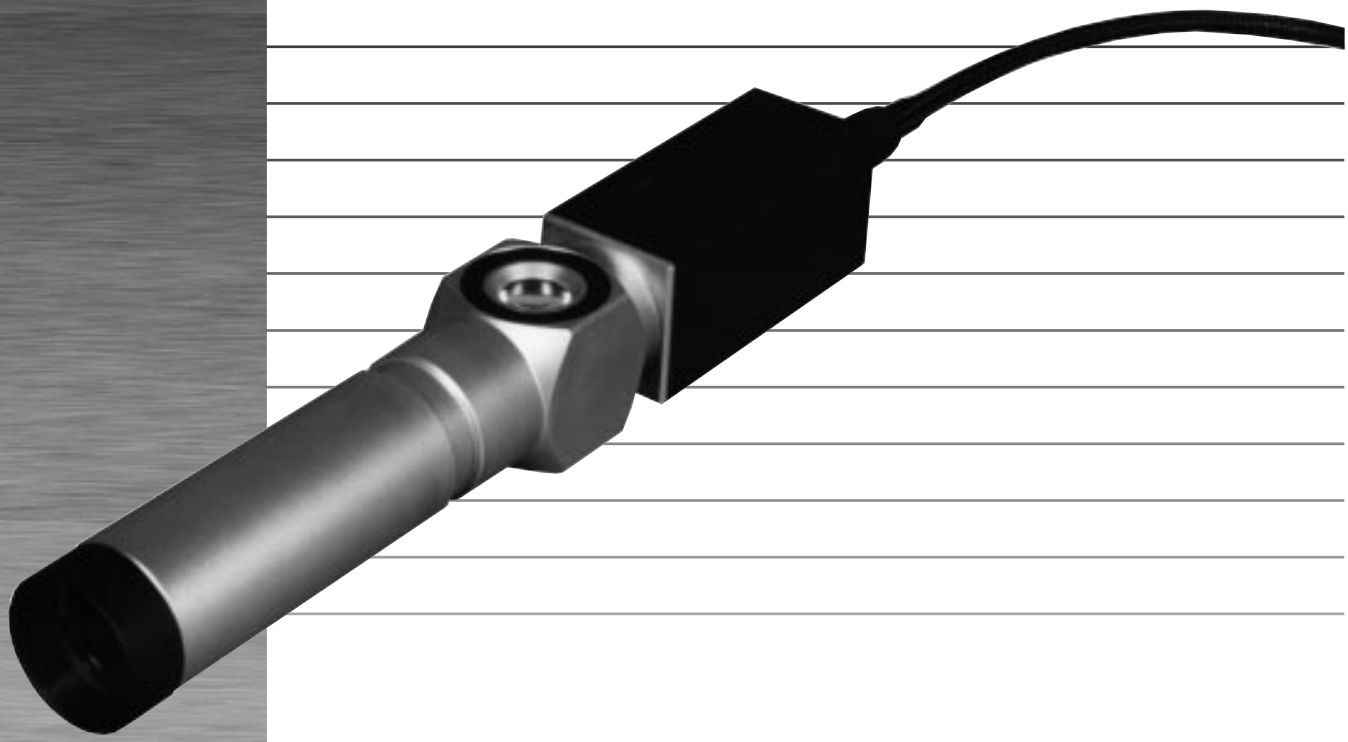
LAE500 Electronic Autocollimator



USER'S MANUAL

Newport

Warranty

Warranty

Newport Corporation warrants this product to be free from defects in material and workmanship for a period of 1 year from the date of shipment. If found to be defective during the warranty period, the product will either be repaired or replaced at Newport's option.

To exercise this warranty, write or call your local Newport representative, or contact Newport headquarters in Irvine, California. You will be given prompt assistance and return instructions. Send the instrument, transportation prepaid, to the indicated service facility. Repairs will be made and the instrument returned, transportation prepaid. Repaired products are warranted for the balance of the original warranty period, or at least 90 days.

Limitation of Warranty

This warranty does not apply to defects resulting from modification or misuse of any product or part. This warranty also does not apply to fuses, batteries or damage from battery leakage.

This warranty is in lieu of all other warranties, expressed or implied, including any implied warranty of merchantability or fitness for a particular use. Newport Corporation shall not be liable for any indirect, special, or consequential damages.

Statement of Calibration

This instrument has been inspected and tested in accordance with specifications published by Newport Corporation.

The accuracy and calibration of this instrument and photodetector (where applicable) is traceable to the "Bureau National de Métrologie" ie. French National Institute for Standards, through equipment which is calibrated at planned intervals by comparison to the certified standards maintained at Newport Corporation.

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LAE500
Electronic Autocollimator

We declare that the accompanying product, identified with the "CE" mark, meets all relevant requirements of Directive 89/336/EEC for Electro-Magnetic Compatibility.

Generic Standard:	Emission	EN50081-1
	Immunity	EN50082-1

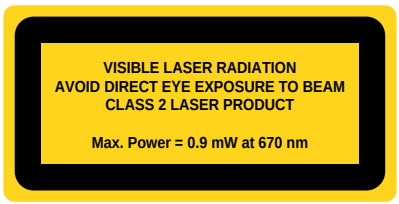
"Residential, Commercial and Light Industry" Standards.

Newport Corporation shall not be liable for damages when using the product:

- Modification of the product.
- Using modified connector, or modified or not supplied cables.
- Connecting this product to non-CE equipments.
- Heavy industrial environment.

Section 1
Introduction

1.1 Warnings



1.2 Your autocollimator

The LAE500 autocollimator is a compact and self-contained measuring instrument. Electrically connected to its electronic controller, LAE500 displays angular variations measuring the position of a spot of light on a detector. The electronic controller has the capacity to store up to 2048 measures and to calculate the averages of these angles.

When linked to a personal computer the LAE500 becomes a very powerful measuring tool. This interfacing allows for the treatment of data for further analysis.

This manual is designed to facilitate the use of the LAE500 autocollimator for all its function modes.

1.3 Equipment

The electronic autocollimator is delivered with the following accessories:

- 1 LAE500 optical head in a protection case.
- 1 Calibration curves and correctives coefficients.
- 1 User manual.
- LAEDEMO 3” $^{1/2}$ disk.
- 1 RS-232-C cable + 1 adaptor Sub-D 25 → Sub-D 9.

The interface cable (5 m or 10 m) and the controller with the protective packaging are delivered separately.

1.4 Specifications

1.4.1 General characteristics

The angular values described correspond to the angular values of the measuring mirror.

	Radians	Degrees
• Resolution (display)	0.1 µrad	0.02 arc-s
• Measurement range α	±2000 µrad	±7 arc-mn
• Error	1 + 2 α / 100 µrad	0.2 + 0.02 α (arc-s)
• Working distance (max.)	20 m	
• Diameter of mirror (min.) [R ≥ 90%]	10 mm	
• Occular field (viewable travel)	±15 mrad	±52 (arc-mn)
• Total average noise	0.1 µrad/√Hz	0.02 arc-s/√Hz
• Sampling frequency (max.)	2 kHz	

The above characteristics are guaranteed under the following conditions:

- Operating temperature : + 15 °C to + 25 °C
- Storage temperature : -10 °C to + 50 °C
- Humidity : 10% to 80%

Optical head	**LAE500-H**
• Laser diode	: 670 nm
• Power limit	: 0.9 mW
• Sinusoidal modulation	: 10 kHz
• Beam diameter	: 31 mm
• Divergence	: 0.1 mrad
• Equivalent F.L.	: 280 mm
• Mass	: 0.9 kg

Controller	**LAE500-C**
• Microprocessor	: 68000 (32 bits - 16 MHz)
• Display	: 2 x 20 characters (adjustable display panels)
• Interfaces	: RS-232-C and lEEE-488
• Power supply	: 220 V or 110 V, 50 Hz or 60 Hz
• Consumption	: 110 W
• Fuses	: 0.5 A (220 V)
	: 1 A (110 V)

1.4.2 Measuring characteristics

Linear error

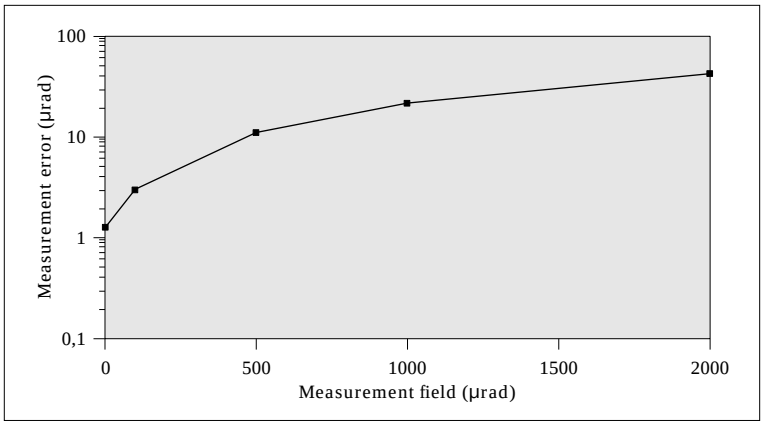
The total error is the sum of the following errors:

- Detector linearity.
- Air turbulence.
- Electronic noise on amplification.

The controller performs a linear correction on the measurements. The residual error is less than 2%. A linear graph in relation to the angle measured is supplied with each detector. Corrective factors are thus established which are then entered into the controller (SETUP mode). The graph below gives the maximum error in relation to the angle range.

Error in function with the angle range

1 + 2 * Angle/100 in µrad



Measurement range

The LAE500 operates for autocollimator/mirror distances up to 20 m. However, as the distance increases the measurements range becomes more limited.

Distance (m)	Range (mrad)
0	±2.0
4	±2.0
5	±1.8
7	±1.4
9	±1.0
10	±0.8
14	±0.6
20	±0.2

Integration noise

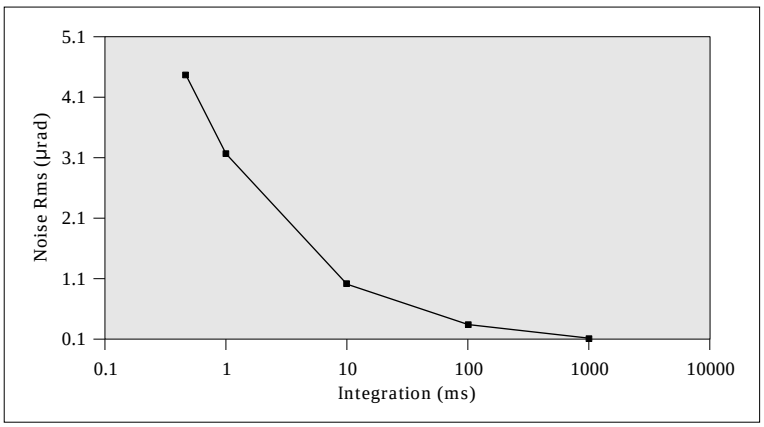
In order to reduce the electronic noise and turbulence, it is possible to select an integration time between 0.5 ms and 1000 ms.

Maximum 2 kHz acquisition frequency performs an analog to digital conversion, with a resolution of 4.4 µrad.

In order to get a 0.1 µrad resolution the signal must be integrated on 1000 ms. (2000 measurement points). The curve below gives RMS value of electronic noise according to the programmed integration duration.

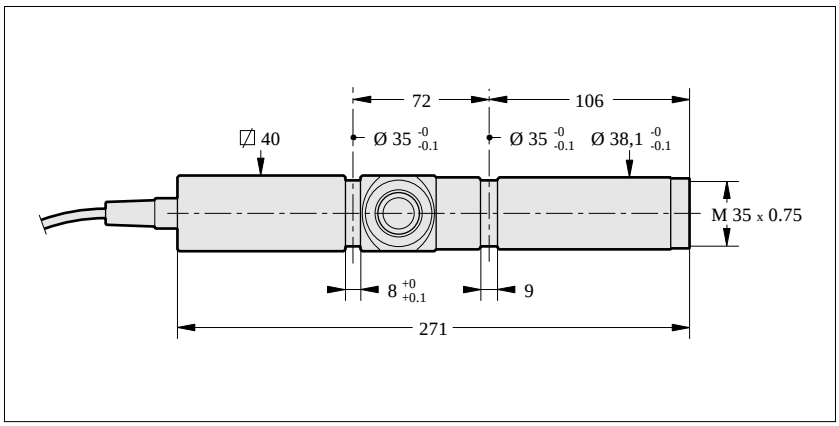
Total average noise

0.1 µrad/√Hz

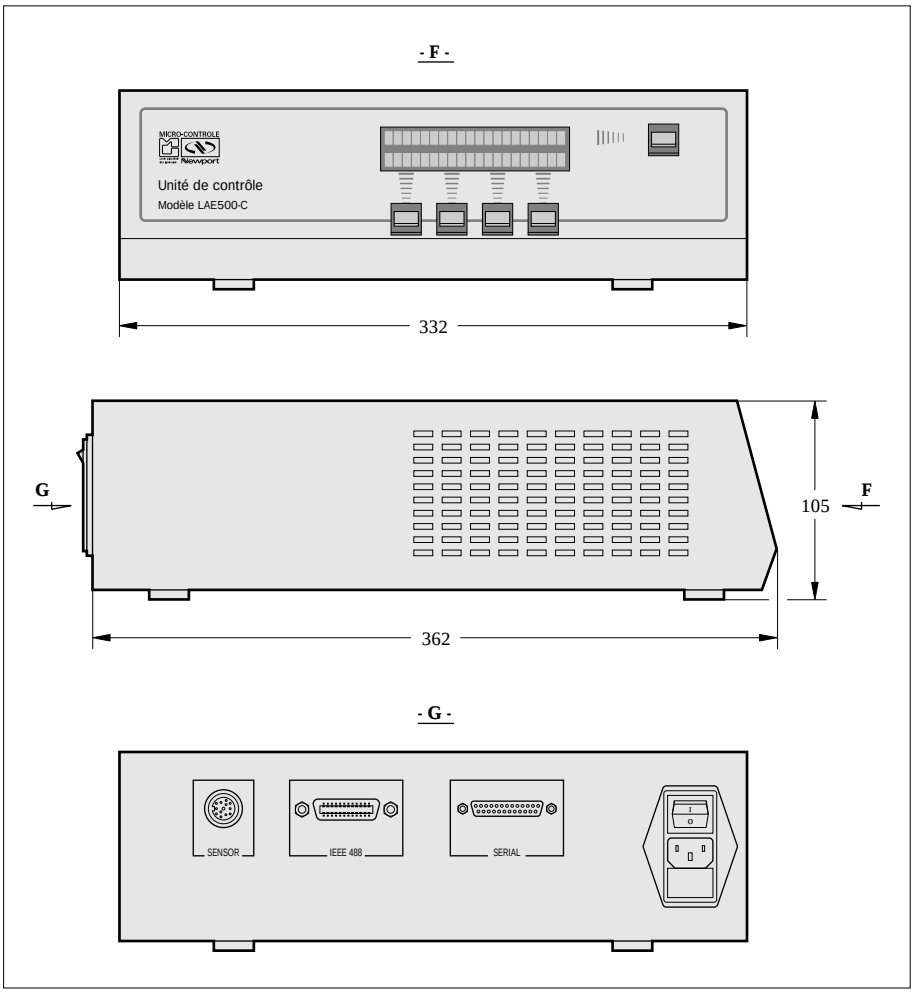


1.5 Description

1.5.1 Optical head LAE500-H



1.5.2 Controller LAE500-C



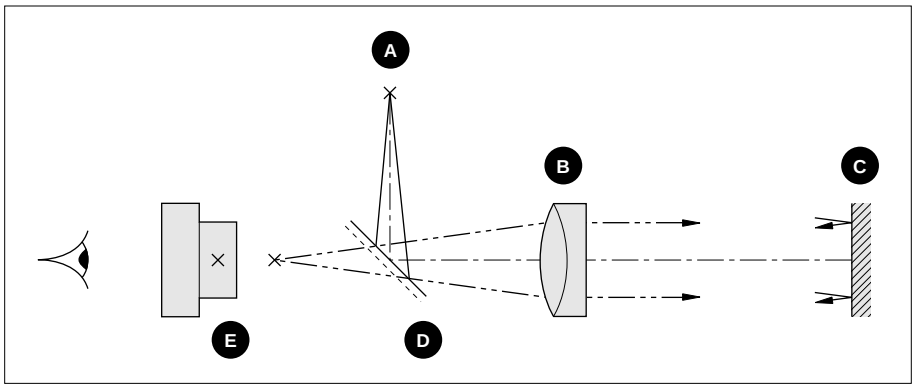
Section 2
Principle of operations

2.1 Basics

The LAE500 autocollimator is based on the well known principle of autocollimation.

Standard autocollimator uses a back illuminated cross light reticle **A**, located at the back focal plane of a collimating lens **B**.

The consequent image is projected to the infinity, to be reflected back to the instrument with a plane reflecting mirror **C**.



LThe reflected image is focalised in the back focal plane of the collimating lens. A beamsplitter **D** is used to collect 50% of the returned light to form an image of the source reticle. Most instruments are using a measuring eyepiece **E** with a dark cross reticle to observe this autocollimating image.

If the direction of the reflected image superposes with the incident beam, one says that the mirror is in autocollimating position. In this case, the last image of the source reticle will superpose with the dark cross line reticle of the eyepiece.

For each angular movement of the mirror **C**, a lateral displacement can be seen for the reflected image in the back focal plane of the collimated lens.

If the value of the focal length of the collimated lens is F, then the lateral displacement will be:

$$\Delta Y = F \times \tan(2\Delta\theta)$$

where $D\theta$ is the angular displacement of the mirror.

This displacement can be measured, using the measuring eyepiece by two ways:

- Mechanical angular movement of the autocollimator $\Delta\alpha$ in order to re-center the reflected image onto the dark reticle (then $\Delta\theta = \Delta\alpha$).
- Lateral movement of the measuring cross reticle to measure ΔY (then $\Delta\theta = \Delta Y/2F$).

Autocollimating principle is a common method to check and align optical elements, such as laser cavities, fabry perot, and is used in all optical workshop to measure prism characteristics and angular deviations.This is also a useful tool to measure table flatness. Mostly, these operations are made manually.

2.2 Electronic autocollimator

The advantage of the electronic autocollimator is to provide an automatic way to perform these measurements.

Then:

- It is possible to perform fast measurements.
- It is possible to get average values of a large number of measurements.
- It gives a way to make automatic alignments.

In the LAE500 Electronic autocollimator, the basic principles are used to get the values of angular displacements:

- The source reticle is a Laser diode.
- The measuring eyepiece is a position sensing device.

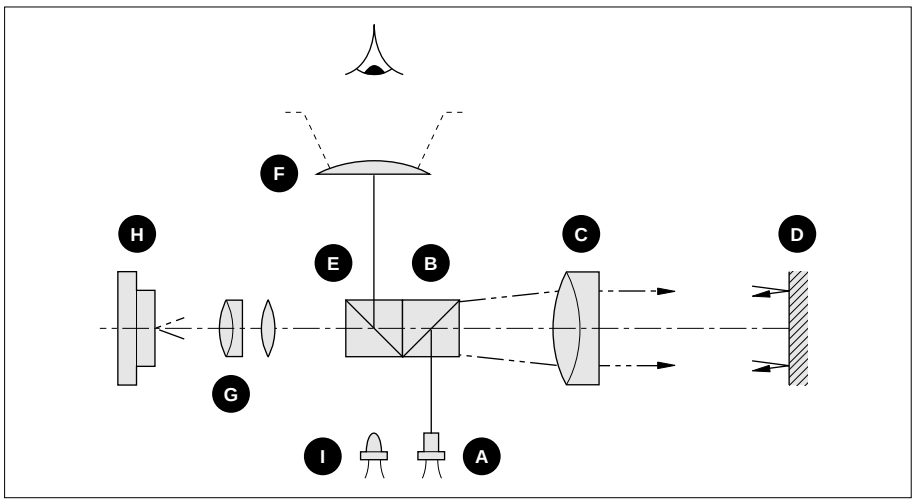
Laser diode spécifications

- 0.5 mW laser diode; λ = 670 nm.
- 10 kHz modulation.

Position sensing device

- Sensing area: Delivers Analog signals proportionnal to the spot ligth positions (Vy and Vz).

The reflected beam is focalised onto the position sensing device and thus the two analog signals are used to calculate the angular deviations.



Description

A Laser diode module
B Beamsplitter I
C Collimating lens
D Mirror
E Beamsplitter II
F Alignment eyepiece
G Magnifier
H Position sensing device
I Lighting LED (red)

One part of the light is used to allow a simple visual first alignment (visible laser diode). A centered circle indicates the acceptance zone for automatic recording.

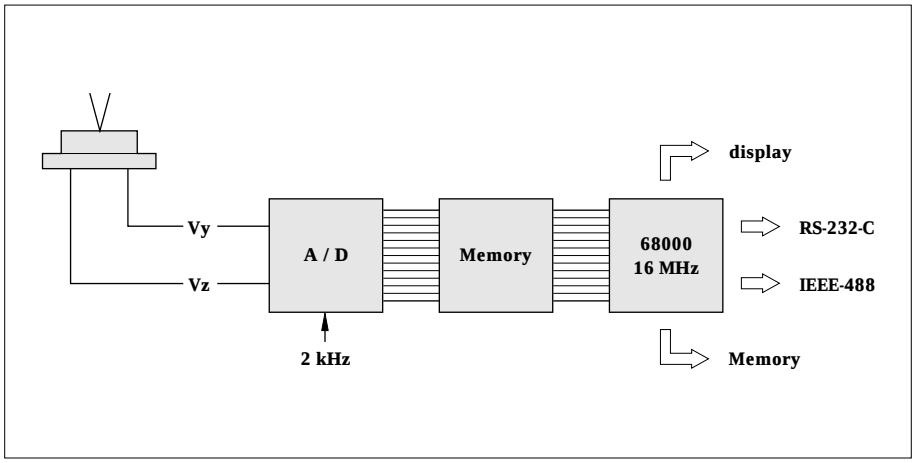
Equivalent focal length, combining the collimating lens and the magnifier, is equal to 280 mm.

2.3 Electronic controller

The LAE500 autocollimator must be connected to its electronic controller.

The electronic controller performs fast acquisition, analog to digital conversion, correction and integration computation, and memory management.

Based on a 68000, 16 MHz processor, it allows communications via RS-232-C or IEEE-488 interfaces.



Section 3
Setting up: Precautions

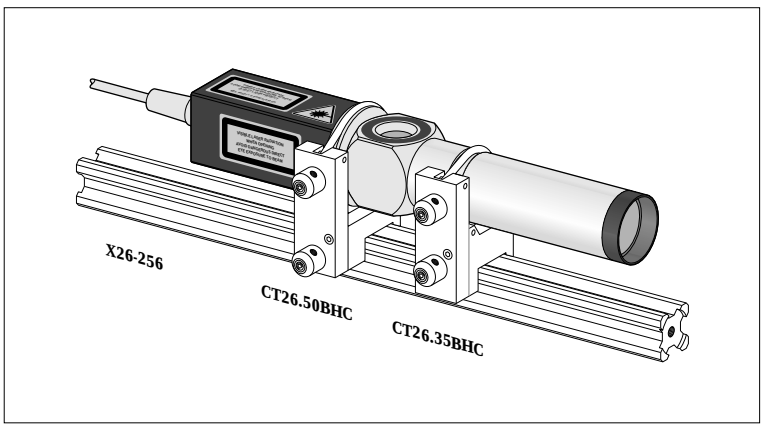
3.1 Mounting

The angular variation measurements between the optical head and the reference mirror require specific precautionary measures regarding the quality of these components. This is particularly important for the autocollimator, mirror and their corresponding supports.

Depending upon the assembly, the autocollimator will either be stationary or on an angular adjustment cradle or a goniometer.

3.2 Accessories

The LAE500 autocollimator is supplied with an adaptor and 2 half shells.



Adjustable assembly is possible using CT26.35 and CT26.50 clamp supports on an X26 microbench. The optical axis height obtained is 73.5 mm if the microbench is mounted on two carriages CN26.12, or 75 mm adding two spacers.

Adjustable CT 26.35 tube support	**CT26.35BHC**
Adjustable CT 26.50 tube support	**CT26.50BHC**
X26 microbench, length 256 mm	**X26-256**
Carriage CN26.12	**CN26.12**
Spacers	**RH-X26**

Stationary assembly is facilitated by the LAE500 flange clamp. Mounting is possible on any type of mechanical assembly with the mounting clamp and 3 M5 screws. This clamp may be fixed to an X26 microbench using two CN26.12 carriages. The optical axis height obtained is 73.5 mm if the micro-bench is mounted on two carriages CN26.12, or 75 mm adding two spacers.

LAE500 Mounting clamp	**LAE-FIX**
X26 microbench, length 256 mm	**X26-256**
Carriage CN26.12	**CN26.12**
Spacers	**RH-X26**

Other assemblies are possible using manual or motorized goniometric cradles (see Newport General Catalog).

The positioning of the measuring mirror requires an adapted support. Mounting should be rigid but should not stress the mirror.

A reflecting mirror should be used for the measuring mirror:

- Rate of R_m reflexion at 670 nm; D_m diameter such as:
  - $R_m \times D_m^2 \geq 90$ mm^2 if Dm ≤ 31 mm, otherwise $R_m \geq 10\%$.
- Noise = $0.1 \times \frac{100\,000}{R_m \times D_m^2}$ µrad/√Hz, with $D_m \leq 31$ mm.
- Mirror quality:
  - PV 1 fringe for 25 mm.

Recommended mirror

50.8 mm diameter - 0° – 45°	**20D04DM.4**

The mirror mounts chosen will depend on the type of application.

Flatness control, granite type

Recommended mirror Ø 50.8 mm - 0° – 45°	**20D04DM.4**
Mirror mount	**SK51BD**
Bridles and screws	**M-BR4**

This mirror mount must be fixed by 2 M6 screws or 4 bridles on a table square. An axis height of 75 mm, compatible with the LAE500 support will be thus obtained.

Lightweight structures control

Recommanded mirror: or	Ø 25.4 mm - 0° – 45°	**10D10DM.4**
	Ø 50.8 mm - 0° – 45°	**20D04DM.4**
ULTIMA mirror mount for mirror	Ø 25.4 mm	**U100-A**
	Ø 50.8 mm	**U200-A**

This mirror support will be fixed on to the structure or on to an adapted frame.

Vibration control

Recommended mirror Ø 25.4 mm - 0° – 45°	**10D10DM.4**
Mirror mount	**M-MM-1**

This mirror will be glued to the vibratory structure either directly or on to the light weight mount which enables mirror adjustment.

3.3 Environment

Ambient air turbulences cause a considerable amount of noise on measurements taken when the autocollimator/mirror distance increases. Turbulence in the vicinity of the measuring bench should be minimized to obtain proper results.

Tests carried out in our workshop, whose environment, between the laboratory and the machine shop, could be considered as average, showed that atmospheric turbulence evolved at 1 µrad per meter to stabilize at 6 µrad after 6 m. Tests showed the presence of very weak frequency variations which were difficult to take into account.

3.4 Connections

CAUTION

BEFORE CONNECTING
CHECK THAT ALL EQUIPMENT
IS SWITCHED OFF

The cable provided with the LAE500 facilitates the linkage between the LAE500 electronic autocollimator and the controller. The male part should be connected to the optical head, the female part to the controller. Please ensure that all connections are correctly screwed in.

The cable is available in 2 standard lengths:

LAE500 cable, length 5 m	**LAE-5**
LAE500 cable, length 10 m	**LAE-10**

For longer lengths please consult us.

A 110 V/220 V selector is used as a fuse holder.

CAUTION

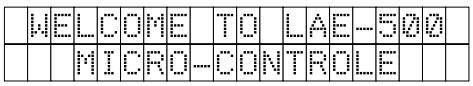
CHECK THAT THE SELECTOR
IS SET AT THE CORRECT
VOLTAGE POSITION

Set the switch to “0” (OFF) position.

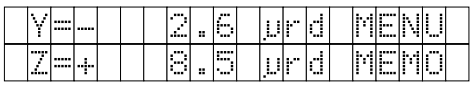
3.5 Power up sequence

Link up the controller to the mains. Set the switch to “I” (IN).

Once turned on, the controller goes to its initialization phase and displays a welcome message.

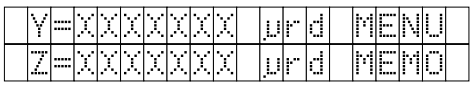


Then, the display of values measured according to programming parameters is displayed:



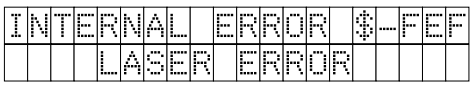
This presumes that the autocollimator is stationary in front of a mirror which sends the correct beam into the measuring range (see following section on alignment).

In other cases, the controller displays a series of 7 X’s instead of the value measured on the given axis:



See following section on alignment.

Other possible messages:



LASER ERROR: This message indicates a connection error in the optical head or a diode laser emission fault.

3.6 Alignment

To take an angular measurement it is necessary to ensure that the return beam penetrates the LAE500 autocollimator and that the return energy is powerful enough.

In other cases, the controller displays a series of 7 X's instead of the value measured on the given axis:

	Y	=	X	X	X	X	X	X	X		µ	r	d		M	E	N	U
	Z	=	+			8	.	5			µ	r	d		M	E	M	O

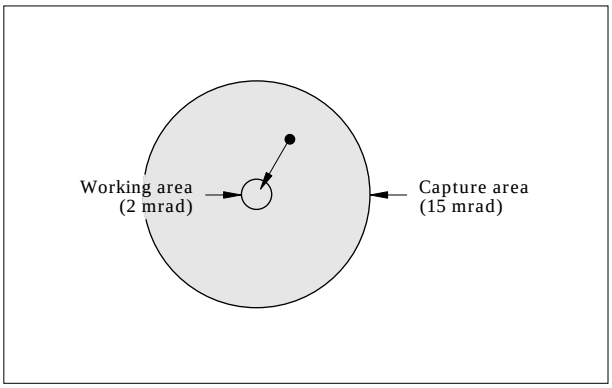
The beam must first be directed at a reflecting mirror.

The usable laser derives from a punctual source, diode laser 1 mW emitting at 670 nm wavelengths, collimated on a 31 mm diameter.

The beam is visible on a screen of white paper which should be placed in front of the autocollimator lens.

The mirror should be placed on the trajectory of this beam, in such a way as to reflect it in the direction of the LAE500 autocollimator's entrance pupil. To obtain this the screen of white paper should now be placed in the area surrounding the autocollimator. The return beam should be centered as closely as possible on the autocollimators' pupil.

Ocular alignment is now possible. The returned beam will focalize on the frosted glass of the LAE500 eyepiece. A crosslink formed from a circle indicates the angular range in which measurement is possible: it is a circle corresponding to a 2 mrad beam angle.



Alignment is then configured by positioning the return beam in this circle. Modify the angular adjustments of the mirror or autocollimator.

As soon as correct alignment is achieved, the controller will indicate values measured as for the following:

	Y	=	-			2	.	6			µ	r	d		M	E	N	U
	Z	=	+			8	.	5			µ	r	d		M	E	M	O

The display may then be used to initiate measuring.

The angular measurements displayed correspond to the rotation values of the mirror.

Section 4
Running modes

4.1 SETUP mode

To access the SETUP menus of the LAE500 electronic controller, hold the F1 and F2 keys pressed down together when on the controller.

```
   MICRO-CONTROLE
LAE-500  VERSION 1.7
```

The number of the LAE500 electronics version is displayed before the SETUP menu.

```
INCR.  1          END
DOWN   UP    –    +
```

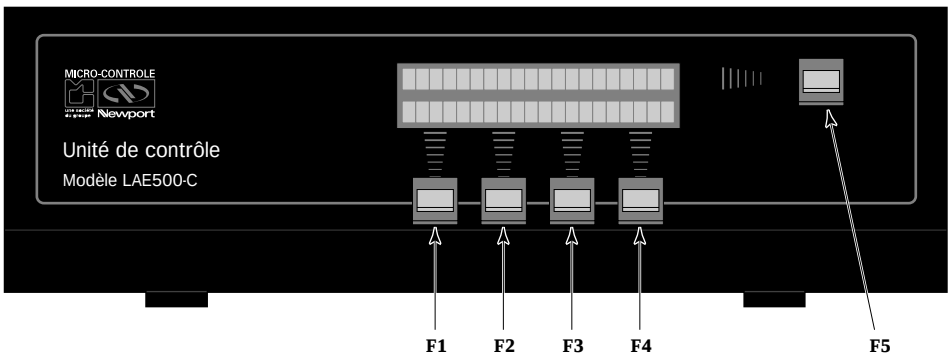
SETUP menu:

F1	DOWN	Rolling
F2	UP	Rolling
F3	–	Choice of parameters
F4	+	Choice of parameters
F5	END	End of SETUP

Return to normal mode; the SETUP will be saved when switched off.

MASTER RESET: If END is pressed for several seconds, the LAE500 proposes resetting the parameter to their default values. This option may also be used when burning by pressing down on the F5 key.

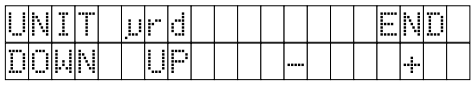
```
  MASTER RESET ?
 YES          NO
```



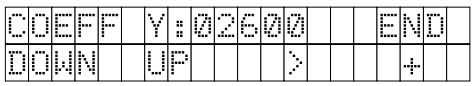
4.1.1 Configurations types

This type of operating mode allows for the proper setting of the international software depending upon the environment where the controller is used:

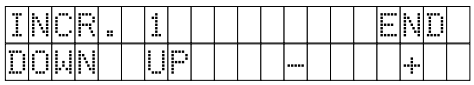
- **The optical head**
  - Display unit:



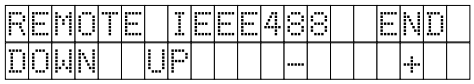
  - Correction coefficients:



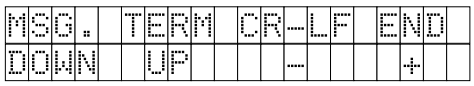
  - Counter increments:

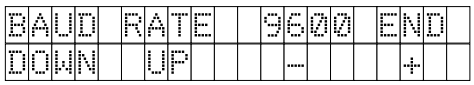


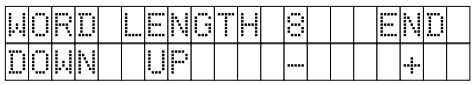
- **Operating mode link up**
  - With IEEE-488 or RS-232-C:

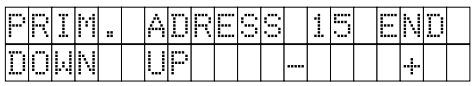


  - and parameters:





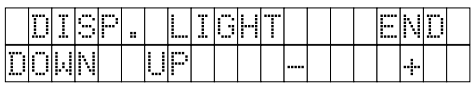




…

…

- **Environment**
  - Brightness display:



4.1.2 Accessibles parameters

The following is a list of accessible parameters:

Parameter	Description	Default value through LAE500	Selection
INCR.	Incremented value display	1	0.1; 0.2; 0.5; 1; 2; 5; 10; 20
UNIT	Displayed unit	µrad	µrad; µm
REMOTE	Active link up	RS-232-C	IEEE-488; RS-232-C
MSG. TERM	End of sequence terminator	CR	CR; LF; CR-LF; LF-CR
ECHO	Send a display echo through RS-232-C link up when active link up is IEEE-488	NO	YES; NO
BAUD RATE	RS-232-C speed	9600	300; 600; 1200; 2400; 4800; 9600; 19200
WORD LENGTH	Word length for RS-232-C	8	7; 8
STOP BITS	Stop bits for RS-232-C	1	1; 2
PARITY	RS-232-C parity	NONE	NONE; ODD; EVEN
PRIM. ADRESS	IEEE-488 primairy adress	15	0; …; 30
SECD. ADRESS	IEEE-488 secondary adress	00	0; …; 30
COEFF Y *	Y channel coefficient of probe	2000	0; …; 29999
COEFF Z *	Z channel coefficient of probe	2000	0; …; 29999
DISP. LIGHT	Display brightness	(Max.)	4 levels

The programmed parameters are stored in memory when turning off the controller.

*** IMPORTANT NOTICE**

The COEFFY and COEFFYZ phasing coefficients are supplied in the LAE500 electonic autocollimator's documents. They guarantee the precision of the read-out values on the controller (mirror rotation).

If these values are modified by a multiplicative factor, the display will take this into account

Example

For the autocollimator supplied, the coefficients are:

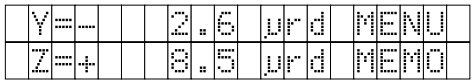
- COEFFY = 4855.
- COEFFZ = 4777.

If COEFFY = 9710 and COEFFYZ = 9554, the controller will display twice the real values of the mirror rotations.

4.2 MANUAL mode

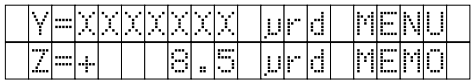
When turned on, the controller proceeds to initialization and displays a welcome message.

A display of values measured according to programmed parameters is proposed:



This presupposes that the autocollimator is stationary before a mirror which sends the correct beam back within the measurement range (see section 3: SETTING UP).

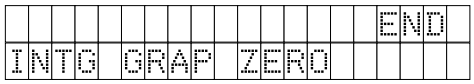
In other cases, the controller displays a series of 7 X's instead of the value measured on the given axis:



Proceed to preliminary alignment to obtain angular values.

F5 (MENU) F4 (MEMO) keys are valid.

4.2.1 MENU (F5): Access to rolling menus

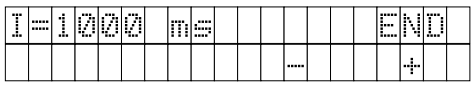


There are 3 options:

- Choice of integration constant **INTG**:

Duration selection for measurements average. This value has a direct influence on measurement accuracy (see chapter measurement characteristics).

Possible values (ms): 0; 1; 2; 5; 10; 20; 50; 100; 200; 500; 1000.



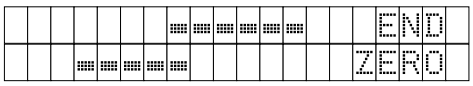
MENU (F5) → INTG (F1) → – (F3) / + (F4) } Integration constant choice.

← END (F5)

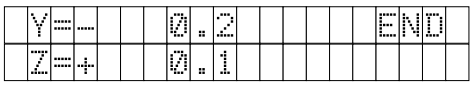
"0" value corresponds to maximum frequency of 2000 Hz (no integration).

- Logarithmic display selection **GRAP**:

A standard bar-graph display is recommended to facilitate alignment. For each axis, the number 8 digit is considered as the optical center of the autocollimator. The angles measured light up the adjacent digits (7 on either side) logarithmically for accurate alignment mode. Positive space values light up the digits to the right. Alignement around the detector center is achieved by switching off as many digits as possible.



In alignment mode, ZERO function (F4) enables measurements to be performed in relation to the current position which becomes a reference point.



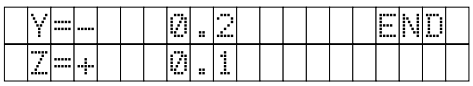
MENU (F5) → GRAP (F2) → Logarithmic ramp display.

→ ZERO (F4) → Display relating to current position to give (0.0).

← END (F5)

- Display selection related to **ZERO** reference position:

In this operating mode, the ZERO (F4) function enables measurements to be performed when related to current position which then becomes a reference point.



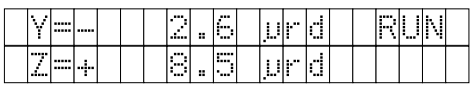
This offset shift is used for successive alignments.

MENU (F5) → ZERO (F4) → Display related to current position which becomes (0.0).

← END (F5)

4.2.2 MEMO (F4): Current position display freeze feature

This option facilitates the correct writing of a couple of position values.



MEMO (F4) → Current position display freeze feature.

← RUN (F5)

4.3 INTERFACE mode

A calculator or computer interfaced to the LAE500-C controller provides controls for the following:

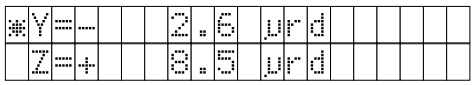
- Toggle between manual mode - interface mode.
- Current position readout (Y & Z).
- Modification of acquisition parameters (integration unit).
- Acquisition sequence release and readout of memory positions.

The controller should be linked up to a calculator (RS-232- C or IEEE-488) through a cable. Once the controller is switched off, interface may be executed.

ATTENTION

BEFORE PLUGGING IN
CHECK THAT EVERYTHING
IS SWITCHED OFF

Once the interface is validated by the calculator (“C-” command), the controller modifies its display by placing an asterik in front of the Y line readout and deactivating the rolling menu function:



The continuous display of angular values is retained in the controller.

Interface mode is only possible if the controller is in its main MENU.

4.3.1 Console interface

In RS-232-C mode, depending on the instructions provided in the console users manual, the LAE500 parameters may be modified: baud rate, parity, stop bit, etc. (see section: SETUP mode).

4.3.2 RS-232-C cable

Provided with the controller (2 m length) with SUB-D 25 male connector on one end and SUB-D 25 female or SUB-D 9 female connector to meet 2 standards on the other end.

4.3.3 IEEE-488 cable

IEEE-488 (GPIB) standard cabe, available ref. **348106** (3 m length). Maximum potential IEEE-488 output frequency of controller is approximately 250 Hz.

The LAE500-C controller interprets messages sent throught interface, and provides a proper response.

4.3.4 List of messages COMPUTER ↔ LAE500-C

The following messages are valid for control of LIAISON interface functions of the LAE500-C controller.

When sending a message to LAE500-C, a response will always be returned.

For inactive words, the LAE500-C controller will return an echo of the message.

Message	Action	Response
"C-" REMOTE	Liaison mode transition (inactive keypad)	C-
"C+" LOCAL	Manual mode transition (active keypad)	C+
"D+"	Active display	D+
"D-"	Frozen display	D-
"Y"	Read Y channel coefficent of probe	Yxxxxx
"Yxxxxx"	Set Y channel coefficent of probe	Yxxxxx
"Z"	Read Z channel coefficent of probe	Zxxxxx
"Zxxxxx"	Set Z channel coefficent of probe	Zxxxxx
"I"	Constant integration readout INTG	Ixxxx
"Ixxxx"	Set INTG (xx = 0 ms to 1000 ms)	Ixxxx
"UM"	Unit = micron (µm)	UM
"UR"	Unit = microradian (µrad)	UR
"S"	Incremental readout value INCR	Sxxx
"Sxxx"	Set INCR (xx = 0.1 to 20)	Sxxx
"P"	Current position readout	P+yyyy.y,-zzzzz.z
"Axxxx"	Launches an acquisition for xx values (an acquisition every INTGS ms); xx may vary from 1 to 2048	Axxxx
"N"	Readout of number of measurements stocked and executed	Nxxxx
"Miiii"	Readout of iiii measurement iiii may vary from 0 to 2047	M+yyyy.y,-zzzzz.z

REMARQUE

In liaison mode, "D-" function gives the priority to the communication, and stops dynamic display of the positions on the LAE500-C controller.

In this mode the display is locked on the position when the "D-" message is received, and is not the real value.

4.3.5 LAEDEMO software

This demonstration software is provided with the autocollimator. The equipement includes a diskette (3" 1/2) DOS compatible.

The necessary equipment is featured below:

- PC compatible mini-computer with minimum 386-16 MHz processor.
- EGA board and monitor minimum.
- RS-232-C interface or IEEE-488 (HP 823358).

Diskette contains:

LAE500.INI

Initialization file (RS-232-C COM1, COM2 or IEEE-488).

LAE500.EXE

Basic software.

BAS/LAERS2.BAS

Example source basic (quick basic from MICROSOFT RS-232-C COM1).

LAEI3E.BAS

Example source basic (Quick basic from MICROSOFT) IEEE-488 with HP 823358 card.

… and different library provided with HP 823358 card.

DOC/LAE500.TXT

Installation text.

4.3.6 LAE500.INI data file

Contains information selections:

- French/English.
- IEEE-488/RS-232-C.
- COM1/COM2.

This data file is produced by LAE500.EXE software.

4.3.7 LAE500.EXE software

This software demonstrates the principal functions of the LAE500 autocollimator:

- Position display through a mobile spot on a target.
- Target diameter adjustable with spot position.
- High resolution mode (0.01 µrad).
- Large type display (readout at distance).
- Dialogue with controller, parameter modification.
- Point to point acquisition sequence, analysis and storage.
- Rapid acquisition sequence (max. frequency 2 kHz), analysis and storage.

4.3.8 Operation

Load LAE500.EXE and LAE500.INI softwares in the work directory. This directory will be writting unprotected for initialization.

- Initialization, type **LAE500 INI**

  The menu guides you to initialize the interface with your equipment.
- Normal mode, type **LAE500**

  You have access to the control screen. In case of error, check the connection or the LAE500-C controller parameters. The functions are validated by the keypad button described in brackets.

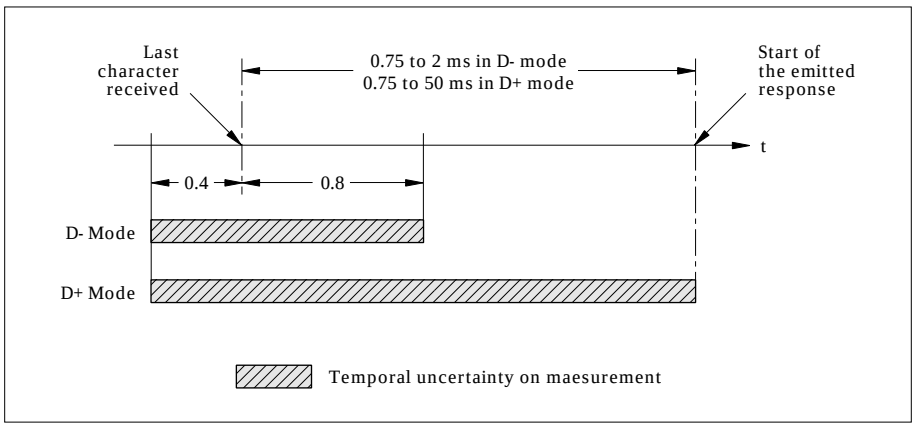
4.3.9 LAE500 - Transmission speed

Data transmission time between LAE500-C controller and a computer may be broken down into 3 specific delays:

- Internal computer delay to interpret the command and control the interface (RS-232-C or IEEE-488): Tpc.
- Signal transmission delay: Ttr.
- LAE500-C controller response (between the last character received and the first character emitted) : Tlae.

If To is the time corresponding to the end of the “P” + MSG.TERM message reception, the position value sended 1.5 to 2 ms later by P + xxxx.x + xxxx.x is the real position at TI time, such:

To - 0.4 ms < TI < To + 0.8 ms



Tpc: The delay varies from a machine to an other. Examples are provided on the following pages, in D- mode.

Ttr: The delay for the position readout (sending “P” and reception of “P + xxxx.x + xxxx.x”) equal approximatly 10 ms in RS-232-C at 19200 bauds and 1 ms in IEEE-488.

Tlae: The delay is contained between 0.75 and 2 ms in D- mode and between 0.75 et 50 ms in D+ mode.

4.3.10 RS-232-C interface at 19200 bauds

The following operation time for the program was timed, written in MICROSOFT QUICKBASIC:

```
FOR I = 1 to 1000
    PRINT#1,"P"
    LINE INPUT#1,R$
NEXT I
```

This program was executed in:

- 15 s with a PC AST Premium 386/33 MHz.
- 17 s with a PC LEANORD 386/16 MHz.

The minimal incompressible transmission time is approximately 12 ms.

4.3.11 IEEE-488 interface with HP82335B

There operation delay should be taken into account which is the minimal waiting time of 1 ms between 2 successive enbies (in addition to eventual readout delay).

Operation time for the following program was timed, written in MICROSOFT QUICKBASIC

```
FOR I = 1 to 1000
    CALL IOOUTPUTS(ADDR,"P",1)
    CALL IOENTERS(CODE,R$,256,LONG)
NEXT I
```

This program was executed in 4.9 s with a PC LEANORD 386/16 MHz.

A temporization is necessary with a faster PC in order to respect the operation time given below:

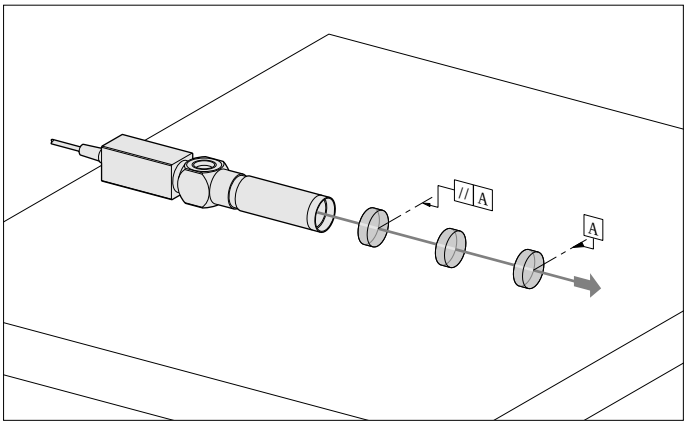
```
FOR I = 1 to 1000
    CALL IOOUTPUTS(ADDR,"P",1)
    CALL IOENTERS(CODE,R$,256,LONG)
    FOR J = 1 to 15 NEXT J ' **durée = 0.6 ms **
NEXT I
```

This program was executed in 4.6 s with a PC AST Premium 386/33 MHz. The minimal is compressible transmission time is approximately 4 ms.

Section 5
Application examples

5.1 Assemblies and measurements

- **Mechanical alignment**



The LAE500 optical axis is used as a reference direction for aligning angles in mixed assemblies of optical mirrors and mechanical interfaces.

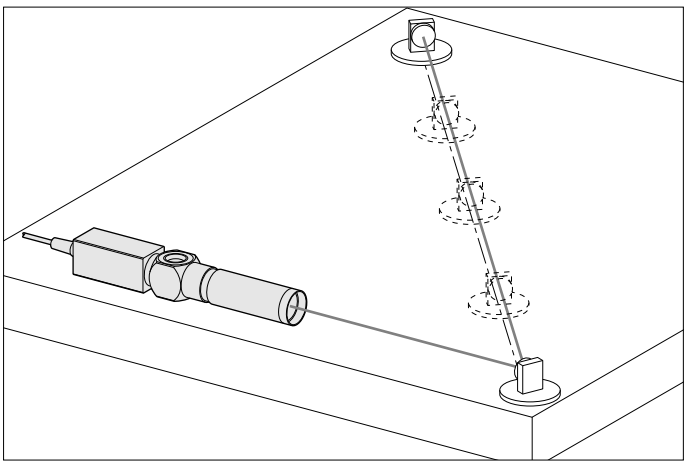
Field:	±2000 µrad (±7 arcmin)
Accuracy:	±1 µrad
Reflectivity:	> 10%
Reflector size:	> 10 mm diameter

Examples: Laser cavity alignment; optical parts assembly, wafer angle position; alignment of structures over long distances.

- **1 axis angular trajectory**

- **2 axes angular trajectory**

- **Flatness measurement (metrology of a granite laboratory table)**



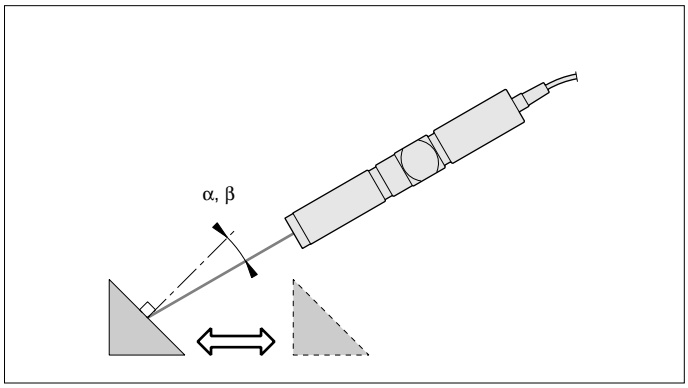
The LAE500 autocollimator can record reflected angle variations when the mirror holder is moved through a trajectory or set at different positions. These values give the slope error.

Field:	±2000 µrad (±7 arcmin)
Range:	20 meters
Accuracy:	±1 µrad
Reflector type:	50 mm mirrors
Communication:	RS-232-C and IEEE-488 interfaces
Software:	Dedicated application software

Example: Qualification of granite optical benches; machine-tool testing.

- **Prism comparison**

- **Prism measurement**

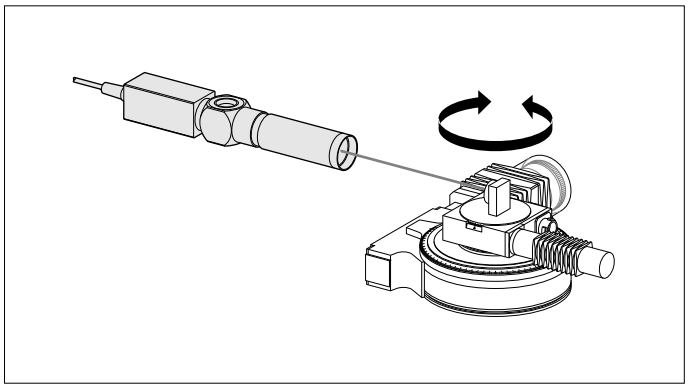


The LAE500 is a powerful tool for measuring angular differences in prism facets or angular deviations in optically transparent prisms. The LAE500-HS high sensitivity option reads signals from low reflectivity samples such as uncoated prism faces.

Field:	±2000 µrad (±7 arcmin)
Accuracy:	±1 µrad
Reflectivity:	> 10%
Reflector size:	> 10 mm diameter

Examples: Comparing work angle with standard block angle; automatic lens centering station.

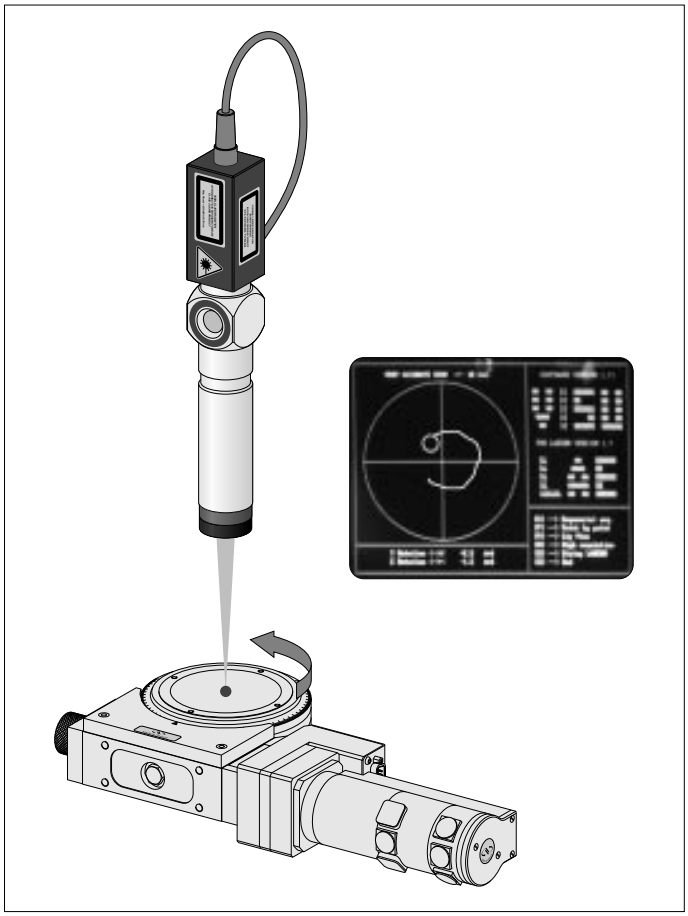
- **Goniometry**



The LAE500 is used to measure angle variations or exact angle trajectories during qualification cycles.

Field:	±2000 µrad (±7 arcmin)
Linearity:	< 2%
Max frequency:	2 kHz sampling rate (standard)
Accuracy:	±4.4 µrad at 2 kHz
Reflector size:	> 10 mm diameter
Internal memory:	2000 readings

Examples: Rotation stage qualification (run-out), pointing mirrors Goniometers qualification.



LAE500 Goniometer Testing Kit

- Direct reading of the concentricity errors.
- Non contact, long working distance measurement (200 mm).
- 1 µm precision over ±1 mm field.
- Immediate data recording via RS-232-C protocol.

The LAE500 goniometer testing Kit provides the most convenient tool for immediate recording of the concentricity errors (sphere of confusion) for any goniometer configuration. By focusing the autocollimator output beam onto a precision reflecting sphere, the system automatically displays the 2-axes motion of the center of the sphere with less than 1µm resolution.

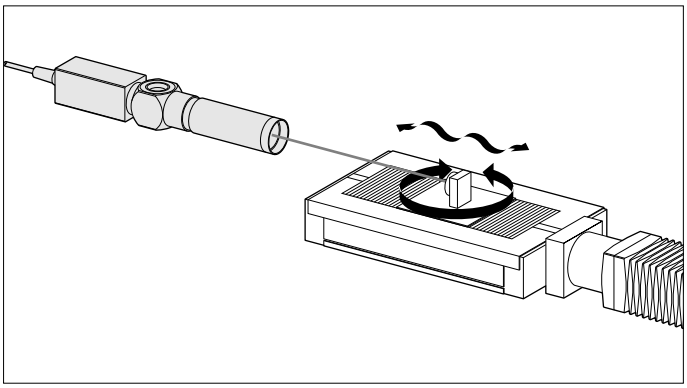
When located in the geometrical center of the goniometer, the reference sphere will precisely follow the goniometer concentricity curves during any axis motion.

Due to the large angular aperture of the reference sphere, this method provides the only way of continous reading of the concentricity errors over the entire angular range for all goniometer axes.

A complete goniometer testing kit includes:

- A LAE500 electronic autocollimator.
- A Precision Reference Ball, and Calibrated focusing lens in a protection case.
- All calibration parameters and Demonstration software (via RS-232-C protocol).

- **Movement monitoring**

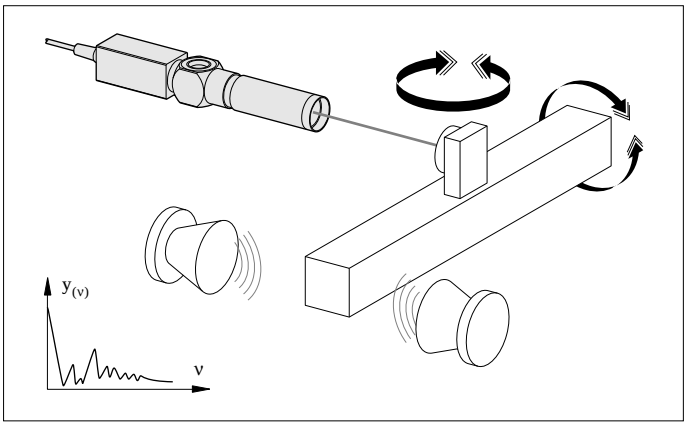


The LAE500 is used to make stages qualifications and record exact angular defects.

Field:	±2000 µrad (±7 arcmin)
Linearity:	< 2%
Max frequency:	2 kHz sampling rate (standard)
Accuracy:	±4.4 µrad at 2 kHz
Reflector size:	> 10 mm diameter
Internal memory:	2000 readings

Example: Linear stage qualification (run-out).

- **Vibration analysis**



The LAE500 is a fast, non-contact tool for recording high-speed angular vibrations over long distances.

Field:	±2000 µrad (±7 arcmin)
Linearity:	< 2%
Accuracy:	±4.4 µrad at 2 kHz
Reflector size:	>10 mm diameter

Examples: Searching vibration modes, fast motion, non-contact acquisition.

Section 6
Maintenance

6.1 Optical head

The LAE500 electronic autocollimator is a precision instrument which should be handled with the upmost care:

- Check that the main's current matches that of the controller.
- Check that the main plug is connected to ground.
- When not in use, always protect the autocollimator with its protective cover.
- Frequently check the autocollimator's optics for dust and, if need be, clean them with a soft cloth and alcohol.

Since any other intervention necessitating disassembly of a part or of the entire machine should be carried out by our maintenance service please consult us.

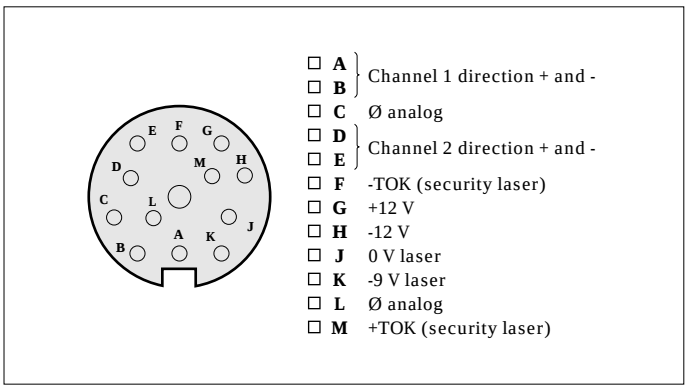
6.2 Controller

6.2.1 Maintenance

Clean the electronic controller with a soft cloth and alcohol.

6.2.2 Connection with LAE500 autocollimator

DIN 12-point female power outlet.



6.3 RS-232-C cables, LAE500-C ↔ PC

6.3.1 PC with 9-pin SUB-D connector

LAE500 25-pin Sub-D male		PC 9-pin Sub-D femal
2 (TxD)	⟷	3 (TxD)
3 (RxD)	⟷	2 (RxD)
7 (GND)	⟷	5 (GND)

6.3.2 PC with 25-pin SUB-D connector

LAE500 25-pin Sub-D male		PC 9-pin Sub-D femal
2 (TxD)	⟷	2 (TxD)
3 (RxD)	⟷	3 (RxD)
7 (GND)	⟷	7 (GND)

Service form

Newport
Tel. (33.1) 60.91.68.68
Fax (33.1) 60.91.68.69
(Evry – France)

Name _____ Return authorization # _____
(Please obtain prior to return of item)

Company _____

Adress _____ Date _____

Country _____ Phone number _____

P.O. number _____ Fax number _____

Item(s) being returned

Model # _____ Serial # _____

Description _____

Reason for return of goods (please list any specific problems) _____

LAE500
Electronic Autocollimator

Newport®

EC Declaration of Conformity

We declare that the accompanying product, identified with the "CE" mark, meets all relevant requirements of Directive 89/336/EEC for Electro-Magnetic Compatibility.

Compliance was demonstrated to the following specifications:

EMISSION:

Radiated and Conducted Emission per EN 50081-1
"Residential, Commercial and Light Industry" Standard.

IMMUNITY:

Radiated and Conducted Immunity per EN 50082-1
"Residential, Commercial and Light Industry" Standard.

Alain DANIELO
VP European Operations
Zone Industrielle
45340 Beaune-la-Rolande, France