saves and displays synthesized images
- Calculates shape factor, aspect ratio and voids number in object
- Area resolution down to 0.01 cm^2
- Unlimited storage capacity (replaceable 4GB SD card)
- USB port for viewing/copying files, upgrading firmware and debuging the output
- Supports USB mass-storage device class
- Serial Flash to store non-volatile scan/file parameters
- Single self-contained instrument with built-in LCD display
- Measure objects up to 150 mm wide and 25 mm thick of virtually unlimited length[1]
- Easy calibration when required
- Rechargeable battery through USB port

1.   See specifications for maximum length and area capabilities.

OPERATING INSTRUCTIONS
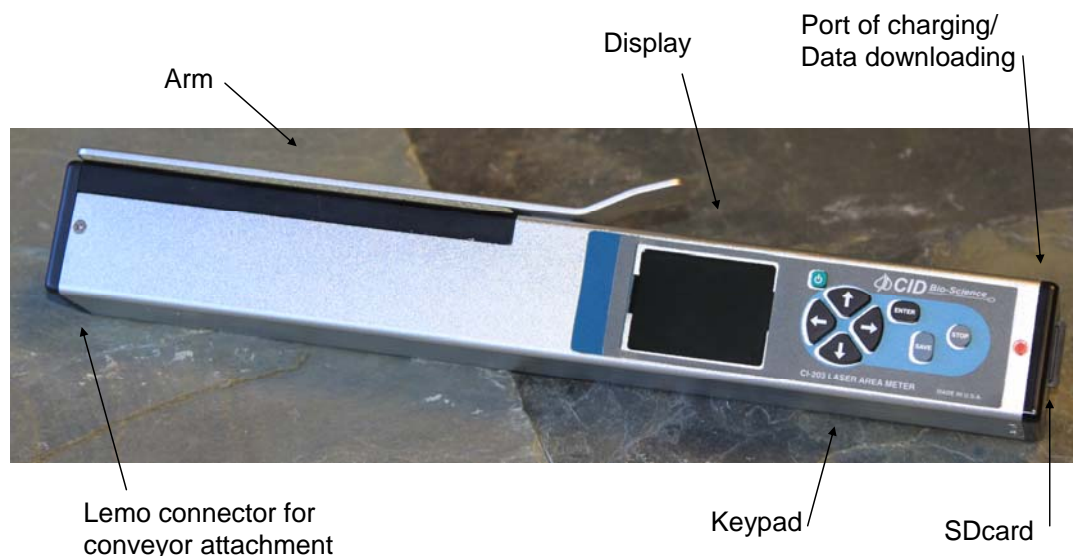
Figure 1. CI-203 Laser Area Meter

The CI-203 is a self-contained, hand-held, battery-powered instrument with a built-in display. It contains an optical scanner to measure leaf width, a roller with a shaft encoder to measure length, and a microcomputer to coordinate the measurement functions, calculate results, and store the collected data.

Taking a measurement is as simple as turning the instrument on, inserting a leaf in the objective, and drawing it out. The instrument does the rest.

To turn the instrument on or off, press the ON/OFF button. When the instrument powers on, a copyright notice will appear for 0.5 seconds. Following this, a menu will appear on the display with the word "Measure" appearing in the upper left-hand corner of the display. You are now in the CI-203 menu system.

Error messages should rarely appear during normal operation of the CI-203. However, in the event that the display does not show the "Measure" prompt after displaying the copyright notice, see the Error Message section of this manual.

Figure 2. CI-203 Keypad

Menus and What They Do

The CI-203 menu system allows you to quickly and easily operate the instrument without requiring consulting the manual. It is recommended to read through the entire manual with the instrument before performing measurements in the field. The screen associated with a menu item will give you information about the choices that you can make or the options that are available. Usually, the top line of the screen will contain information about where you are in the menu system, and the bottom line will contain information about buttons to press to change the current status of the instrument. The UP/DOWN arrow keys can be used to scroll between menu option screens.

Measure

In the measure mode, the top line of the screen will read "Measure" on the left with the name of a file on the right. The bottom line of the screen will have the word "arm" in brackets on the left, and the four direction arrows on the right.

```
        Measure     file00
        <arm>      ←→↑↓
```

The options are:
- to select another mode with the UP or DOWN arrow keys
- to select another file (if there is more than one file) with the RIGHT or LEFT arrow keys
- to take measurements

To start measuring, open the measurement arm until extended completely, and then allow it to slowly close upon the leaf to be measured. This begins the measurement process. The motor will start spinning up to speed as soon as the arm opens, and the display will read "Measurement" on the top line and "spinning up" on the bottom line. When the arm closes, the laser will power on and the bottom line of the display will read "stabilizing" for about0.25 seconds while the instrument adjusts the scan rate. When the instrument is ready to take measurements, the bottom line of the display will read "measuring". At this point, draw the leaf being measured out of the instrument. When the leaf has been drawn out completely, the instrument will stop automatically and display the results of the measurement. At this point, preview the results and decide whether the measurement should be saved and under which file it should be stored. An operating file is automatically created when the CI-203 is powered on, allowing the menu to start right away and measurements to be stored.

The display will show the name of the current file in the upper left-hand corner of the screen and the sequence number of the measurement in the upper right-hand corner. Below these the parameter names appear on the left and parameter values on the right of the screen.

```
         file00              4
           <stop>    <save>
     area = 44.04 cm²
     length = 13.64cm
     width =9.91cm
     perim = 54.30cm
     ratio = 1.38
     fact = 0.49
     voids = 2
```
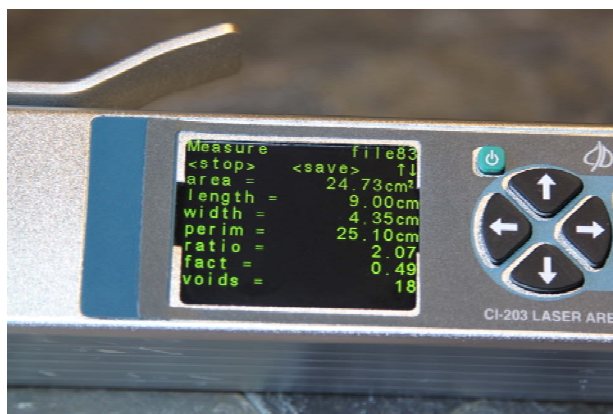
Figure 3. CI-203 display read out and key pad

To bring an image into view, press the LEFT arrow key. To return to the data display, press the RIGHT arrow key. Repeatedly pressing the RIGHT/LEFT arrow keys will cycle between those 2 display modes. To discard the last measurement, press the STOP/RESET button to erase. Now another measurement may be taken, if required. Depending on the set-up of the automatic save function of the instrument (see the Set-Up Auto Store parameter section on page 11) the measurement will or will not be saved.
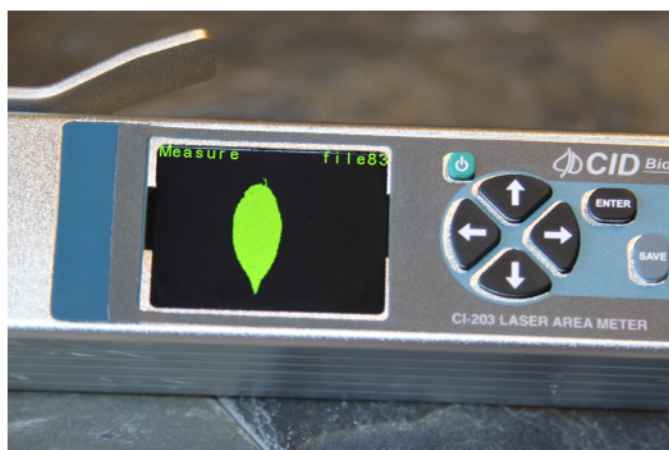
Figure 4. Image of measured leaf on CI-203 display screen

To save the measurement, press the SAVE button; the word "saved" will flash on the bottom line of the display to confirm that the data is saved. Make sure the SDcard is present when saving data to a file. The user may verify and save files by connecting the instrument to a computer using the USB host. TO access saved files, the SDcard should be mounted on the computer as a local drive; then open the file explorer to view the files. Files should be copied from the SDcard and saved to the hard drive before proceeding with any calculations or data manipulation.

View Data

To view collected data, use the view mode from the instrument menu. In the view mode, the top line of the display will show the word "View" on the left and the name of a file on the right. The bottom line will show the word "enter" on the left and the four direction arrows on the right.

```
┌─────────────────────────────┐
│    View        file00       │
│   <enter>      ←→↑↓          │
└─────────────────────────────┘
```

The options are:
- to start the viewing process by pressing the START/ENTER button
- to select a file (if there is more than one file) with the UP or DOWN arrow keys
- to select another mode with the RIGHT or LEFT arrow keys

Once you have selected a file to view and pressed the ENTER button, you will be able to look at the data in the file. The top line of the screen will have the file name at the left. On the right will be the number of the last recorded measurement (file record number).

```
┌─────────────────────────────┐
│      file00          6      │
│            <stop>           │
│    04/03/2010     16:04:16  │
│  area = 82.15cm²            │
│  length = 15.94cm           │
│  width  = 8.90cm            │
│  perim =  43.50cm           │
│  ratio = 1.79               │
│  fact =  0.55               │
│  voids = 2                  │
└─────────────────────────────┘
```

Note: Because of the amount of information displayed on this screen the CI-203 cannot display any prompts in this mode.

The data displayed on several different screens include the most current measurement, the GPS location of measurement, and the synthesized scan image. To bring another screen into view, press the RIGHT or LEFT arrow key. Repeatedly pressing the right arrow will display the files, voltage, battery power remaining, GPS location, time stamp (time and date) and the properties of the SDcard. If no SDcard is in the instrument, or if the SDcard is not fully inserted, "no" will appear in the display next to SDcard. The GPS may read "nofix" if the instrument is located indoors and cannot connect with a satellite.

To bring another measurement into view, press the UP or DOWN arrow key. Pressing the UP arrow key will display the total values for all measurements in the file. The first value shown is the average value for all of the measurements in the file, followed by a list of all measurements in the file, beginning with the most recent and ending with the first measurement taken and saved.   This view mode is similar to a computer spreadsheet program allowing the user to view one cell (measurement) at a time.

To return to the main view mode, press the STOP/RESET key.

Manipulate Files

The CI-203 uses an SDcard to store all measurements. This means the user is able to create, truncate and delete any measurement file. The instrument uses a regular FAT32 file system to access stored data.

To view data on a computer, simply connect the instrument to the USB port on the computer with the USB cable included. The computer should automatically detect the SDcard as a new storage device and mount the drive so that measurement data will be accessible by any computer application. When the user creates a file to store data on the computer, the same file name created on the SDcard will be used, with the file extension .img. The image file is used to store synthesized images for each measurement.

The options are:
- to select another mode, use the UP or DOWN arrow keys (possible modes include: create files, delete files, and clear files)
- to select a particular action to carrying out on files, use the RIGHT or LEFT arrow keys
- to start the selected action, use the START/ENTER key

The possible actions available on the file mode are as follows:

Create a File

When the START/ENTER key is pressed, "Name: Files" is displayed on the top line, indicating the unit is in *create files* mode. The top line of the screen will read "Name" on the left, and a file name (e.g. "file00") on the right. The bottom line will read "enter" at the left, "erase" at the center, and the four direction arrows appear at the right.

```
┌─────────────────────────────┐
│   Name:          file00     │
│   enter    erase    ←→↑↓     │
└─────────────────────────────┘
```

NOTE: The STOP key can be pressed at any time to abort the file creation process and to return to this point.

Pressing the arrow keys will allow the user to enter an alpha or numeric selection for a seven-character file name (up to 250 character file names are possible). The right and left arrow keys select which character in the file name to edit and the up and down arrow keys are used to choose a character. The chart below lists the available characters.

! " # $ % & ' ( ) * + , - x / 0 1 2 3 4 5 6 7 8 9 : ; < = > ?
@ A B C D E F G H I J K L M N O P Q R S T U V W X Y Z [¥] ^ _

Pressing the SAVE/ERASE key in the "Create files" mode deletes the character under the cursor. Also, characters cannot be inserted into an existing file name. Should the file name be identical to another file name, the instrument will display the message "duplicate name" on the top line of the display and "enter" on the bottom. The CI-203 will save all parameters for each measurement (width, length, perimeter, area, aspect ratio, and shape factor) on the SDcard. Once finished creating the file name, press the ENTER key. The file confirmation screen will appear. Press ENTER again for confirmation to create the file, or press STOP to abort the process.

```
┌─────────────────────────────┐
│   file00       created      │
│   <enter>      <stop>       │
└─────────────────────────────┘
```

Delete a File

Pressing ENTER when "Delete files" is displayed on the top line engages the unit in the *delete file* mode. This mode will erase a file completely from the memory/SDcard. In this mode, the top line of the display reads "Delete" on the top left line and the name of a file on the right. The bottom line of the display reads "start" on the left and the up and down direction arrows appear on the right.

```
┌─────────────────────────────┐
│   Delete       file00       │
│   <start>        ↑↓         │
└─────────────────────────────┘
```

To delete a file, use the UP or DOWN arrow keys to select a file. Once a file is selected to be deleted, press the START/ENTER key. The instrument will confirm the deletion with the line "<enter> <stop>". To delete the file, press the ENTER key. The instrument will display "Done" when the file is deleted. To escape without deleting the file, press the STOP key.

Clear/Truncate a File

Pressing the START/ENTER key when "Clear files" is displayed on the top line engages the unit in the *file truncate* mode. This mode allows the erasure of the file contents without changing its name or its set-up. This feature is useful if it is necessary to do a number of similar measurements. The user can take these measurements to a particular file, copy the results, clear the file, and be ready to take a new set of measurements to that file.

In the *file truncate* mode, the top line of the display reads "Clear" on the left and the name of a file on the right. The bottom line of the display reads "start" on the left and the up and down direction arrows on the right.

```
┌─────────────────────────────┐
│   Clear        file00       │
│   <start>        ↑↓         │
└─────────────────────────────┘
```

To clear a file, use the UP or DOWN keys to select the file. Once a file is selected, press the START/ENTER key. The instrument will confirm the clear with the line "<enter> <stop>". To clear the file, press the ENTER key; to escape the file-clearing process, press the STOP key. The instrument will display "Done" after the file is truncated.

Transfer Data to a Computer

To view the collected data on a computer, use the supplied USB cable and connect the instrument to the USB host (computer). The user can view/manipulate data over the USB connection, or may remove the SDcard and view files/data on the SDcard on another computer.

Once the instrument is connected to the computer via USB cable, it is strongly recommended that the user copy and resave the files and images to the hard drive of the computer. The computer application used to view the files can also be used to resave. It is recommended that the user does not work from the original file on the SDcard after the measurement has been made, because if any changes are made to the original file, it can break the alignment of the file causing error and possible data loss.

In order to keep the file system in sync, perform any editing or further calculations on the copied file saved to the computer hard drive. **Do not edit the file directly on the instrument**.

Figure 5. SDcard and USB cable connection for CI-203

Do not connect the USB cable to the instrument and the computer while performing measurements. If the user tries to operate the instrument through the computer, the files are subject to becoming out of sync, breaking alignment and causing errors in the files. This can also lead to problems with saving data.

If an error occurs in a specific data file, it can be deleted and created again. Go to the File Menu on the instrument; delete the file where the error has occurred. If the file has been transferred to the computer, delete it on the computer also. Once the corrupted files have been deleted, create the file again (if it has been properly deleted, the same file name can be used) and re-take the measurement.

How Data Appears in a File

Data saved by the instrument during measurement can be viewed later on a computer using a spreadsheet program. Twelve different columns of data will be seen in the downloaded or transferred file, including the date (month/day/year), time of measurement (hour/minute/second), area, length, width, perimeter, ratio, factor, voids, latitude, longitude and altitude. The last three columns are related to the new GPS function of the instrument and are for imaging purposes (i.e. these columns do not relate directly to leaf measurements).

Date	Time	Area	Length	Width	Perim	Ratio	Factor	Voids	Lat	Long	Alt
09/19/10											

How to Work With or Manipulate Data Files

The CI-203's removable SDcard makes it easy to work with and manipulate data files after taking measurements. Remove the SDcard from the CI-203 after powering off the instrument. Insert the card into a computer. Copy and save the files from the SDcard onto the hard drive of the computer. Open the files saved on the hard drive to start any data manipulation or management work. Saving the data files in this manner and not working directly from the SDcard will help to prevent the corruption of the data on the SDcard and the instrument. Once files are copied and saved to a hard drive, they can be deleted from the SDcard.

Do not edit files directly on the instrument. Doing so may corrupt data and cause loss of files.

Set-Up Instrument

The CI-203 has a number of utility functions that allow the user to manage the instrument's capabilities. These functions are accessed using the *setup* mode. When the instrument is in the *setup* mode, the top line of the display reads "Setup" on the left and one of the following words "comm", "auto store", "scanner" or "storage" on the right. The bottom line of the display reads "start" on the left and the direction arrows appear on the right.

```
        Setup        comm
        <start>      ←→↑↓
```

The options are:
- To select another mode using the UP or DOWN arrow keys
- To select an area to set-up using the RIGHT or LEFT arrow keys
- To begin the set-up process by pressing the START/ENTER key

Set-Up Scanner Thresholds

NOTE: **Normally, there is no need to adjust the threshold of the CI-203 because the instruments are factory-adjusted to a threshold level that is ideal for "all-around" use.**

The CI-203 automatically adjusts an internal threshold to a level that is optimum for detecting the presence of a leaf in the scanner objective. If out-of-the-ordinary measurements are being made or if the instrument has suffered from abuse or excessive aging, the threshold may need to be adjusted. If the instrument appears to be making incorrect measurements, make sure the instrument is clean and the reflective tape and the objective window appears to be undamaged and in good condition. If there is something blocking the optical path in the scanner, no amount of threshold adjustment will correct the problem. Refer to the section on cleaning and maintenance for more information on insuring that the instrument is clean. Please do not hesitate to consult with the manufacturer or with the nearest manufacturer's representative if there is a problem and the threshold needs adjustment.

Threshold Adjustment (Width Calibration)

In the event you need to alter the normal threshold settings, perform the following steps. First, adjust the threshold of the CI-203 alone, with its arm in place. To do so, select "Setup Scanner" in the display window and press ENTER. Select "HiThld" and press ENTER again. The instrument will compute the high threshold. Next, switch to "LoThld" menu and place a piece of white paper on either side of the arm and press ENTER. Let the scanner run. Remove the paper from under the arm. Next switch the instrument to manual mode and set threshold on average Hi and Lo threshold. Make sure that the width reads 0 when there is no object under the arm. Stop the manual scan and then quit "Setup Scanner" menu by pressing the STOP button. Save the new threshold you have set to non-volatile memory when prompted. Repeat the same procedure in root and conveyor mode.

The next step is very important: every time the threshold is changed in any mode, switch to the "Measure" menu and press the LEFT and RIGHT key at the same time. The instrument will automatically compute and save the timing parameters. The user should repeat this computation a few times allowing the instrument to generate an accurate leaf width reading. Make sure to check the width reading with and without the filter. When checking the reading without the filter, the width should above 0 but still a very small value.

If the instrument malfunctions after manual threshold adjustment, contact CID Bio-Science, Inc. for assistance.

Calibration of the Scanner Lens

In order to calibrate the scanner lens, put the instrument into Measure mode. Push the LEFT and DOWN arrow keys simultaneously, or press the RIGHT and DOWN arrow keys at the same time. This will start the lens calibration and the user should be able to see the scanner running.

Slowly draw a piece of white paper through the scanner several times. After doing this a few times, push STOP. The lens should now be calibrated. To see the image and measurement information, press the right or left arrow keys.

Set-Up Storage (SPI Flash Management)

SPI (serial peripheral interface) flash plays an important role in the architecture of the CI-203. It holds all the non-volatile scan parameters, the copy file descriptors, the measurements buffers, etc. The total size of the serial flash is 1MB, or 16 sectors with 64KB in each sector. Currently the CI-203 uses 4 sectors; sector 0 is inerasable while sectors 1-3 could be erased by the user from the "Set-Up Storage" menu. Sector 0 is protected because it holds all of the scan/timing parameters. The user is allowed to modify these parameters, but not to erase them. Sectors 1-3 could be erased thus eliminating all the files from CI-203.

The user should create at least one file or else the "Measure" menu will be inaccessible. When the user creates a file the instrument allocates data structure at sector 1 of the serial flash. In addition to this, the same file is created on the SDcard. This is necessary because the CI-203 uses only special files with the removable SDcard. Without the SDcard inserted, the instrument is still able scan an object, but can not store or save the measurement.

```
          space =    15984
            <stop>    ↑↓
```

Pressing the START/ENTER key when "format storage" is displayed on the top line indicates the unit is in the *storage format* mode. Be careful! Formatting the storage space of the CI-203 will erase all data and all files. This is convenient when starting a new year's work, but treat this command with care.

In the format storage mode the top line of the display will read "Clear all data". The bottom line of the display will have the word "stop" to the left and "erase" to the right.

```
          Clear all data
         <stop> <erase>
```

To delete **every** file in your instrument, press the SAVE/ERASE key. The instrument will erase **ALL** data from the memory, leaving the maximum possible amount of memory free for use. To stop the deleting process, press the STOP/RESET key.

Set-Up Auto Store Parameter

Pressing the START/ENTER key when "Setup auto store" is displayed engages the unit in the *set-up auto store* mode. This allows the user to set-up the instrument to automatically store measurements, and to start a new measurement without explicitly saving the old one. This mode is convenient when taking fast, repetitive measurements as well as when it is not necessary to review each measurement immediately after taking it.

In the *auto store setup* mode, the top line of the display will read "auto store =" on the left and either "yes" or "no" on the right. The bottom line of the display will read "stop" and "save" and the directional arrows.

```
      auto store = yes
    <stop> <save> ↑↓
```

To set the instrument up to automatically store measurements press the UP arrow key to bring the word "yes" onto the display, then press the SAVE/ERASE key to save the configuration. To set the instrument up to automatically discard measurements, press the DOWN arrow key to bring the word "no" onto the display, then press the SAVE/ERASE key to save the configuration. To avoid changing the configuration, press the STOP/RESET key.

Set-Up Time and Date

To change the time and date stamp on the CI-203, press the START/ENTER key when "Setup Time" is displayed indicating the unit is ready to have the time stamp (date and time recorded with each measurement) corrected.   This allows the user to set-up the instrument in different time zones or to adjust the time after daylight savings.

To change the time on the instrument, use the up and down arrows to change the values of the first row (hour: minute: second). When the appropriate column is highlighted, make the appropriate shift in time and press <save>. To change the date in the second row, press the left and right arrow keys simultaneously. The second row (month: day: year) should now be accessible and the date can be changed using the up and down arrow keys. When done changing the date, press <save> or <stop> to clear any changes made.

```
 Setup              Time
 <stop> <save>      ←→↑↓


        14:40:32
        10:20:10
```

GPS Menu

The new CI-203 has a built-in GPS system which can relay the longitude, latitude and altitude of the instrument when performing measurements. The figure below shows the GPS menu display. The GPS uses GMT or Greenwich Mean Time for a standardized time. The GMT is displayed as the time (TIM) on the GPS menu and is synchronized with minute and second alignment. Often when the instrument is turned on indoors, the latitude, longitude and altitude will read "no fix."   This occurs when no satellite signal can be obtained by the instrument. Powering up the CI-203 outdoors will correct this problem and allow latitude, longitude and altitude readings to be taken along with leaf measurements.

Figure 6. CI-203 GPS menu

THEORY OF OPERATION

Overview of the Parts of the Instrument

The CI-203 consists of a number of sub-systems. It has a laser width scanner that is capable of measuring the width of an object in its objective 500 times a second to a resolution of 0.1 mm. It has a roller length measuring system that can measure length steps of 1 mm. The entire instrument is controlled by a microcomputer system that allows the user unparalleled flexibility in configuring the instrument to make measurements accurately, easily and quickly.

The Width Scanner

When the instrument is in the scanning mode, a rotating mirror causes a laser beam to scan across the objective 400 times a second. This beam is reflected off the special surface of the measuring arm and received by a light sensor inside the unit. The level from this sensor is compared to a threshold. The output of the "comparator" is fed to a counter, which is sampled at intervals during the width scan. This count is used to calculate the width measurement for each scan.

The Length Step (Roller System)

The instrument includes a roller under the measurement arm that determines length information. Each time the object being measured travels 1 mm, the computer is alerted, and integrates the width and length scan information into the various parameters being measured.

Computing the Parameters

The CI-203 measures only two parameters directly: width and length. From these it derives area, perimeter, aspect ratio, and shape factor from each scan.

Each time the meter senses the leaf has progressed 1 mm, the computer will check if the width reading is a non-zero value.

If the width measurement is non-zero, the computer takes the following actions:

> The width measurement is added to the area accumulator.
> If the width measurement is greater than the currently stored maximum width, the maximum width is updated.

The perimeter increment is calculated and added to the perimeter accumulator. This perimeter increment is calculated using the function:

$$\Delta p = \sqrt{4\Delta l^2 + (W_0 - W_1)^2}$$

Where Δp is the perimeter increment,

Δl is the length increment (always 1 mm),

W_0 is the current width measurement, and

W_1 is the previous width measurement.

If the width measurement reaches zero and the instrument is not operating as part of the conveyer attachment, the measurement stops and is displayed.

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Computing Aspect Ratio and Shape Factor Information

Aspect ratio and shape factor information can be easily determined from other calculated values. These derived quantities are not stored but calculated, whenever necessary, for the purposes of display or data dumping. The calculations used are shown below.

Aspect ratio is the ratio of the leaf length to its maximum width. It can be calculated from the equation:

$$r = \frac{l}{W_m}$$

Where r is the aspect ratio,

W_m is the maximum width, and

l is the length.

Shape factor is the ratio of the leaf area to the leaf perimeter, corrected so that the shape factor of a circle is equal to one. It can be calculated from the equation:

$$f = 4\pi \frac{a}{p^2}$$

Where f is the shape factor,

a is the area, and

p is the perimeter.

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Charging the Battery

When "Low Battery" is displayed, the battery is discharged below the recommended operating level. Measurements may continue for another 15 minutes; however, we recommend the battery be recharged as soon as possible after seeing the low battery warning. To charge the battery, connect the charger output to the battery port on the instrument (the same port you would use to send data) for at least 14 hours. Batteries should be fully charged soon thereafter. Storing a battery in a discharged state could permanently damage it.

Care and Cleaning

Treat the CI-203 as any other fine optical instrument. Keep the lens clean and free from scratches. When not in use, keep the instrument in its protective case. Use only a mild detergent and damp cloth to clean the exterior areas of the instrument. Use a high quality lens cleaning cloth to clean the window. Do not submerse or use an overly wet cloth to clean the instrument. Do not drop the instrument.
For an extended storage period, we recommend storing the instrument in a cool and dry place.

Taking Care of the Rubber Roller in the CI-203

When the rubber roller in the CI-203 gets dirty, it will stick or fail to spin as smoothly as it should. As a result, certain sections of the leaf will be scanned twice or more causing the measurement to not be repeatable. To correct this problem, the user should take the roller out. To remove the roller, press the roller towards the hand-held end, then gently lift it up from the hand-held end while pulling it out in the same direction.

The rubber roller may not be snug in its place, or it may shift out a little so that the scanning result is not linear. The user needs to make sure that the roller is snug in place to perform measurements correctly.

Error Message

The following error messages should rarely appear in normal operation. If they do appear, see Appendix III and follow the steps to restore the setup data.

MESSAGE:	MEANING:
Bad NVRAM Checksum <start>	Instrument setup data has been lost. Pressing the START key will restore default values and display the message "NVRAM Defaults Saved". Measurement will not be accurate until re-calibrated (See Appendix III).
Leaf Not Cal'ed <start> Root Not Cal'ed <start> Conveyor Not Cal'ed <start>	Conveyor, Leaf or Root mode selected when the power turned on has not been calibrated. Pressing the START key will dispatch the message and allow the instrument to operate, but measurements will not be accurate until calibrated. This message will appear every time the power is turned on, until the instrument is calibrated.
Bad EPROM Checksum	EPROM containing instrument firmware has bad checksum, indicating it has failed. The instrument will not operate with a bad EPROM.

APPENDIX I: OPERATING THE CI-203 LASER LEAF AREA

METER WITH THE CI-203CA CONVEYOR ATTACHMENT

IMPORTANT - Note: for shipping and transportation purposes <u>only</u>, the glass roller needs to be tightened down. There is a nylon screw on one side of the conveyor (see Figure 7) to hold the glass roller in place. Loosen screw for use; tighten the screw for shipping and transportation. For the conveyor to operate properly, loosen the screw.

This appendix explains how the CI-203 is installed in the CI-203CA, and differences in operations between the CI-203 alone and used with the CI-203CA.

Hardware Set-Up

To use the CI-203 with the CI-203CA, the CI-203 must be installed in the CI-203CA. Do not turn the CI-203 on from its keypad. To install the CI-203CA, follow these steps:
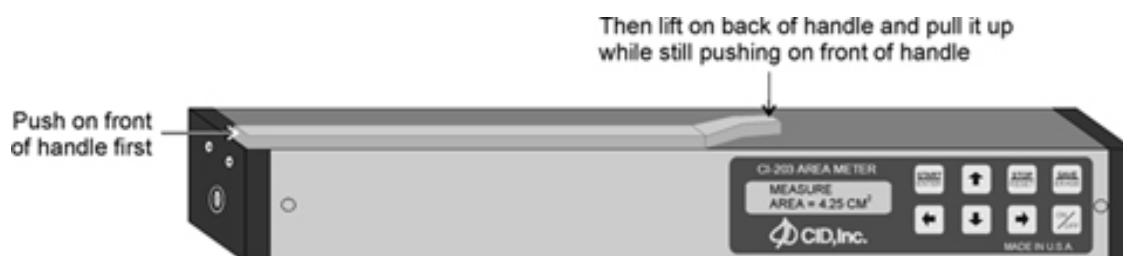

Figure 7. Illustration of the removing and receiving arm.

1. Remove the roller arm on the CI-203 Laser Leaf Area Meter by pushing the thumb section of the arm slightly back toward the display and lifting it out (see Figure 6). Orient the CI-203 so that the display will be lined up with the notch on the housing of the CI-203CA. Once this is done, insert the CI-203 all the way into the hole in the side of the CI-203CA. Confirm that the CI-203 is inserted into the CI-203CA all the way by verifying that the housing on the CI-203CA covers the left edge of the display. Once this is done, rotate the Lock lever on the CI-203CA counter-clockwise to secure the CI-203.
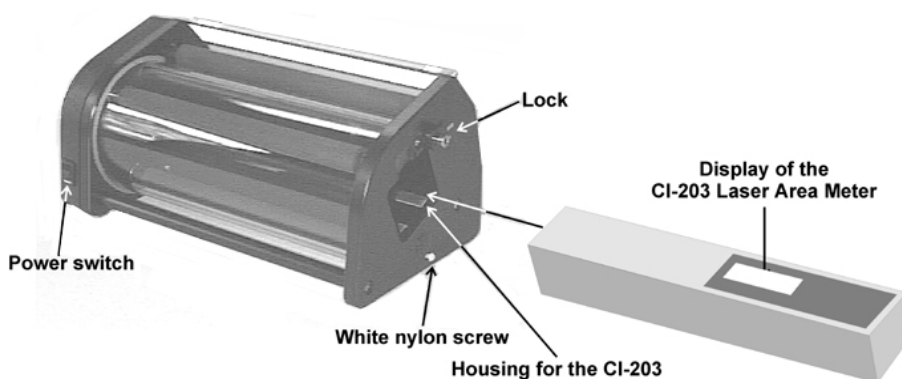

Figure 8. Insert the CI-203 into the housing (hole) in the side of the CI-203CA.

2. Connect a suitable 6V DC power source, such as the AC adapter supplied by CID Bio-Science, Inc., to the power input socket on the back of the CI-203CA.

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← RS232 port

← Power input

Figure 9. The RS232 port and the Power Jack of the CI-203CA.

3. Press the power switch on the CI-203CA (see Figure 8) to the ON position. ***Note: The CI-203/CI-203CA combination must be turned on with the switch for the CI-203CA in order to take measurements!***

Measure

When the CI-203 is used with the Conveyor Attachment, it is assumed the user wishes to measure a large number of leaves all in one batch. Because of this, the instrument does not stop after each measurement to allow the user to preview and make a "save/no save" decision. Rather, the instrument will take measurements and automatically save them until the user stops the process.
In the Measure mode, the top line of the screen will read "Measure" on the right and the name of the file on the left. The bottom line of the screen will read "<start>" on the left and four direction arrows on the right.

File00	Measure
<start>	←→↑↓

The options are:
1. To select another mode with the ↑ or ↓ keys.
2. To select another file (if there is more than one) with the ← or → keys.
3. To take a set of measurements.
To begin a set of measurements, select a file to write to and press the *Start* key. The conveyor, scan motors, and the laser beam will come on when the start key is pressed. The display will read "Measure" on the upper right corner with the name of the file in the upper left corner. The display will read "Stabilizing" on the bottom line for 0.25 seconds while the instrument adjusts the scan rate. When the instrument is ready to start taking measurements, the bottom line of the display will read "Measuring". Begin feeding leaves into the conveyor. Once the first leaf has been measured, and for all subsequent leaves, the instrument will display the file name in the upper left of the display and the sequence number in the upper right. The lower line of the display will show the area measurement for the last leaf measured.
NOTE: Because of the amount of information displayed on this screen, the CI-203 cannot display prompts in this mode.
To stop taking measurements, press the STOP button. The instrument will turn off the laser, conveyor, scan motors and laser and will return to the Measure menu. To view the measurements, see the View Data section on page 4 of the manual.

Set-Up Instrument

There are some operating modes which are not available to the user when the CI-203CA is being used. The user does not have access to the menu options for the CI-203CA when the CI-203 is being used. The threshold setting is available only when the CI-203CA is being used (at the same time, the hand-held threshold setting is not available).

Changing Springs

The tension on the rubber rollers is maintained with dowel pins and springs that are at each end of the rollers. If you desire to ease the tension of the rubber roller for thick and juicy leaves, you can use the alternate springs provided in the accessories. The plate above the rubber rollers holds the springs and pins in position. If this plate is removed to change the springs, take care not to get fingerprints or dirt on the reflective tape, which is on the underside of the plate. Also, take care in removing the plate so that the springs do not fly loose when the plate is removed. (Observe the orientation of the reflective tape, since on some units the tape is closer to one end than the other.) Since the conveyor allows direct measurements of difficult leaves through changing to alternate springs, there is no need for a sheath.

Unavailable Parameters

When used with the CI-203CA, the CI-203 will automatically save leaf measurements independent of the state of the *Auto Save* mode. Consequently, the instrument does not allow the user to access the Setup *Auto Save* options.

Set-Up Scanner Threshold

The operation of this menu item is identical to the operation described in the manual. However, when the CI-203CA is being used, the threshold that is being set is the one that is used during conveyor measurements. In order to completely set up the instrument, it is necessary to set up threshold both with the hand-held instrument and in the CI-203CA. Also, when one is setting thresholds with the CI-203CA, the conveyor motor does not come on, as the objective is for the conveyor to keep measurement standards.

APPENDIX II: THE CI-203RL ROOT LENGTH MEASUREMENT

APPLICATION

When properly set up, the CI-203 allows measurements of root lengths by the line intersection method (Tennant, 1975). This appendix explains how to set up and use the CI-203 in the root measurement mode.

Hardware Set Up

In order to use the CI-203 in the root measurement mode, the instrument must be reconfigured to allow use of the CI-203RL. Set-up includes selecting the root measurement mode from the CI-203 keyboard as well as changing the hardware setup. To install the CI-203 in the CI-203RL, follow these steps:

- Remove the roller arm on the CI-203 Leaf Area Meter by pushing the thumb section of the arm slightly back toward the display and lifting it out. Insert the supplied "T" shaped slide adapter into the CI-203 with the groove in the base of the "T" facing towards the right end of the instrument. The arm will snap into place when it is located correctly. See Figure 10 on page 22.

- Turn the instrument on, enter the Set-Up Measure menu, and set the measurement mode to "root". Then press the *Save* key to set the instrument to measure roots (this procedure is described in more detail in the section titled "Set-Up Instrument").

Measure

The CI-203 keeps track of the contents of files, and will not allow the instrument to record measurements to files that are not appropriate. If the instrument is in the root length measurement mode, it will attempt to find a file that is set up to record root length measurements. If it cannot find such a file, it will create one to avoid inadvertent measurements from not being recorded. Conversely, when the instrument is in the leaf measurement mode it will find or create an appropriate file. To use a file of root length measurement it must be set up for this mode! The "Create a File" section describes how to create a file for root length measurements (see page 6.)

In the *measure* mode, the top line of the screen will read "Measure" on the left and the name of a file on the right. The bottom line of the screen will read "start" in brackets on the left and four direction arrows appear on the right.

The options are:

- To select another mode with the up or down arrow keys.
- To select another file (if there is more than one) with the right or left arrow keys.
- To take a root length measurement.

Prepare for a root length measurement by placing a root specimen in the CI-203RT Root Tray and filling the tray with just enough water to allow the root to spread out. Insert the CI-203RT Root Tray into the side of the CI-203RL Root Length Measurement Attachment, making sure the tray is pushed in all the way. If this tray is not fully inserted the CI-203 may make an inaccurate measurement. Select the Measure mode on the CI-203 by pressing the Up or Down arrow keys until the word "Measure" appears in the upper right-hand corner of the display. Once in the Measure mode, select the file to write to by pressing the left or right arrow keys. Next, fit the slide adapter into the slot in the CI-203RL Root Length Measurement Attachment (the instrument will be upside down). The instrument should slide freely in the slot.

To begin the measurements, press the START key. The scan motor and the laser will come on, and the display will read "Measure" in the upper right corner with the name of the file being written in the upper left corner. The display will read "Stabilizing" on the bottom line for 0.25 seconds while the instrument adjusts the scan rate. When the instrument is ready to start taking measurements, the bottom line of the display will read "Measuring". Slowly slide the instrument across the root tray. Once the instrument has been still for 0.5 seconds, the scan will stop and the root length measurement will be displayed. Depending on the set-up of the automatic save function of the instrument (see "Setup Auto Store" parameter in the main section of this manual), the measurement will or will not be saved.

NOTE: ***Because of the amount of information displayed on the screen, the CI-203 cannot display prompts in this mode.***

To change files before saving data, use the Up and Down arrow keys to step through the files. To discard the measurement, press the STOP/RESET button. This allows the user to save different measurements types under different file names without having to set-up the measurement process each time.

Set-Up Instrument

An extra parameter capable of root length measurements is available in the "Setup Measure" menu. The "measure type setup" parameter allows the user to choose between root length or leaf measurements.   The threshold setting for root length measurements is different for leaf measurement and must be set up separately (see below). This threshold setting is available only when the CI-203 is in the root length measurement mode (at the same time, the leaf measurement threshold setting is not available).

Set-Up Measure

Pressing the ENTER key when the display reads "Setup measure" allows the user to enter the *measure type setup* mode. The upper line of the display will read "measure=" on the left and "root" on the right. The lower line of the display will read "stop" and "save" along with up and down direction arrows.

To set the instrument for root measurements press the UP ARROW key. To set the instrument for leaf measurements press the DOWN ARROW key. To save the setup, press the SAVE/ERASE key. The instrument will flash "saved" on the display and return to the setup menu. To change the mode of the instrument, press the STOP/RESET key. The instrument will return to the setup mode without changing its measurement type.

Set-Up Scanner Thresholds

In order to completely set up the instrument, it is necessary to set-up thresholds in all three possible modes: in hand-held leaf measurement; CI-203CA conveyor; and root measurement. If the root measurement or conveyor is not going to be used, the instrument only needs to have the leaf threshold set-up.

Setting the thresholds for the CI-203 in root length measurement mode must be done using the CI-203RL Root Length Measurement Attachment and the CI-203RT Root Tray. This allows the CI-203 to set its threshold under conditions that it will be required to operate under while measuring root length.

References:
Tennant, D. 1975. A test of a modified line intersect method of estimating root length. J. Ecol. 63:995-1103.
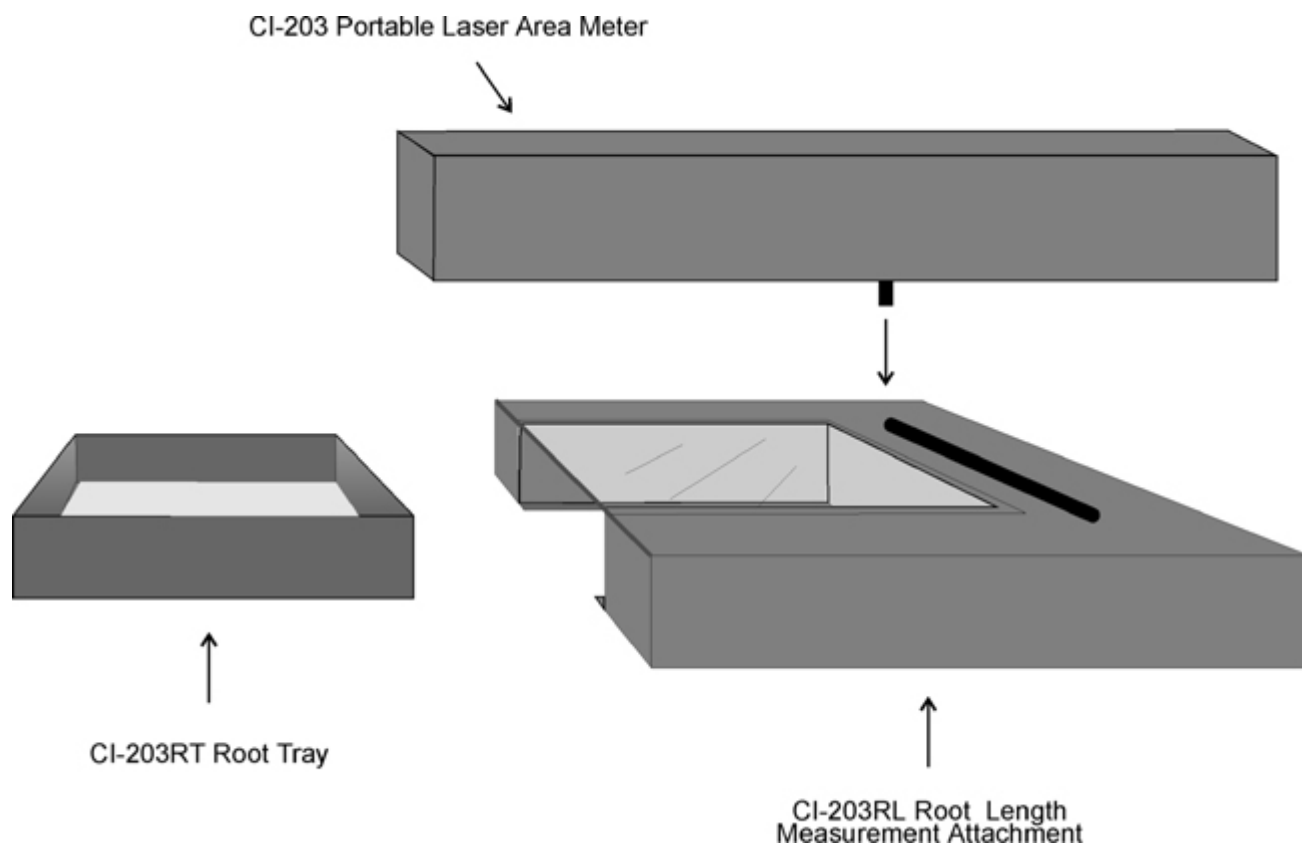
CI-203 Portable Laser Area Meter

CI-203RT Root Tray

CI-203RL Root Length
Measurement Attachment

Figure 10. Root length measurement setup.

APPENDIX III: RESTORING SET-UP DATA

Restoring Set-Up Data for the CI-203

"Leaf Not cal'ed" or "Bad NVRAM Checksum <start>".

If the display has the message: "Leaf Not cal'ed" or "Bad NVRAM Checksum <start>", the instrument may have lost the setup data. To correct this, in the same display window, press START. Then using the DOWN arrow key, go to the instrument "setup" screen.

> Use arrow forward to choose "setup scanner".
> Press START.
> This puts you one of 3 scan windows:
> While holding down the "save" key, press the "stop" key.

In this new screen, you have a series of items to check using the forward or back arrows. The numerical values are to the right of the items.

For this particular instrument, please ensure that you have the following data which can be set using the up and down arrow keys.

> Precharge = _____   ***see below
> Scan width = _____
> Scan time = _____
> Step length = _____

After checking the above figures, press "stop" and "stop" again. If you have made changes, it will ask if you want to save changes. Press "save".
> Now you are back in the "setup scanner" window.
> Press "start".
> Arrow up or down to the "manual scan" window.
> Press start.

Use the arrow up and down key to set "t" = ____. Press stop and stop again. Save changes.

If there are no other problems, the instrument should now be in working condition.

***   This following step may not be required.
> To set the precharge value: In the "precharge xxx" display window, press "start".

We are looking for a stable reading of "499X". Use the up or down arrow key to get a stable reading for the 499 digits. The "X" or last digit will change rapidly. Set the value of this digit so that 499 does not change to 500 or does not change to 498. Once you have a stable "499X" reading, press stop.

After checking the above figures, press "stop" and "stop" again. If you have made changes, it will ask if you want to save changes. Press "save".

Restoring Set-Up Data for the CI-203CA Conveyor Attachment

"Conveyor Not Cal'ed <start>

To restore setup data in the conveyor, plug the CI-203 into the conveyor and switch on the conveyor power. With the display showing, "Conveyor Not Cal'ed", press start. Use the arrow keys to go to the "setup" screen.

     Use arrow forward to "setup scanner".
     Press "start".
     This puts you in one of 3 scan windows.

While holding down the "save" key, press the "stop" key.
In this new screen, you have a series of items to check using the forward or back arrows. The numerical values are to the right of the items.

For this particular instrument, please ensure that you have the following data which can be set using the up and down arrow keys.

        Precharge = ____
        Scan width = ____
        Scan time = _____
        Step length = _____

After checking the above figures, press "stop" and "stop" again. If you have made changes, it will ask if you want to save changes. Press "save".

     Now you are back in the "setup scanner" window.
     Press "start".
     Arrow up or down to the "manual scan" window.
     Press start.

     Then set threshold = ___.

Additionally, please ensure that the reflective tape surface for the laser on the conveyor is clean and undamaged.

CID Bio-Science, Inc. Hardware Warranty

Important: Please Read

Seller's Warranty and Liability: Seller warrants new equipment of its own manufacturing against defective workmanship and materials for a period of one year, of a single shift operation, from date of receipt of equipment - ***the results of ordinary wear and tear, neglect, misuse, accident and excessive deterioration due to corrosion from any cause is not to be considered a defect.*** Any defect must be called to the attention of CID Bio-Science, Inc., Camas, Washington, USA, in writing, within 90 days after receipt of the unit.

Seller's liability for defective parts is limited to the repair or replacement of any part of the instrument without charge, if CID Bio-Science, Inc.'s examination discloses that part to have been defective in material or workmanship, and in no event shall exceed the furnishing of replacement parts F.O.B. the factory where originally manufactured. No equipment may be repaired or altered by anyone not authorized by CID Bio-Science, Inc.

Material and equipment covered hereby, which is not manufactured by Seller, is to be covered only by the warranty of its manufacturer. Seller shall not be liable to the Buyer for loss, damage, or injury to persons (including death), or to property or things, whatsoever, including, but without limitation, products processed by the use of the equipment; or for damages of any kind or nature (including, but without limitation, loss of anticipated profits), occasioned by or arising out of installation, operation, use, misuse, nonuse, repair, or replacement of said material and equipment, or out of the use of any method or process for which the same may be employed. The purchaser is to pack, ship, or deliver the instrument to CID Bio-Science, Inc., in Camas, Washington, USA, within 30 days after CID Bio-Science, Inc. has received written notice of the defect at the customer's expense. No other arrangements may be made unless otherwise approved in writing by CID Bio-Science, Inc.

The use of this equipment constitutes Buyer's acceptance of the terms set forth in this warranty. There are no understandings, representations, or warranties of any kind, express, implied, statutory, or otherwise ***(including, but without limitation, the implied warranties of merchantability and fitness for a particular purpose)***, not expressly set forth herein.

CID,Inc.   **CI-203**

PRODUCTION TEST CHECK SHEET

SERIAL NUMBER:	RMA #
	ROM VERSION:

TESTING FUNCTION	
THRESHOLD: H L	THRESHOLD SET:
PRECHARGE:	SCAN WIDTH:
SCAN TIME:	STEP LENGTH:
SD CARD:	FINAL:

INITIAL TEST DATE:	BY:
ENVIRONMENTAL TEST DATE:	BY:
FINAL CHECK TEST DATE:	BY:

NOTES: _____

_____

CONVEYOR AND/OR ROOT LENGTH			
THRESHOLD LOW:	THRESHOLD HIGH:		THRESHOLD SET:
PRECHARGE:	SCAN DELAY:	SCAN TIME:	STEP LENGTH:

ROOT LENGTH		
THRESHOLD SET:	SCAN DELAY: MAX 290	SCAN TIME:
STEP LENGTH:		