1.0 Overview Of The Instrument

1.1 Overview

The Nano Indenter® XP is a complete system, ready to run once it is assembled. This means there is no additional hardware required, other than the air supply required for the vibration isolation table.

1.2 The Nano Indenter® XP System

The Nano Indenter® XP system is composed of a number of "subsystems" that will be explained in detail in Sections 2.0 through 6.0. These subsystems are: the computer system, the motion system, the optics system, the gantry & isolation equipment, and finally the heart of the Nano Indenter® XP, the indenter head.

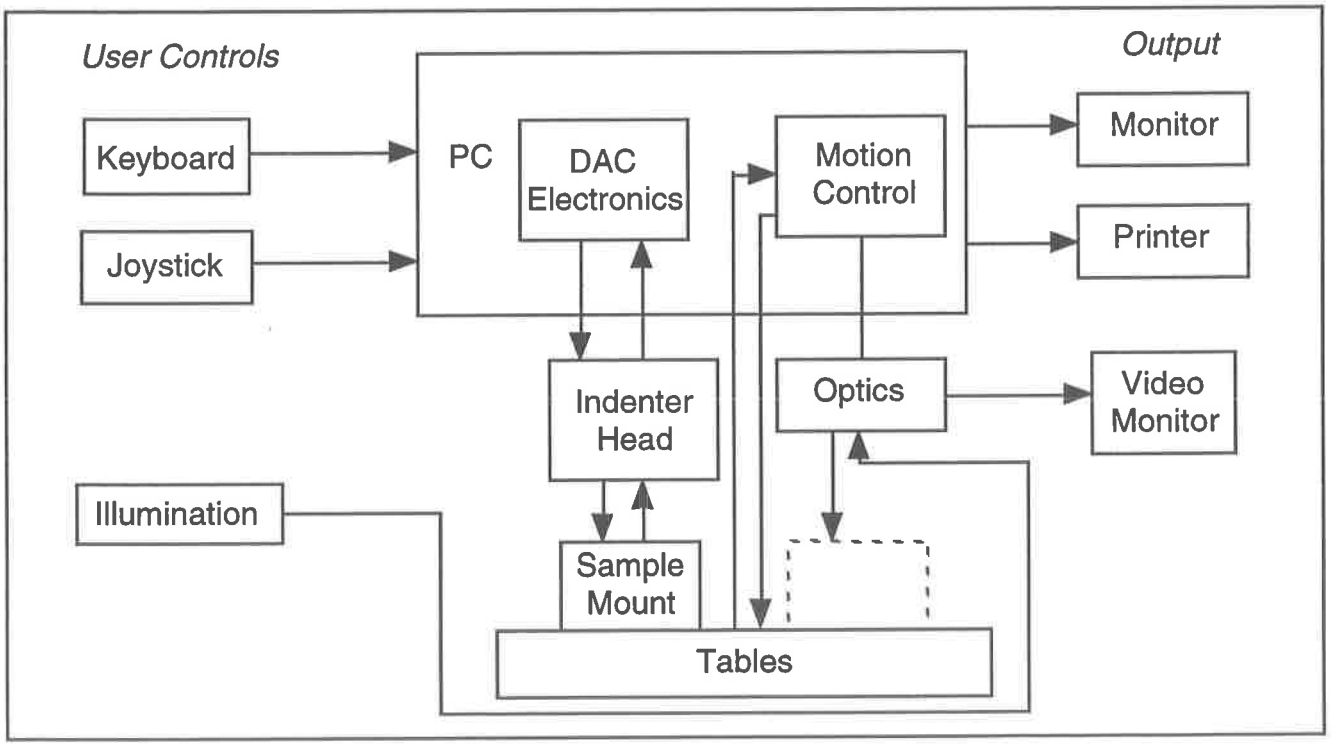

Figure 1.1. Nano Indenter® XP System Diagram

1.2.1 User Interface

The Nano Indenter® XP subsystems are fully integrated, primarily through the computer. All user input and control is remotely managed from the operator station. Only minor adjustments must be made on the instrument itself, such as the polarization on the microscope.

User control is accomplished through the joystick, the computer keyboard, and the fiber optic illumination power source.

1.2.2 Control Modes

There are two modes of control of the Nano Indenter® XP: automated experiment control and direct user control.

1.2.2.1 Automated Experiment Control

Automated experiment control refers to the actual performance of experiments. Once the samples are loaded and the test is defined, the test is automatically performed by the instrument. No user input is necessary during the test. All movement of the positioning stages and the indenter itself are controlled directly by the Nano Software.

1.2.2.2 Direct User Control

Direct control of the Nano Indenter® XP is necessary when loading samples or changing the indenter tip. Direct control is also necessary during the "select position of indents" section of the test set-up procedure. Some other routines, such as calibration of the instrument, provide direct control as well, but it is primarily the "Load Specimens/Manual Control" routine (Section 10.0) which requires and enables user control of the physical system.

2.0 The Computer System

2.1 Overview

The computer is the central control unit for the Nano Indenter® XP. Most of the electronics that drive the system are housed in the PC, as is the operating software and, finally, the resultant test data. The computer system is composed of the PC itself, the internal electronic cards, the printer, the monitor, the joystick, and the software.

2.2 The PC

The baseline PC used in the Nano Indenter® XP system is a 486 based PC with 4MB RAM and an 840MB Hard Drive. The internal slots are 16 bit ISA. The computer is pre-configured for the Nano Software. There is no need to install any software modules in order to use the instrument.

The locking door on the front of the PC conceals the power and reset buttons, as well as the floppy drive.

When you start the PC, the AUTOEXEC file will automatically load Microsoft Windows[1] (see Section 2.7).

2.3 The Internal Electronic Cards

The internal electronic cards drive the motion system, the indenter head, and the computer/software interface. There is no reason for the user to access the internal electronic cards. If a problem is suspected, please contact Nano Instruments.

All of the cards fit into standard ISA slots. Several of the slots are open. While it is possible to use one of these open slots for ethernet capability, this use is not supported by Nano Instruments.

2.4 The Printer

The baseline printer for the Nano Indenter® XP system is a Hewlett Packard HP LaserJet 5L Printer connected through the parallel port to the PC.

The printer is a required feature of the Nano Indenter® XP system. After the completion of an experiment run (that is, after the completion of an entire test) data is automatically printed in a pre-formatted report. If the printer is off-line, disconnected, out of paper, or out of ink, the software will pause and wait for the problem to be corrected before allowing you to continue with the Nano Software.

Refer to the printer manuals provided with the instrument for more information about

[1]Windows is a trademark of Microsoft Corporation.

printer operation.

2.5 The Monitor

The baseline monitor for the Nano Indenter® XP system is a Hewlett Packard Super VGA 14" color monitor. This monitor is connected to a video driver card in the PC. Refer to the manuals provided with the instrument for more information about the monitor.

2.6 The Joystick

The joystick used with the Nano Indenter® XP system is capable of a number of different functions. The stick itself precisely controls the X-Y tables, and can be used for "fast" moves by depressing the trigger button on the joystick. In addition, the joystick buttons and speed control knob can be used to control the optic system focussing and speed of focussing. For more information about the use of the joystick, refer to Section 10.0.

2.7 The Software

There are two significant software packages associated with the Nano Indenter® XP: HTBasic[2] and the Nano Software. Both MS-DOS and Microsoft Windows[3] are installed on the system. Use of MS-DOS is anticipated and it is possible to "shell-out" of the Nano Software in order to manipulate files via MS-DOS. For file manipulation and running external applications, a menu item in the Nano Software is provided that returns to Windows.

2.7.1 HTBasic

The HTBasic software is necessary in order to run the Nano Software. HTBasic provides the programming environment for the Nano Code. For more information about HTBasic, refer to the manuals that were provided with the instrument.

One important note: HTBasic will not run without the HTBasic "key." This key is installed in the parallel port on the PC. Do not remove this key.

2.7.2 The Nano Software

The Nano Software is activated by double-clicking on the "Nano" icon located in the Applications folder in the Program Manager.

The Nano Software uses a menu-based interface to control the instrument. The specifics of the software are described in Sections 7.0 through 11.0. These sections are the only documentation of the Nano Software you will receive.

Some useful commands that can be used with the Nano Software are:

ALT-G[4] Performs a graphic screen dump to the

[2]HTBasic is a trademark of TransEra Corporation.

[3]MS-DOS is a registered trademark, and Windows is a trademark of Microsoft Corporation.

[4]Combinations of keyboard keys are shown in all caps. Lines to be typed are shown in lower case.

	printer, requires form feed on printer
SHIFT-PRINT SCREEN	Performs a text dump to the printer
CONTROL-BREAK	Interrupts the Nano Software
run	To be typed after CONTROL-BREAK in order to restart the Nano Software
continue	Re-enters the Nano Software if possible
quit	Shuts down HTBasic and exits to Windows

Finally, an important feature of the Nano Software is the use of the function keys, which control movement through the menu structure.

2.7.2.1 The Function Keys

An important aspect of the Nano Software operation is the use of the function keys to move between menus and activate menu operations. As shown in Figure 2.1, the functions these keys perform are shown at the bottom of each menu. The function keys, of course, are the physical function keys across the top row of the keyboard.

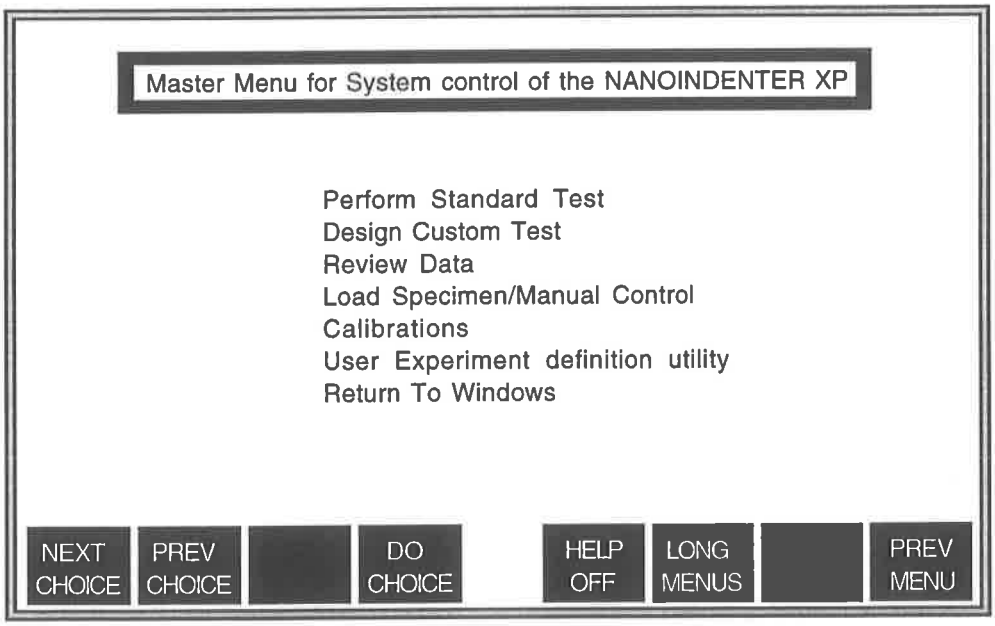

Figure 2.1 The Master Menu & Function Keys

The convention for the use of function keys is that these keys are used only to select menu options. For inputting information, or selecting default text from on-screen prompts, the "Enter" or "Return" key should be used.

There are two other additional methods for selecting menu items. The "Up" and "Down" arrow keys are also activated, and will toggle through the menu options in the same manner as the function keys. The "Enter" or "Return" key functions in the same manner as the "Do Choice" function key.

The second additional method for menu item selection is to use the trackball on the keyboard to move between menu items, and use the buttons on the lower left side of the keyboard to select items.

The more common function keys are listed in the following subsections. For specific information on function keys that appear in specific subroutines (such as "Test Motion Of Indenter") see the applicable section describing that subroutine.

2.7.2.1.1 Next Choice

The Next Choice key moves to the next menu item down in the list displayed on the screen. Using this key on the last menu item will move to the top menu item. As described above, you can also use the "Down" arrow key or the trackball for this function.

2.7.2.1.2 Previous Choice

The Previous Choice key moves to the previous menu item up in the list displayed on the screen. Using this key on the first menu item will move to the bottom menu item. As described above, you can also use the "Up" arrow key or the trackball for this function.

2.7.2.1.3 Continue

The Continue key simply resumes a function or operation in progress. This key is most often used with the on-screen help function.

2.7.2.1.4 Do Choice

The Do Choice function key executes a choice selected on screen. As described above, you can also use the "Enter" key or the keyboard trackball buttons for this function.

2.7.2.1.5 Help Off/Help On

Selecting this key will toggle the on-screen help function on or off.

2.7.2.1.6 Long Menus/Short Menu

Using this function key will toggle back and forth from the standard "short menu" to the more advanced "long menu." For more information about this option, see Section 2.7.2.2.

2.7.2.1.7 Previous Menu

The Previous Menu key steps back one level in the software to the previous displayed menu. This key is useful for aborting from specific test set-up procedures, but should certainly not be used if you want to keep information that you have input. In most cases, you will use the ALL DONE, CONTINUE ON menu function to move through the software, as this function stays within the expected path of the code.

2.7.2.2 Standard & Extended Menus

There are two essential modes of operation of the Nano Indenter® XP: The Standard Mode and the Advanced Mode. The Standard Mode is intended for use in laboratory or QC environments where push-button operation is desired and ease of use is more important than flexibility. When the instrument is in Standard Mode, only the "Short Menus" are enabled. These menus contain all options necessary to set up a test, but do not display the more advanced options that are needed less often. By default,

the Nano Indenter® XP always operates in Standard Mode.

When you switch to Advanced Mode (using the "Long Menu/Short Menu" function key) more options are displayed for configuration of tests, manipulation of data, and calibration of the instrument. These options are documented in Part Three of the operating instructions. On some instruments, the Advanced Mode may be disabled at the request of the customer, or per specific arrangement for the end use of the instrument. In such cases, Part Three of the operating instructions will not be supplied as a part of this manual.

2.7.2.3 Exiting The Nano Software And Returning To Windows

To exit the Nano Software, simply use the "Return To Windows" option located on the Master Menu screen of the Nano Software (see Figure 2.1).

2.7.3 MS-DOS

To use MS-DOS, you must select the MS-DOS icon in the "Main" folder in Windows.

3.0 The Motion System

3.1 Overview

The sole function of the motion system in basic operation is to move the samples from the microscope focal point to under the indenter, and then to move to each position for indentation. There are three subsystems in the motion system: the positioning tables, the sample mount, and the limit switches.

3.2 The Positioning Tables

The positioning tables are cross-roller bearing supported, lead screw driven stages. The motors, gearboxes, and encoders that interface with the tables are enclosed in the gantry. There should be no reason for the user to access these components.

The Positioning Table subsystem is composed of two stages, the X stage (lower stage) and the Y stage (upper stage). Two rails are mounted on the Y stage. These rails are used to attach the sample mount.

3.3 The Sample Mount

The sample mount system consists of the clamping mechanism and the sample tray. The following directions for the loading of the sample tray into the Positioning Tables is intended as a physical description of the process. For information about using the joystick and keyboard commands to control the motion of the positioning tables (i.e., to position the tables in order to load the sample tray), refer to Section 10.0.

3.3.1 Loading the Sample Tray Into the Rails

The tray slides into the rails on the Y stage, and the clamping mechanism slides into the vertical posts on those rails, and the slot on the sample tray. Turning the clamp screw forces the sample tray into the wedges on the rails, and tightly locks the sample tray in place.

3.3.2 Removing the Sample Tray From the Rails

Removing the sample mount tray from the rails is a simple reversal of the procedure described above. Given the force applied when turning the clamp screw, it will be necessary to loosen the clamp screw before the tray will be able to easily slide out of the wedges on the rails (see Figure 3.1). Simply turn the clamp screw until the tray slides toward you.

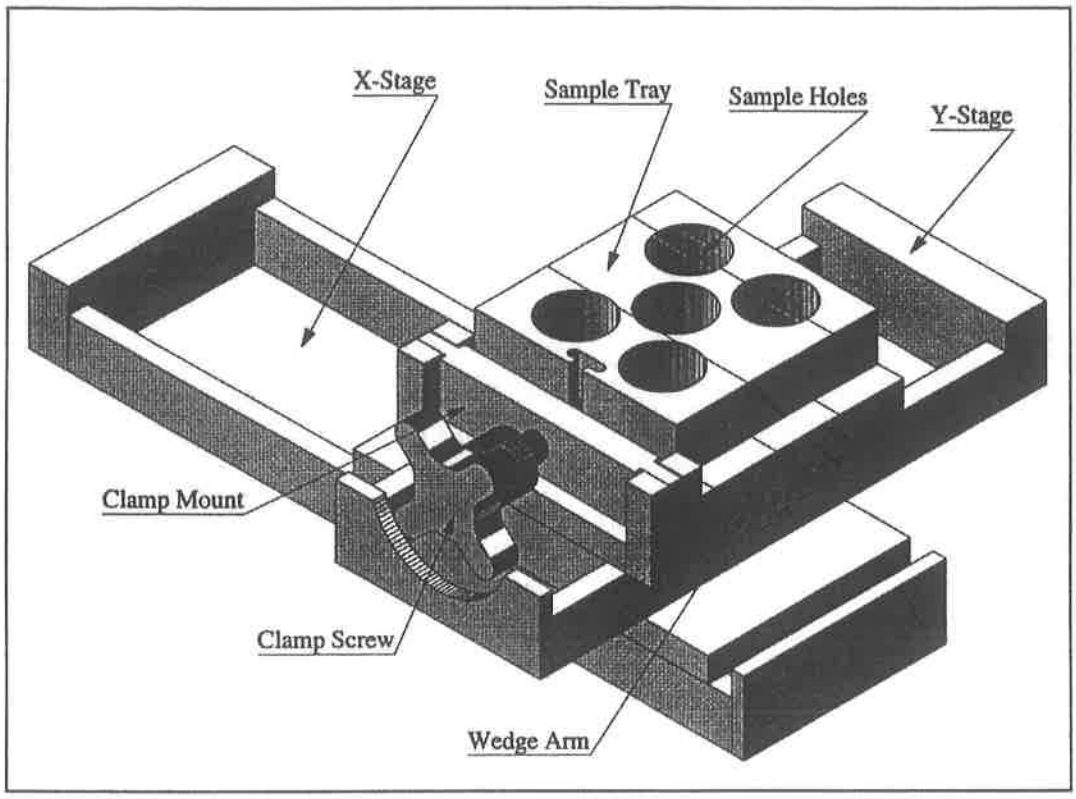

Figure 3.1. The Sample Tray Mounted On The X-Y Stages

3.3.3 Loading Samples Into The Sample Tray

The standard sample tray can accept up to five samples on standard metallographic mounting disks (1.25" diameter, 1" height). To load the samples, insert the sample disk into the bored sample hole and tighten the set screw in place against the sample disk. Repeat this procedure until all desired samples are loaded. Once the samples are loaded, and all are tightened in place, turn the sample mount tray upside down so that the levelling arms are facing downward, and set the sample mount tray on a flat, smooth, and lint-free surface. Loosen all of the sample disks, so that the sample tray rests entirely on the sample levelling arms. Once all of the samples are loose and resting against the "flat surface," retighten the set screws until each sample disk is fixed firmly in place. Turn the sample tray back over, and sight across the levelling arms to ensure that all of the samples are even and level. The sample tray is then ready to load into the rails (see Figure 3.2).

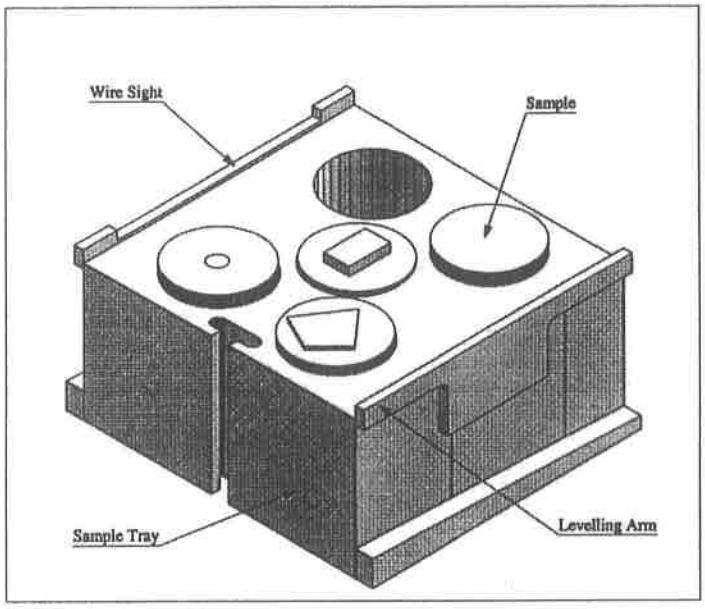

Figure 3.2. The Sample Tray With Loaded Samples

3.4 The Limit Switches

The limit switches are inaccessible to the user. When moving the tables, however, the stage can be driven until the limit switches are tripped. Once they are activated, the limit switch routine will assume control of the positioning tables and move them back and away from the limit switches. This safety precaution is used to prevent "locking" the tables against the end stops, which could result in damage to the gearmotors.

3.5 A Warning Concerning The Motion System

If the indenter is ever damaged, it is most likely the motion system that is the immediate cause of the damage. This can occur in a number of ways. While the Nano Indenter® XP is an extremely robust system, excessive force applied laterally to the indenter shaft can result in internal damage to the displacement sensing system, a misalignment of the load application system, or, most likely, damage to the diamond tip itself. The following warnings should minimize the possibility of accidentally damaging the system.

3.5.1 Mounting Samples At Improper Height

It is important that the proper height for the exposed portion of the sample be established. When the instrument arrives at your site, the levelling arms will have been adjusted for this height. Depending on sample use and mounting procedures, it is possible for you to change this "default" sample height. Although the indenter is retracted into the indenter housing, you should take care that the samples are not mounted too high in the sample tray. The maximum height of the samples must be lower than the bottom of the indenter housing.

If the samples are mounted too low in the sample tray, the indenter will not be

able to reach the surfaces, causing the experiment run to abort, but no damage to the system will ensue.

3.5.2 Mounting Samples At Unequal Height

Not only must the samples be mounted at the proper height, but all of the samples surfaces must be at the same height. If there is a large deviation in height from one sample to the next, problems can arise during indentation.

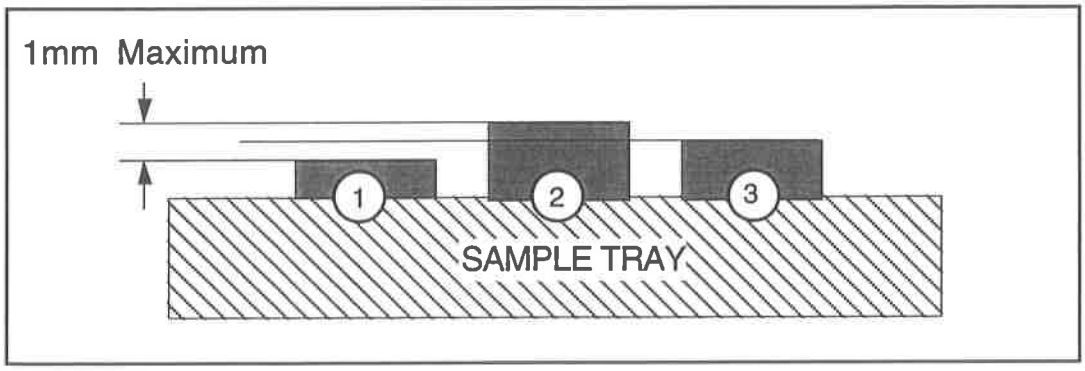

Figure 3.3. Maximum Sample To Sample Height Deviation

The maximum allowable deviation between sample height is 1mm. This deviation is measured from the "highest" sample to the "lowest" sample.

3.5.3 Samples With Surface Height Variation.

Some samples themselves will have unusual geometries that require care in setting up the test. A good example of this type of sample is the micro-cantilever beam. It is important to select the proper indentation site so that the indenter is not struck from the side during a repositioning operation.

3.5.4 Surface Slope

While the indenter will automatically compensate for significant sloping of the sample surface, care should be taken that the surface slope does not exceed about 3°. The maximum height compensation the indenter can achieve during a single array of indentations is 1mm.

4.0 The Optics System

4.1 Overview

The Optics system is almost entirely enclosed inside the gantry. However, adjustments to the optics system can be performed without the need to open the body of the gantry. These adjustments include insertion of different objectives, parcentricity adjustment, polarization, iris diaphragm adjustment, and intensity control. Re-alignment of the optic system requires access to the inside of the gantry, and is not recommended without specific instructions from Nano Instruments.

The major components of the optics system are the microscope, the video monitor, and the illuminator.

4.2 The Microscope

The microscope body is fully contained with the Nano Indenter® XP gantry. The only exposed region is at the base of the microscope, in the working area of the gantry. It is in this region that removal of the objective occurs, and all adjustments to parcentricity are made here as well.

There should be no need for the user to access the video camera, microscope alignment screws, or optic focus motor, all of which are housed inside the gantry.

One particular aspect of the microscope's operation is worth noting here. The microscope moves in the Z-direction on an eccentric bearing. Thus, moving the microscope continuously "downward" will result in an upward motion once the bearing rotates past the point of maximum eccentricity. See Section 10.0 for more information about operating the microscope focussing.

4.2.1 Inserting And Removing Objectives

Objective lenses for the Nano Indenter® XP optics system are mounted on precision slides so that they can be interchanged easily. Parcentricity adjustment of the objectives is also enabled by these slides, so that each objective can be aligned and interchange can be accomplished without a need to re-find positions (see Section 7.0). To insert an objective mounted on a slide, simply grasp the objective itself, turn the slide so that the parcentricity adjustment screws point to the front and right sides of the slide, and insert the slide into the mounting rails on the microscope until the slide snaps into place (see Figure 4.1).

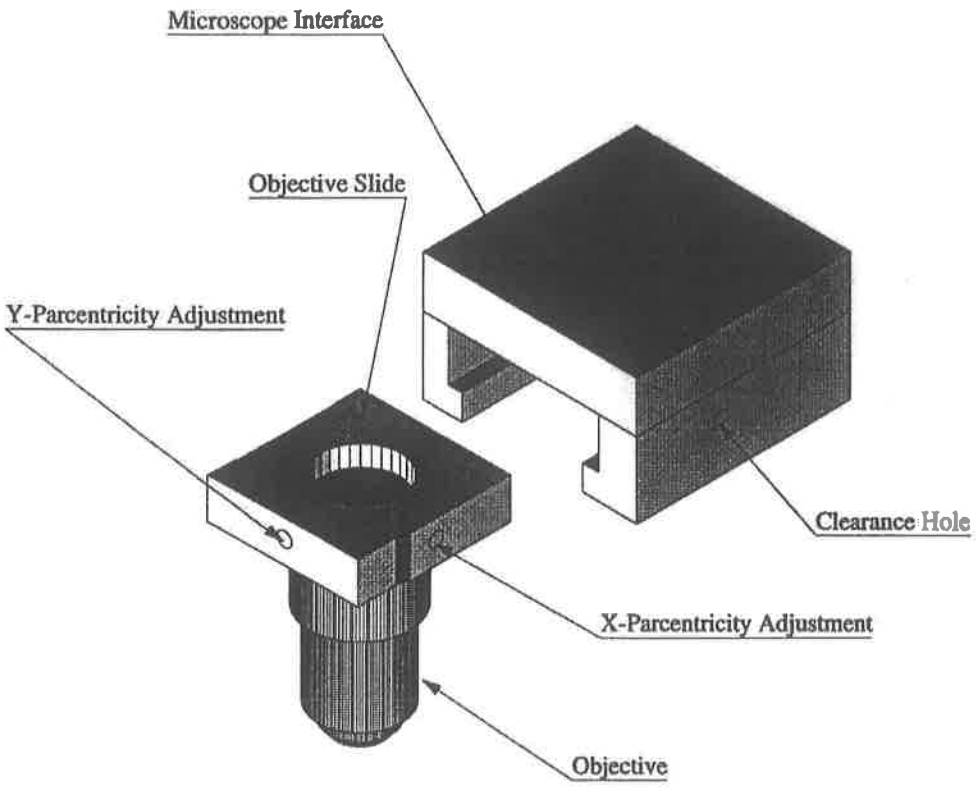

Figure 4.1. Inserting The Objective Slide

To remove the objective, simply reverse the procedure, grasping the objective and sliding it out of the mounting rails.

Because of the nature of the infinity-corrected optics, some height deviation exists in the focal points of the objectives. While this height deviation is insignificant between the higher power objectives, the deviation between the 5X and 20X objectives is large enough to require additional height adjustment of the objective. This height adjustment is accomplished with a spacer ring, which is added to all objectives except the 5X. Make sure that this spacer ring (threaded between the objective and the slide) is in place on higher power objectives.

4.2.2 Adjusting The Parcentricity

Adjustment of the parcentricity, or the X-Y focal location is an iterative process. While the adjustment screws themselves are oriented in the X-Y directions, turning the screws results in an "angular" movement of the focal location. Obviously, the travel enabled on the 5X objective will be less "effective" in terms of screen location than the travel enabled by the higher power objectives. Some adjustment of all objectives will probably be necessary. That is, for an 80X objective to be aligned to the same point as the 5X objective, the 5X objective may need to be set to a different focal location so that the 80X objective adjustment range can meet with that of the 5X objective (see Figure 4.2).

Adjustment is performed with the objective mounted on the microscope. The parcentricity adjustment screws themselves are mounted in the objective slide.

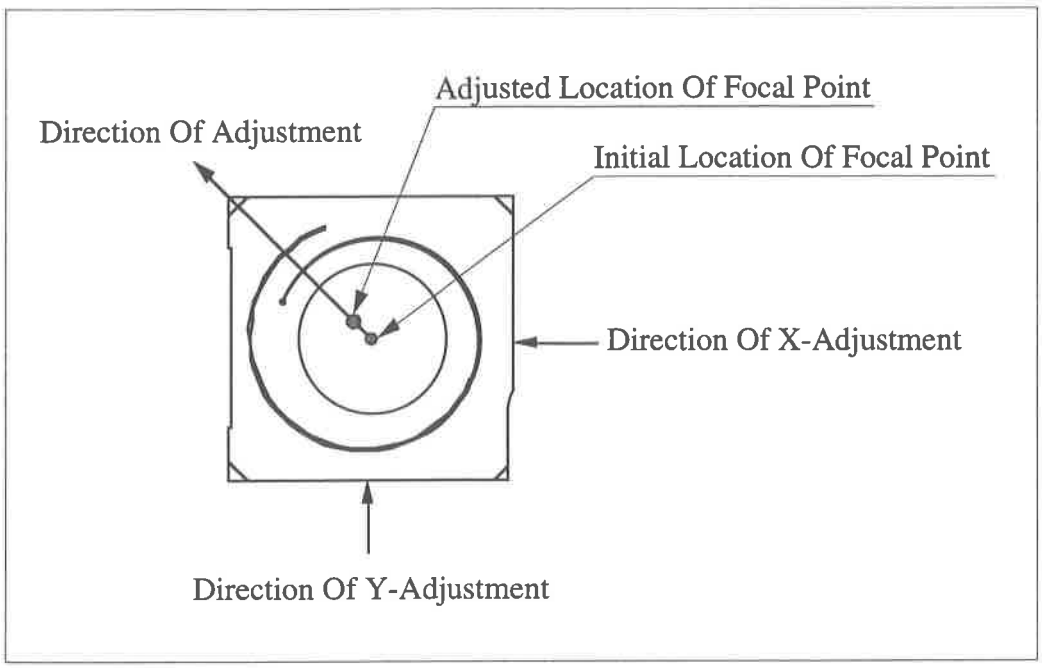

Figure 4.2. Adjustment Of Parcentricity.

There is a clearance hole drilled through the side of the microscope mounting rails so that the "X" direction adjustment screw can be reached while the slide is in place. To turn the adjustment screw, use a metric 1.5mm allen wrench.

4.2.3 Adjusting The Polarization

The optic system polarizer is located inside the gantry, and is adjusted by means of a push rod that extends through the front of the gantry. This push rod simply rotates a polarized lens relative to a fixed polarized lens.

4.2.4 Adjusting The Iris Diaphragm.

The iris diaphragm is located inside the gantry, and is adjusted by means of a push rod that extends through the front of the gantry. This push rod simply opens and closes the iris.

Centering of the iris is performed at Nano Instruments. There should be no need to adjust the iris center once the instrument is at your site. Contact Nano Instruments if you have questions about the center point of the iris.

The iris diaphragm is sometimes useful in finding the surface of very smooth or translucent specimens. By partially closing the iris, then focussing on the iris itself, you can get a very good estimate of the focal point on the sample.

In additional, opening or closing the iris can enhance the contrast on the sample surface.

The best iris position should be determined through use of the instrument.

4.3 The Video Monitor

The video monitor included with the system is the only output location for the optics system camera. Refer to the manual included with the instrument for more information about the video monitor.

4.4 The Illuminator

The fiber optic illuminator is located with the PC and other remote operating equipment. The illuminator features a power switch and an intensity control knob. The intensity is adjustable from 0 to 100%. The fiber optic cable from the illuminator to the microscope system plugs into the front of the illuminator.

The illuminator uses a halogen bulb, USHIO part number EKE 21V 150W. If you need replacement bulbs, contact Nano Instruments, or your local representative.

5.0 The Gantry & Isolation Systems

5.1 Overview

The Nano Indenter® XP is a complete system, including all components necessary for operation of the instrument. These components include the gantry housing for the primary components of the instrument and the isolation systems that enable operation in otherwise unsuitable environments.

5.2 The Gantry

The Nano Indenter® XP gantry provides isolation of the internal components of the indentation, positioning, and optic systems. All areas of user interface are left exposed, while the cables, electronics, and mechanical parts are enclosed in either the gantry itself or the protective back cover.

There should be no need for the user to access the inside of the gantry. All cable connections are provided on the outside surface of the gantry. There are no user-serviceable parts inside the gantry body.

If you suspect there is a need to access the inside of the gantry, please contact Nano Instruments first in order to avoid damage to the internal components.

5.3 The Isolation System

The isolation system for the Nano Indenter® XP is divided into two major components: the environmental isolation cabinet and the vibration isolation table.

5.3.1 The Environmental Isolation Cabinet

In order to prevent thermal or acoustic disturbance of the system during operation, the Nano Indenter® XP is provided with a cabinet that fully encloses the system. The cabinet is constructed of wood and lined with eggshell foam so that it provides maximum internal damping of air movement.

For best results, the instrument should always be operated with the cabinet closed.

A useful technique for taking advantage of the thermal isolation provided by the cabinet is to leave your samples in place for several hours prior to testing, so that the samples reach equilibrium with the thermal mass inside the cabinet.

5.3.2 The Vibration Isolation Table

The Vibration Isolation table is separated from the isolation cabinet for maximum protection against transmitted mechanical vibrations. The isolation table is constructed of two primary components: the legs and the table top. The legs

contain pneumatic pistons that support the laminated granite table top. When these pistons are properly levelled and provided with the correct air supply, the table can attenuate at least 90% of all vibrations above 7 Hz.

6.0 The Indenter Head

6.1 Overview

The Indenter Head is the heart of the Nano Indenter® XP. All of the other subsystems can be considered as support systems for the indenter head. While the body of the indenter head is enclosed within the gantry, the active area is exposed. This active area is limited to the indenter's diamond tip, which is only exposed during operation of the instrument, or when no power is supplied to the indenter's loading system.

6.2 The Diamond Tip

While operation of the indenter is achieved entirely through the Nano Software interface, there are some occasions when you will work directly with the indenter head itself. The most notable occasion is during the tip change procedure (see Appendix A).

The most common diamond tip geometry used with the indenter head is the Berkovich diamond. The Berkovich diamond is a three sided pyramid-shaped indenter, whose e follows the same function as the Vickers indenter.

Any diamond indenter geometry that is desired can be used with the indenter head, provided that the diamond mount is configured to fit into the indenter shaft. Contact Nano Instruments for more information about alternative diamond tip geometries.

6.3 Working With the Indenter Head

Any time you are working near or with the diamond tip, you should be careful not to accidentally strike or move the indenter, as it is possible to damage the indentation system.

You should be most careful to avoid applying lateral forces to the indenter shaft, as this is the most likely way to cause damage to the displacement sensing system.

It is useful to occasionally run diagnostic routines to test the indenter head. The most useful of these routines are the DAC calibration (Section 11.2.2) and the Test Motion Of Indenter function (Section 11.2.3).

If you suspect that the indenter head has been damaged or is not functioning correctly, it is likely that the results of the DAC calibration or the Test Motion procedure will be required in order to correctly diagnose the problem. Thus it is worthwhile to familiarize yourself with these routines.