ZAPP
Zygo Automatic Pattern Processor
Operation and Maintenance Manual
OMP-0023H

Zygo Corporation
Laurel Brook Road
P.O. Box 448
Middlefield, Connecticut 06455-0448

Telephone: (860) 347-8506
Fax: (860) 346-4188
E-mail: inquire@zygo.com
Website: www.zygo.com

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

LIST OF FIGURES

LIST OF FIGURES (continued)

LIST OF TABLES

1. INTRODUCTION

The usefulness of an interference pattern in production, quality assurance or the laboratory depends upon having available a method of providing an objective, repeatable evaluation. The ZYGO Automatic Pattern Processor* (ZAPP) is designed to evaluate the data rapidly, accurately, and automatically and to eliminate the commonly used manual technique (Fig. 1-1).

To evaluate an interferogram with ZAPP, the operator simply pushes two control pushbuttons in sequence. ZAPP automatically acquires the fringe center coordinates, performs the data reduction, and displays the output on the video monitor. It takes ZAPP only a fraction of a second to acquire the X,Y coordinates of up to approximately 500 fringe centers.

The key elements of the ZAPP system are shown in the block diagram (Fig. 1-2).

The ZAPP is used to evaluate rapidly and accurately either real time interference patterns or interferograms that have been transduced by a CCTV camera. The system has been designed to provide quick and easily interpretable feedback so that the operator can monitor the system's measurements. The system includes: (1) an automatic mode, (2) a semi-automatic mode to facilitate the measurement of difficult interference patterns, and (3) an integral, easily used calibration mode. The results of the least squares evaluation are available in a variety of formats.

Quality workmanship and unique performance features are standard with the ZAPP system. The compact, enclosed instrument that is characterized by its simplicity of operation and ease of use makes the ZAPP system a pleasure to use. The modular, versatile design of the system and its accessories not only permits expansion of the system's measurement capability but also accommodates a wide variety of measurement situations.

*U.S. Patent Nos. 4,169,980 and 4,159,522

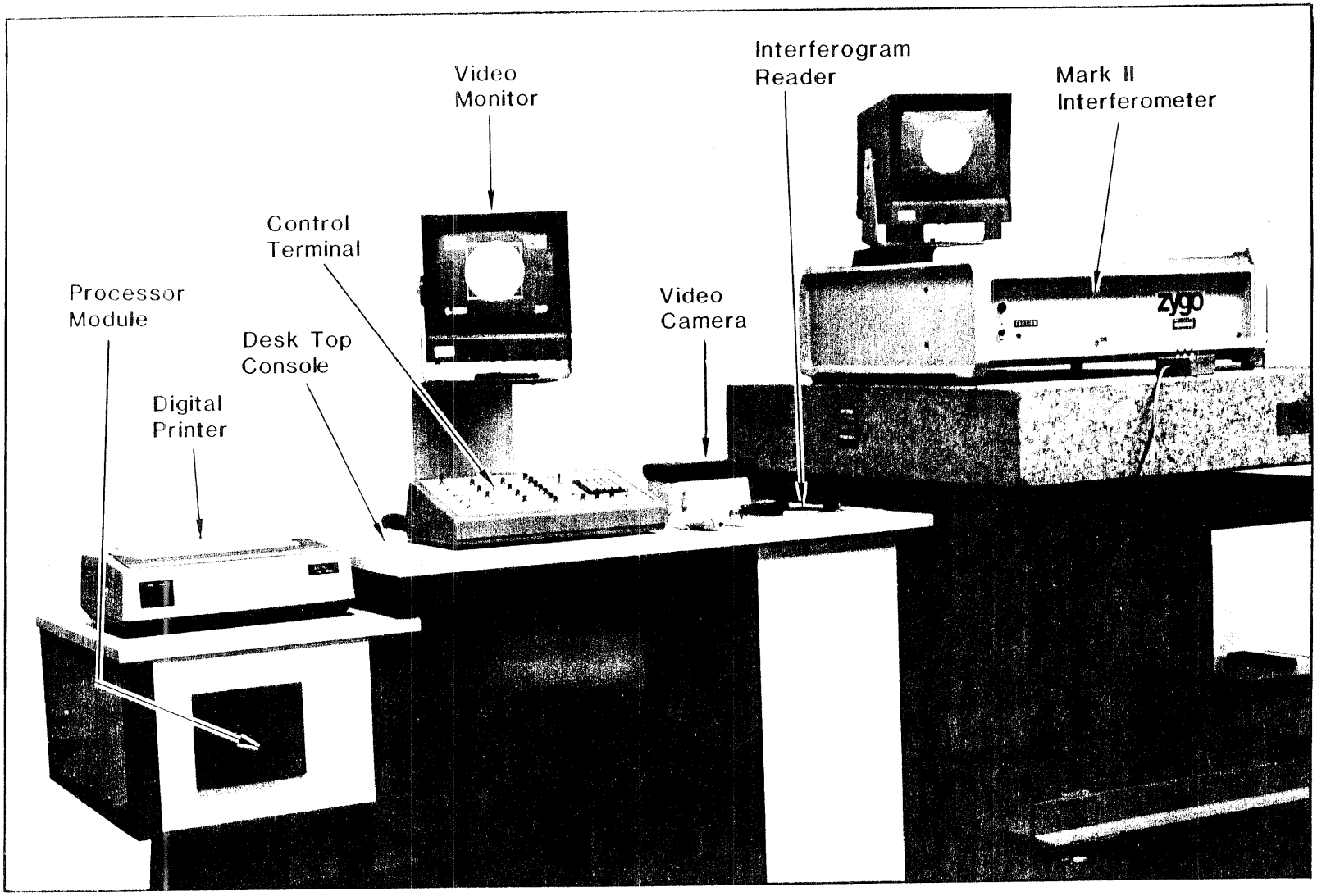


Figure 1.0-1 Zygo Automatic Pattern Processor (ZAPP)

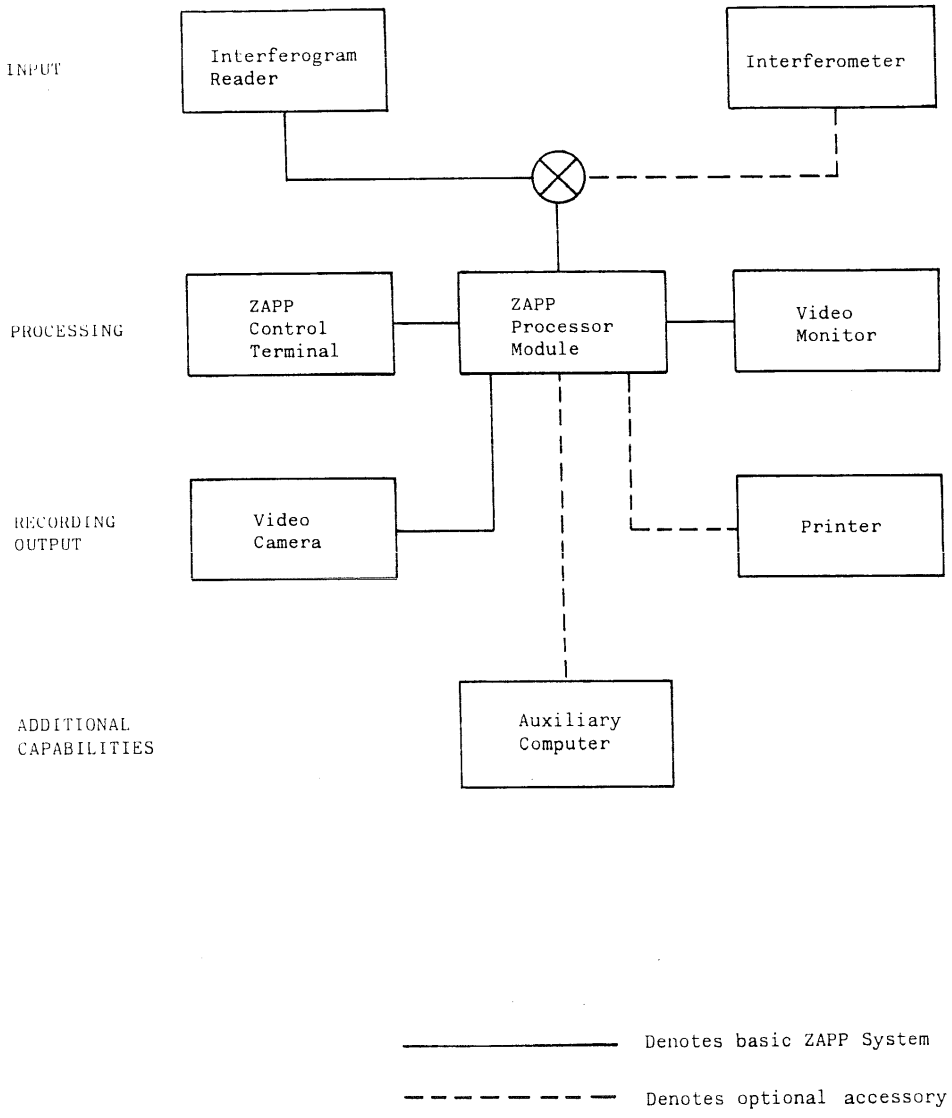


Figure 1.0-2 Zygo Automatic Pattern Processor System Diagram

2. SPECIFICATIONS

2.1 ZAPP SYSTEM

This system is comprised of the Processor Module (PM-2), the Control Terminal (CT-1), the Video Monitor (VM-2), the ZAPP Console, which consists of the Interferogram Reader (IR-1) and Video Camera (VC-1A) modules mounted in a pre-wired desk console (DT-2), and interconnecting cables.

TOTAL SYSTEM

RESOLUTION:	Automatic	Manual	Fiducial
Vertical	32 equally spaced scan lines	32 equally spaced scan lines	1 part in 256
Horizontal	1 part in 1000	1 part in 1000	1 part in 1000

NUMBER OF FRINGES: $\leq$ 25

ACQUISITION TIME: 1/60 or 1/12 sec* (Automatic)

FRINGE SPACING: $\geq$ 25 resolution units

FRINGE GEOMETRY:

Automatic
a) Slope $\leq 45^{\circ}$ from vertical
b) Fringe width variation $\leq$ 3:1
c) No closed fringes

Manual
a) No closed fringes

FRINGE TYPES:
a) Either two beam $\cos^2$ or multiple-beam high-finesse fringes

b) Either interferogram or real-time interference patterns

LEAST SQUARES COMPUTATION TIME: 0.25 sec to 5 sec depending upon number of fringe centers acquired

COMPUTER INTERFACE: Alphanumeric characters in ASCII code
9600 baud rate
8 data bits
1 stop bit
no parity bit

*The acquisition time is 1/12 second only when the BROAD/NARROW/NORMAL control switch is in the BROAD position (see Sec. 4.3.5).

CONNECTORS:	BNC type
ELECTRICAL SIGNAL INPUTS:	Video, horizontal sync, and vertical sync. These signals are provided by either the Interferogram Reader or a CCTV camera. The video input is terminated in 75 Ω.
ELECTRICAL SIGNAL OUTPUTS:	Video and composite sync
VIDEO OUTPUT:	525 lines/60Hz, 2:1 Interlace, RS170 standard or 625 lines/50Hz, 2:1 Interlace, CC1R standard
ELECTRICAL POWER REQUIREMENTS:	115 ± 10 VAC, 60 Hz or 100 ± 10 VAC, 50 Hz* or **230 ± 10 VAC, 50 Hz* 75 watts single phase with monitor**

2.2 VIDEO MONITOR, Model VM-2

SIZE:	9-inch diagonal
GEOMETRICAL DISTORTION:	≤ 0.5% for a central circular area, 80% screen height (after 30 minute warm-up)
ELECTRICAL SIGNAL INPUTS:	Video and external sync. The video input has either a 75 Ω or a high impedance termination.
SYNC:	Internal or external, switch selectable
ELECTRICAL POWER REQUIREMENTS:	115 ± 10 VAC, 60Hz or 115 ± 10 VAC, 50Hz* 35 watts, single phase

2.3 INTERFEROGRAM READER, Model IR-1

RANGE:	35mm to 4 x 5-inch format, either prints or transparencies
GEOMETRICAL DISTORTION:	≤ 0.5% for a central circular area, 80% screen height (after 30 minute warm-up)
ZOOM RANGE:	6:1
ELECTRICAL SIGNAL OUTPUTS:	Video, horizontal sync, and vertical sync

* When wired for this input voltage and frequency, there is a duplex outlet on the Mark III which provides 115 ± 10 VAC, 50 Hz for the Video Monitor and/or the Video Camera.

2.4 VIDEO CAMERA, Model VC-1A

EXPOSURE TIMES: Controlled by an intensity knob which adjusts the integral monitor's video levels

CONNECTORS: BNC type

ELECTRICAL SIGNAL INPUTS: Video, horizontal sync, and vertical sync

CAMERA BACK: Polaroid® CB-101 Land Camera or Canon Model AT-1 35mm camera back

FILM: Polaroid® Land type 107 or 35mm film

2.5 DIGITAL PRINTER, Model DP-1

PRINT PERFORMANCE: 80 characters per second
8.0-inch (204mm) maximum print width
80 character columns

CHARACTERS: 9 x 7 dot matrix

CHARACTER SPACING: 10 cpi (for 80 character columns)

DATA INPUT: Serial Interface (RS-232C)

2.6 DIMENSIONS AND WEIGHTS

MODULE:	Length (in.)	Width (in.)	Height (in.)	Weight (lb.)
Processor	24	18	8 1/2	45
Control Terminal	8	14	4	3
Video Monitor	12-1/4	9	9-1/2	14
Video Camera	25-5/8	10-5/8	9-3/4	33
Interferometer Reader	28-1/4	10-5/8	7-1/2	20
Digital Printer	13-2/5	9-2/5	4	14
Desk Top Console*	51	26	29	50

*without modules

3. DETAILS OF THE SYSTEM

3.1 GENERAL

ZAPP is a complete system (Fig. 3.1-1) which can evaluate an interference pattern by performing a least squares fit to an array of points located on the center of fringes. The processor module is essentially a video fringe center coordinate digitizer with the numerical computational capability to do rapid, sophisticated analysis of the data. It provides an objective, essentially real-time interference pattern evaluation capability.

The ZYGO Automatic Pattern Processor System is composed of the following modules and optional capabilities.

3.2 INTERFEROGRAM READER

When a hardcopy interferogram is to be evaluated it is placed on the platen of the Interferogram Reader. This module contains an integral CCTV camera, low distortion zoom imaging optics, and an internal light source. It accommodates interferograms ranging in size from 35mm to 4 x 5 inches. The continuous zoom feature permits up to 6X magnification of small patterns.

3.3 INTERFEROMETER

ZAPP was designed to be compatible with the Mark II Interferometer or the GH Mainframe modified with a suitable TV viewing system or any other interferometer with a suitable TV viewing system. The CCTV camera can interface a real-time interference pattern directly to the ZAPP system. This mode is feasible when the interference pattern to be evaluated is relatively stable and not adversely affected by vibration and/or drifts in the interferometer setup.

3.4 PROCESSOR MODULE

This module with its built-in microprocessor is the heart of the ZAPP System. It contains the electronic hardware and software that allows ZAPP to perform its tasks. For example: executing diagnostics at system power-up or reset, automatic fringe center acquisition, manual fringe center acquisition, least-squares analysis calculation, fiducial digitization, 3-D plot generation, video graphics, operator prompting, generation of error codes, and interfacing with an auxiliary computer.

3.5 CONTROL TERMINAL

This module contains the controls with which the operater interacts with the ZAPP system (Fig. 3.5-1). The controls are arranged into four functional groups:

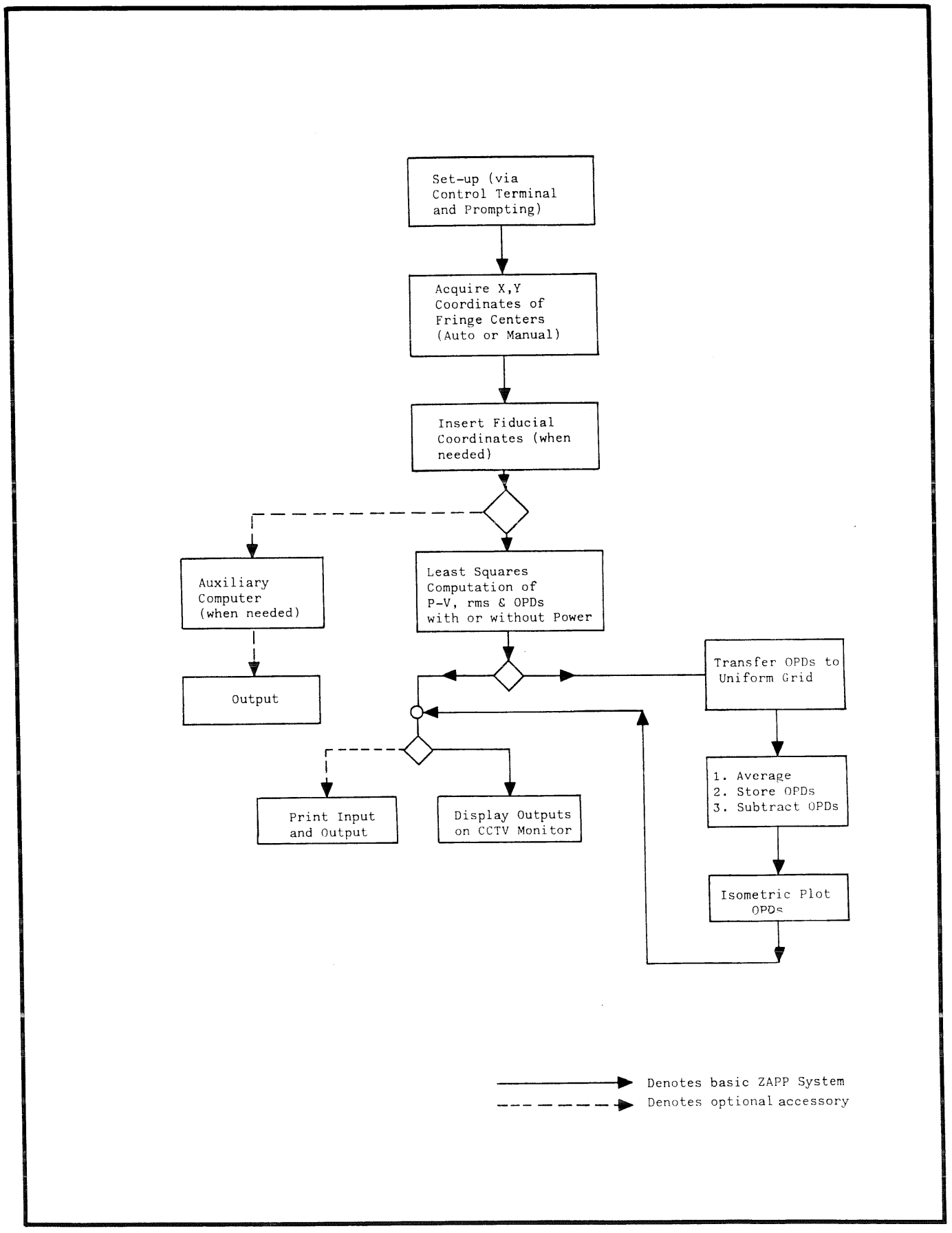


Figure 3.1-1 ZAPP Block Diagram

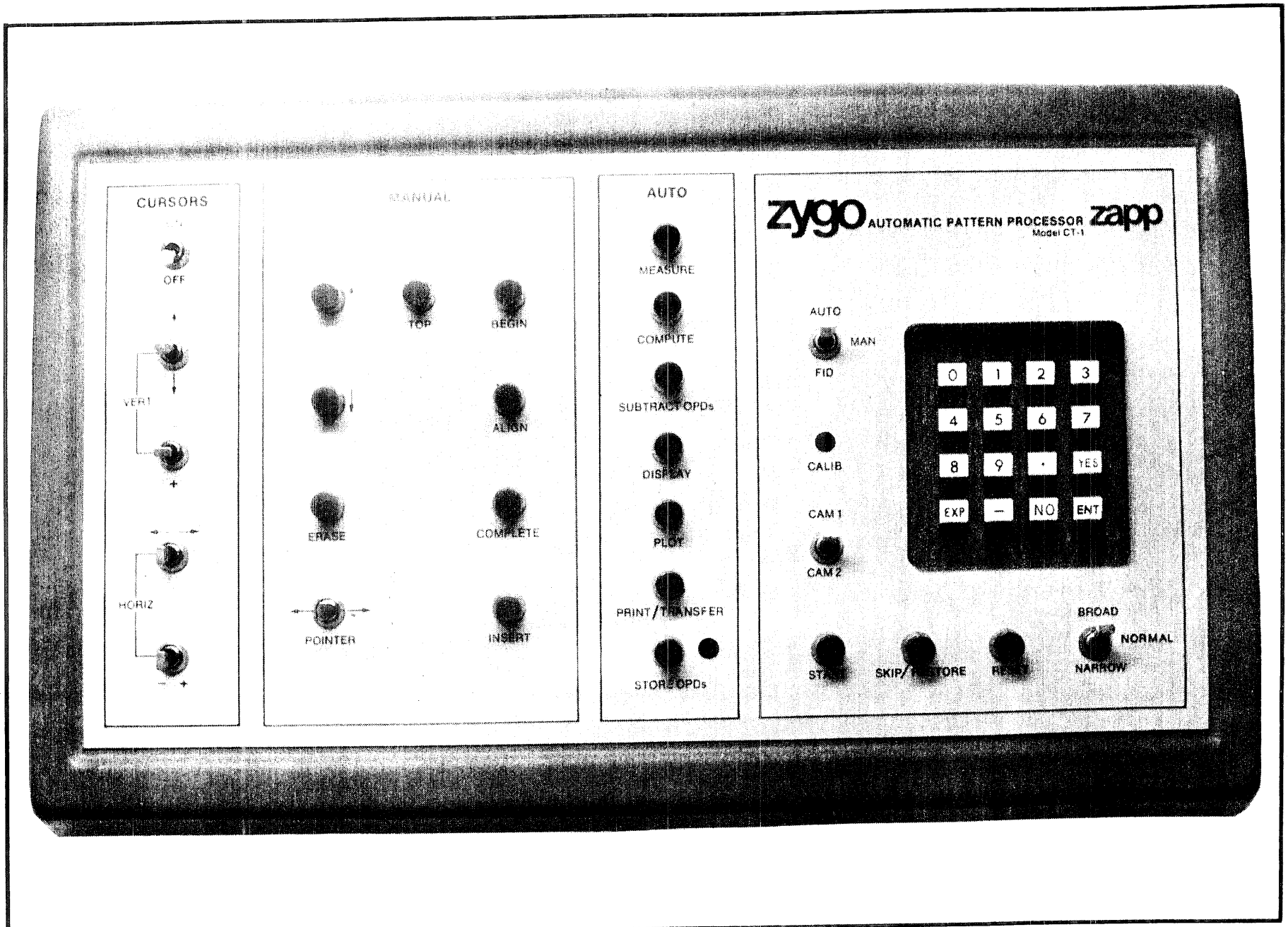


Figure 3.5-1 Control Terminal

1. *The keypad start-up and set-up controls* provide a convenient, flexible means to access a useful array of options for the evaluation of an interferogram. Parameters can be set-up in two ways: by a series of microswitches and by a software program in the processor. Once set-up, they do not have to be touched again unless the operator wishes to change the evaluation parameters or the information.

   ZAPP uses a prompting format to enter the information in Fig. 3.5-2.

2. *Clear aperture cursor controls* provide for adjusting lines which appear on the monitor's viewscreen. The lines can be moved horizontally and vertically to accommodate a wide variety of clear aperture sizes.

3. *Manual controls* can be used either to locate manually the coordinates of the centers of the fringes, or to erase manually any spurious or erroneous fringe centers or manually entered points. In addition, they allow the operator to repeat calculations with different parameters.

4. *The command controls* cause the Processor Module to acquire and display automatically the coordinates of an array of points falling on the fringe centers once the clear aperture cursors have been positioned. The controls also cause the Processor Module to execute the various computations. The results of the data reduction appear on the Video Monitor in the output information format (Fig. 3.5-3).

3.6 VIDEO MONITOR

The Video Monitor displays the interference pattern, either real-time or interferogram, as well as the digital and video information inserted by the operator and produced by the Processor Module. The 3-D plot appears on the Video Monitor.

3.7 VIDEO CAMERA

A permanent record of all information displayed on the Video Monitor can be obtained with the Video Camera. This module contains an integral monitor, a video-synchronized shutter, low distortion imaging optics, and either a Polaroid land or a 35mm camera back.

3.8 DIGITAL PRINTER

The printer produces a hard copy of the digital information display on the Video Monitor. The input is transmitted through a standard RS-232 interface. The printed page may be reproduced on an office copy machine.

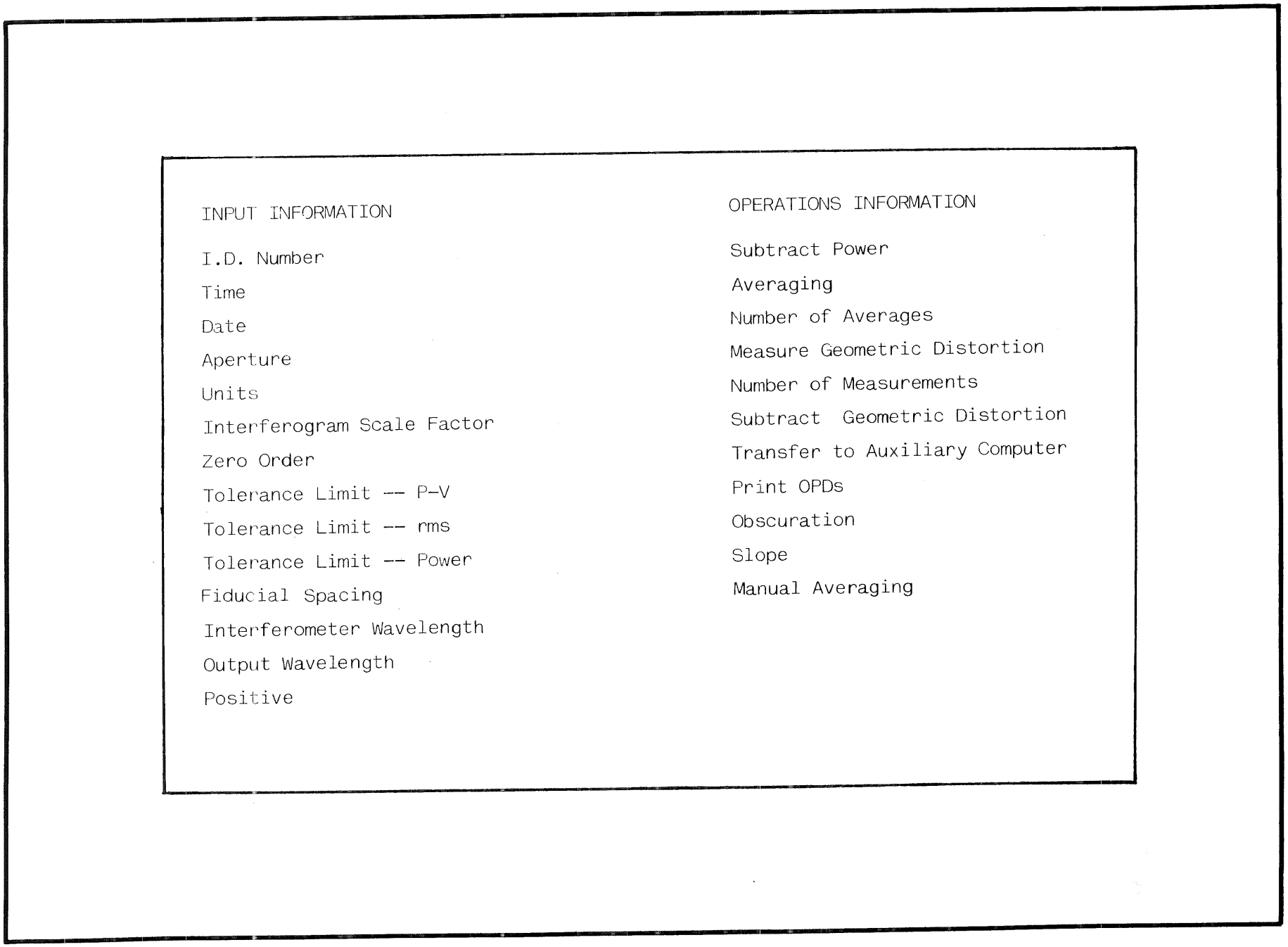


Figure 3.5-2 ZAPP Set-Up Information

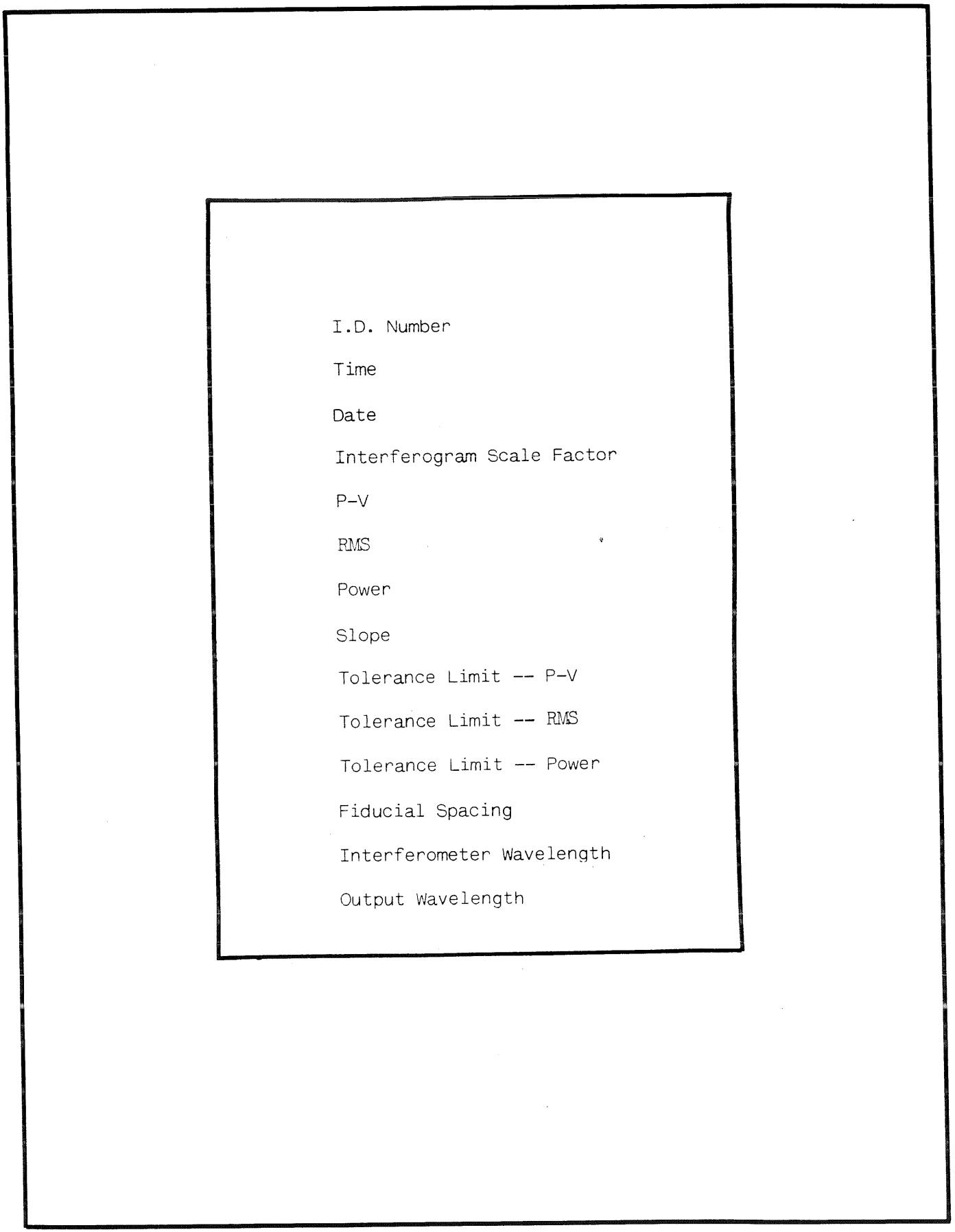


Figure 3.5-3 ZAPP Output Information

3.9 AUXILIARY COMPUTER

The ZAPP provides a digital output to an auxiliary computer through a standard RS-232C bidirectional port. This digital output is compatible with the FRINGE program, which can be run on an auxiliary computer to provide Zernike polynomial coefficients or other aberration coefficients, point spread function, MTF, and other computations.

An optional feature allows the use of ZAPP's graphic capability to display contour plots generated by an external computer.

4. INPUTS, OUTPUTS AND CONTROLS

This section describes the inputs, outputs and controls of the ZAPP Processor and Control Terminal modules. A complete description of the inputs, outputs, and controls of the Interferogram Reader, Interferometer, Video Monitor, Video Camera, Digital Printer and Auxiliary Computer can be found in their respective manuals.

4.1 PROCESSOR MODULE ON/OFF SWITCH

The on/off switch for the Processor Module is located on the left-hand side of the instrument. After the Processor Module is turned on, the system diagnostics program is automatically executed (for more details, see Section 7.1.3). Following the execution of this program, system warnings may appear on the Video Monitor (see Section 5.12).

4.2 PROCESSOR MODULE CONNECTOR PANEL

The connector panel is located at the rear of the Processor Module. It provides input and output connectors for the interconnection of the system modules (Figure 4.2-1).

4.2.1 Camera 1 BNC Connectors: The three BNC connectors provide the interconnection for the CCTV Camera in the Interferogram Reader Module.

CAM 1 -- Accepts Interferogram Reader video out

HOR 1 -- Accepts Interferogram Reader horizontal sync

VERT 1 -- Accepts Interferogram Reader vertical sync

4.2.2 Camera 2 BNC Connectors: The three BNC connectors provide for the interconnection of the Video Camera in the Interferometer.

CAM 2 -- Accepts Interferometer video out

HOR 2 -- Accepts Interferometer horizontal sync

VERT 2 -- Accepts Interferometer vertical sync

4.2.3 Control Terminal Connector: ZAPP Control Terminal output.

4.2.4 Monitor Connectors: The two connectors provide output signals to the Video Monitor.

COMP SYNC -- Composite sync

VIDEO OUT

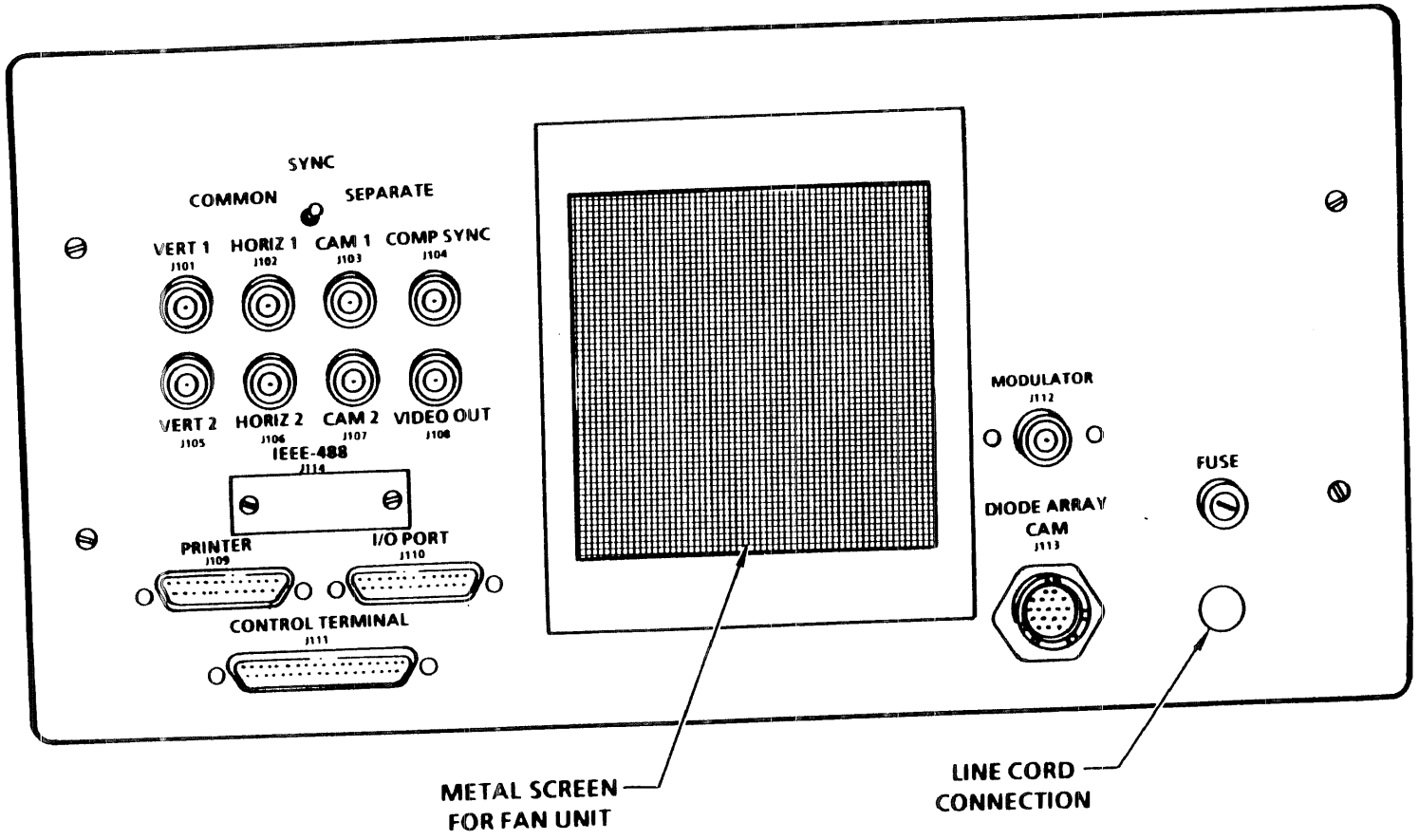


Figure 4.2-1 Processor Module Connector Panel

4.2.5 Printer and Auxiliary Computer Connectors: The two connectors provide outputs to the Printer and Auxiliary Computer.

PRINTER

I/O Port -- Auxiliary Computer

4.2.6 A/B SYNC Switch: This two-position switch should be in the "A" position for systems without a Mark II Interferometer and at the "B" position for systems which include the Mark II Interferometer.

4.3 CONTROL TERMINAL -- KEYPAD AND SET-UP

4.3.1 Keypad: The keypad can be used to generate 12 different characters and 4 different command codes. The commands are:

YES

NO

ENT -- Enter data and move pointer forward through lines or pages

EXP -- 1. Back pointer through lines or pages

2. Erase numerical data in middle of entry

To send a character or command you simply press the appropriate key.

4.3.2 START: Depressing the START button causes the first Input Information Form to appear on the video display for review and update. The input forms consist of four displays (Figs. 4.3.2-1, 4.3.2-2), sequentially displayed by actuating the SKIP button. After the fourth display, the following prompt appears, "Standard Defaults?". The keypad reply by the operator should be either YES or NO. A YES answer puts ZAPP into an operational mode. A NO answer causes the default parameters to reappear.

4.3.3 SKIP/RESTORE: Depressing the SKIP button will cause the next set of defaults to be displayed when examining defaults or adding information. It can also be used to step through the displayed output information. Additional functions enable the operator to redisplay previously acquired fringe centers and exit from warning displays.

4.3.4 RESET: Depressing the RESET button executes the system diagnostics program (for more details, see Section 7.1.3) and then discards the default information previously entered through the keypad as well as all calibration data and stored OPD data.

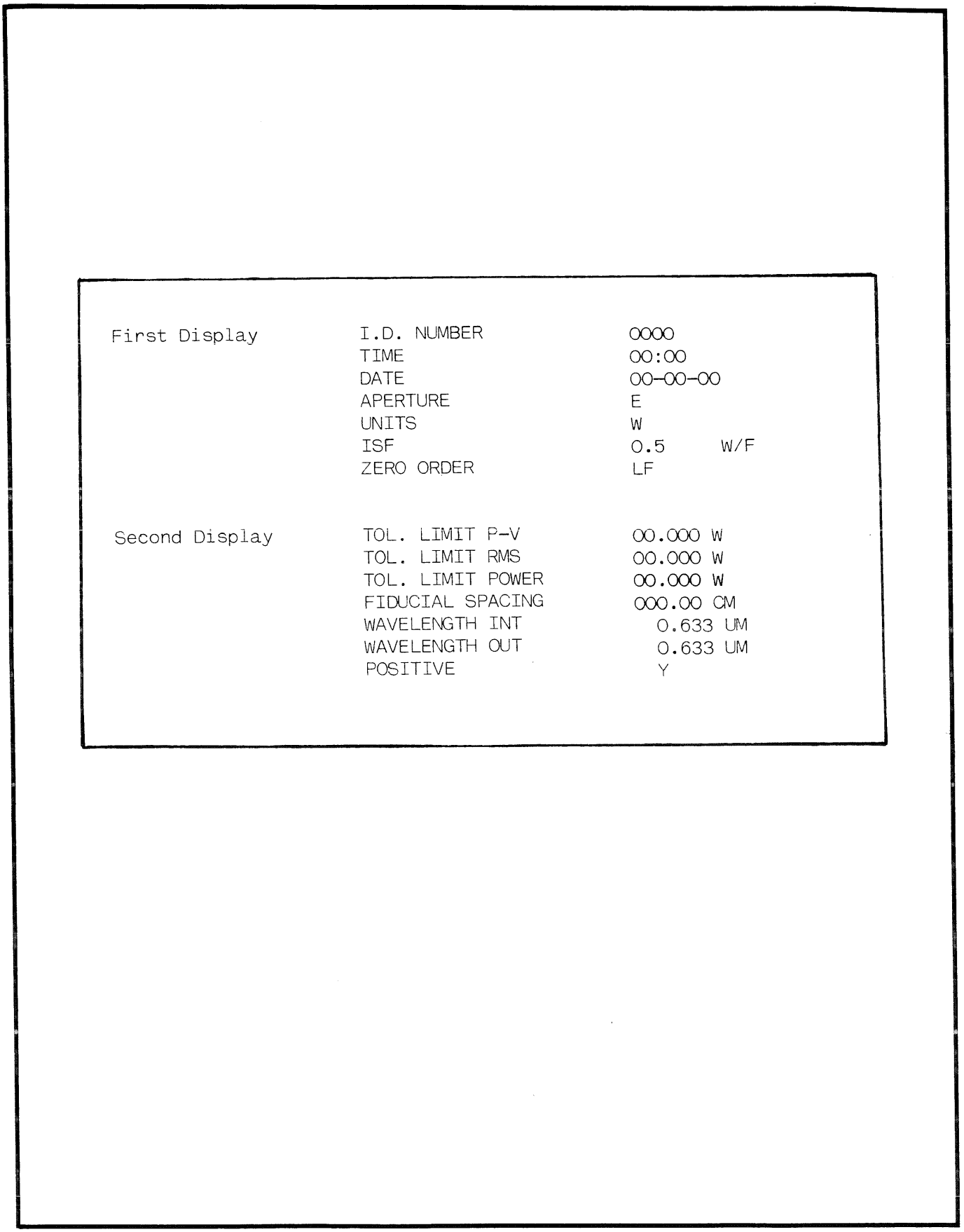


Figure 4.3.2-1 The Input Information Default Parameters as they appear on the video monitor for review and update.

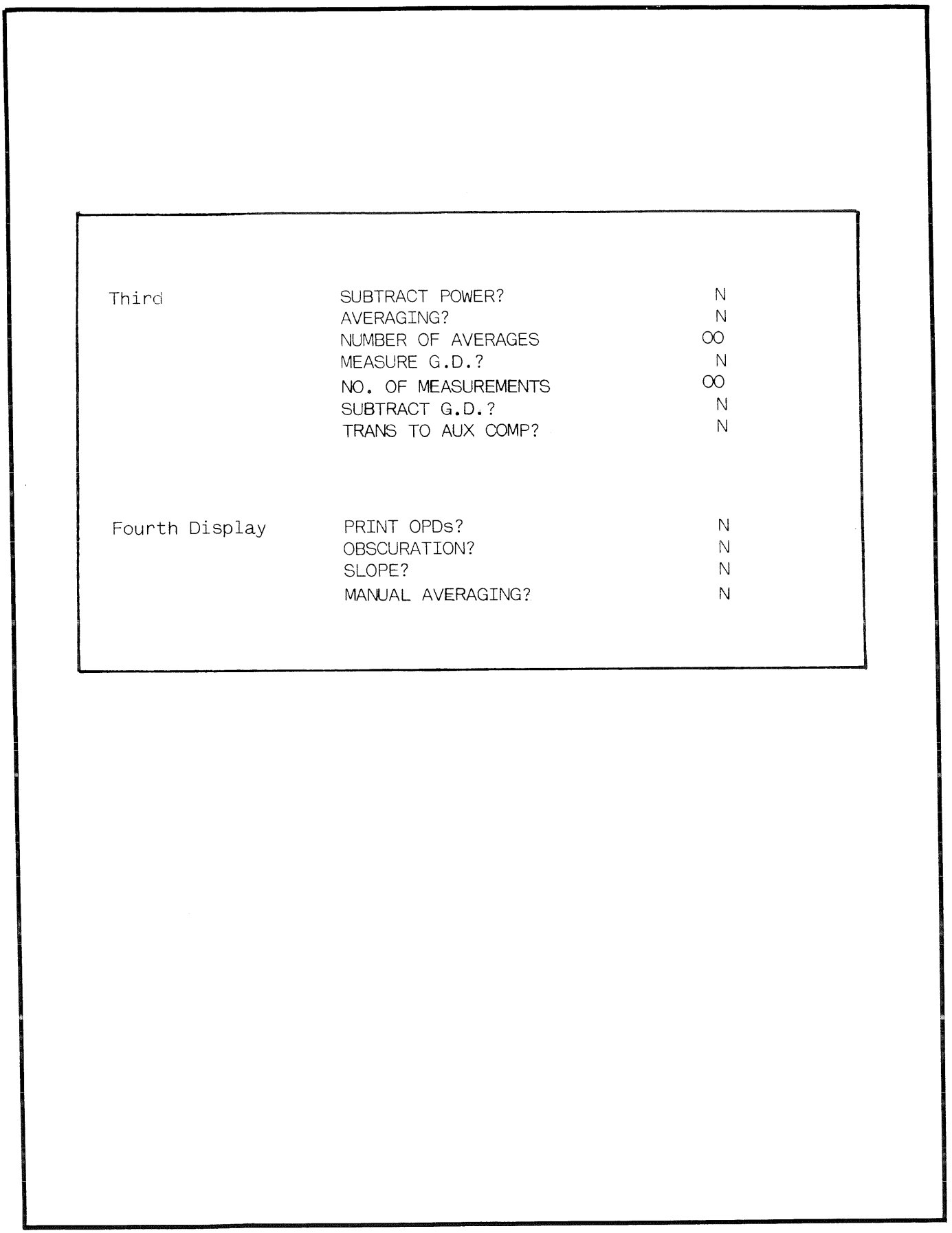


Figure 4.3.2-2 The Operations Information Default Parameters as they appear on the video monitor for review and update.

NOTE: Following the execution of the diagnostics program, system warnings may appear on the Video Monitor if any of the diagnostic tests fail (see Section 5.12).

4.3.5 BROAD -- NORMAL -- NARROW: This three position toggle switch allows the operator to compensate for a variety of fringe conditions:

BROAD (Upper Position) -- very broad fringes

NORMAL (Middle Position) -- all high contrast fringes

NARROW (Lower Position) -- low contrast fringes.

4.3.6 AUTO/MAN/FID: This switch provides a choice of three methods of acquiring and editing fringe centers.

AUTOMATIC -- ZAPP automatically acquires the fringe coordinates. It takes 1/60 sec to acquire the X,Y coordinates of up to approximately 500 fringe centers. When the BROAD--NORMAL--NARROW switch is in the BROAD position the fringe centers are acquired in 1/12 sec.

MANUAL -- The operator can manually insert the coordinates of the centers or erase spurious fringe centers found by the automatic mode.

FIDUCIAL -- This mode allows the digitization of interferogram fiducial points displayed on the monitor with a vertical resolution of 1-TV line rather than the 8-TV lines in the manual mode.* The coordinates of the pointer position appear in the lower right-hand corner of the screen. If the pointer is moved off the screen to the right, it will reappear on the left and vice versa.

4.3.7 CAM 1/CAM 2: ZAPP can interface with a real-time interference pattern or an interferogram. The CAM 1/CAM 2 toggle switch selects the desired input.

CAM 1 -- CCTV camera in the Interferogram Reader Module

CAM 2 -- Video camera in the Interferometer.

4.3.8 Calibration Light: The calibration light is activated when geometric distortion has been computed through the use of calibration grids and is to be subtracted from subsequent measurements as requested in the defaults. Geometric distortion data is obtained from measurement of a calibration grid using MEASURE and COMPUTE and then stored in a special calibration array by pressing ENT.

*ZAPP systems which operate at a frequency of 50Hz have a vertical resolution of 10-TV lines in the manual mode.

4.4 CURSORS

The cursor controls provide for adjusting the four lines which appear on the monitor's viewscreen. These lines can be moved horizontally and vertically to accommodate a wide variety of clear aperture sizes. The cursor controls are operable with the AUTO/MAN/FID switch in the AUTO position.

4.4.1 ON/OFF Switch: Placing the cursor on/off switch in the ON position causes four cursor lines to appear on the monitor's viewscreen. The OFF switch position causes the lines to disappear (Fig. 5.4-1).

4.4.2 VERT ↕ : This two position, center-off momentary switch permits manual control of the vertical position of the upper horizontal cursor line. Using this switch, the line is placed tangent to the upper-most position of the clear aperture of the interference pattern.

4.4.3 VERT ±: This two position, center-off momentary switch is used to control manually the vertical position of the lower horizontal cursor line. The lower horizontal cursor line is placed tangent to the lower-most portion of the clear aperture of the interference pattern.

4.4.4 HORIZ ↔ : This two position, center-off momentary switch permits manual control of the horizontal position of the left-most vertical cursor line. The line is placed tangent to the left-most position of the clear aperture.

4.4.5 HORIZ ±: This two position, center-off momentary switch permits manual control of the horizontal position of the right-most vertical cursor line. The line is placed tangent to the right-most position of the clear aperture.

4.5 CONTROL TERMINAL -- AUTOMATIC

The command controls cause the processor module to automatically acquire and display the coordinates of an array of points falling on the fringe centers. The controls also cause the processor module to execute the various computations. To operate ZAPP in the automatic acquisition mode, the AUTO/MAN/FID three position toggle switch should be placed in the AUTO position.

4.5.1 MEASURE: Depressing the MEASURE pushbutton will cause the processor module to automatically acquire and display on the monitor viewscreen the coordinates of any array of points falling on the fringe centers. The automatically acquired data is displayed by a series of x's and +'s to allow the operator to verify the fringe order (Fig. 5.4-2).

4.5.2 COMPUTE: Depressing the COMPUTE pushbutton causes the processor module to perform the requested computation. The peak-to-valley, root-mean-square, and accept/reject (if applicable) are immediately displayed on the monitor viewscreen (Fig. 5.4-3).

If no data appears on the screen, pressing COMPUTE will cause the processor module to perform the requested computation on previously acquired data. This is useful when it is necessary to change defaults on the same set of fringe centers.

4.5.3 STORE OPDs: Depressing the STORE OPDs pushbutton causes the OPDs to be transferred to a uniform grid and to be retained in Random Access Memory (RAM) for future use. This uniform grid is fixed relative to the monitor display and is dimensioned in Fig. 4.5.3-1.

The STORE OPDs button must be pushed prior to subtracting, plotting or printing OPDs except when operating in the averaging mode. In the averaging mode, the operator can PLOT or PRINT OPDs without depressing STORE.

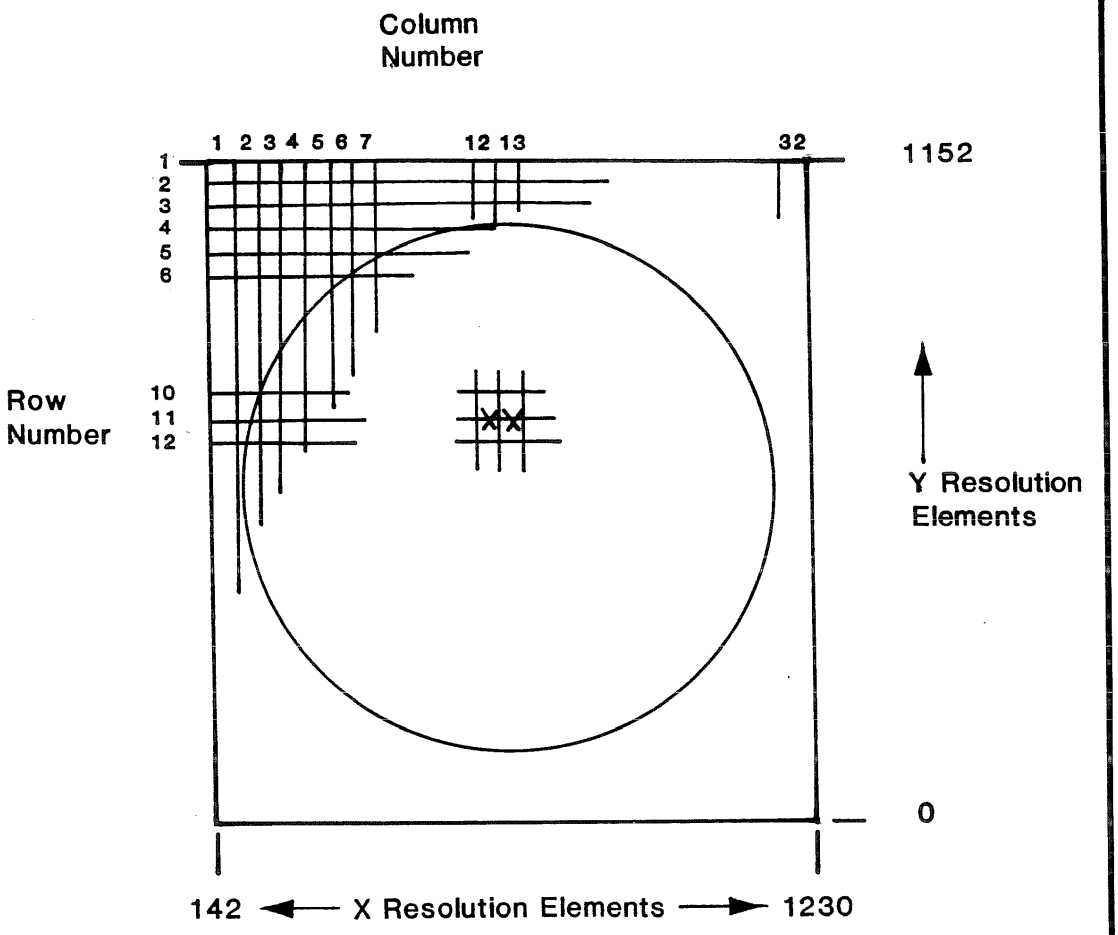
4.5.4 Stored OPDs Indicator Light: The light next to the STORE OPDs pushbutton indicates the presence of stored OPDs. This data is always retained and is changed by storing new data or by pressing the RESET button.

4.5.5 SUBTRACT OPDs: This pushbutton transfers the OPDs of the interference pattern being currently evaluated to a uniform grid and causes the stored OPDs to be subtracted from the interference pattern OPDs.

4.5.6 DISPLAY: Depressing the DISPLAY pushbutton causes the output format and the output information to appear on the monitor viewscreen (Fig. 4.5.6-1). The SKIP pushbutton or the DISPLAY pushbutton is depressed to step through the output information.

4.5.7 PLOT: Depressing the PLOT pushbutton causes the 3-D plot of OPDs in the uniform grid to appear on the monitor viewscreen. If PLOT is depressed after a subtract operation, the difference map will be displayed without altering data in the STORE OPDs memory.

4.5.8 PRINT/TRANSFER: When PRINT OPDs is not requested in default, pressing PRINT/TRANSFER causes the printer to produce a print ticket of the output format. When PRINT OPDs is requested in default, pressing the PRINT/TRANSFER pushbutton causes the printer to produce a hard copy of the output format, output information, and the stored OPDs. When transfer to AUX COMP is requested in default, pressing PRINT/TRANSFER causes the acquired fringe centers to be transferred to an auxiliary computer (see Sec. 5.10 for a complete description).



Column Width (Resolution Element) = 34 (32)

Row Separation (Resolution Element) = 48

Center of Circle (x,y) 667, 554 approximate

Radius of Circle $\simeq$ 463 (R.E.)

x -- OPDs for Row 11, Column 12, 13

Figure 4.5.3-1 ZAPP Uniform Grid

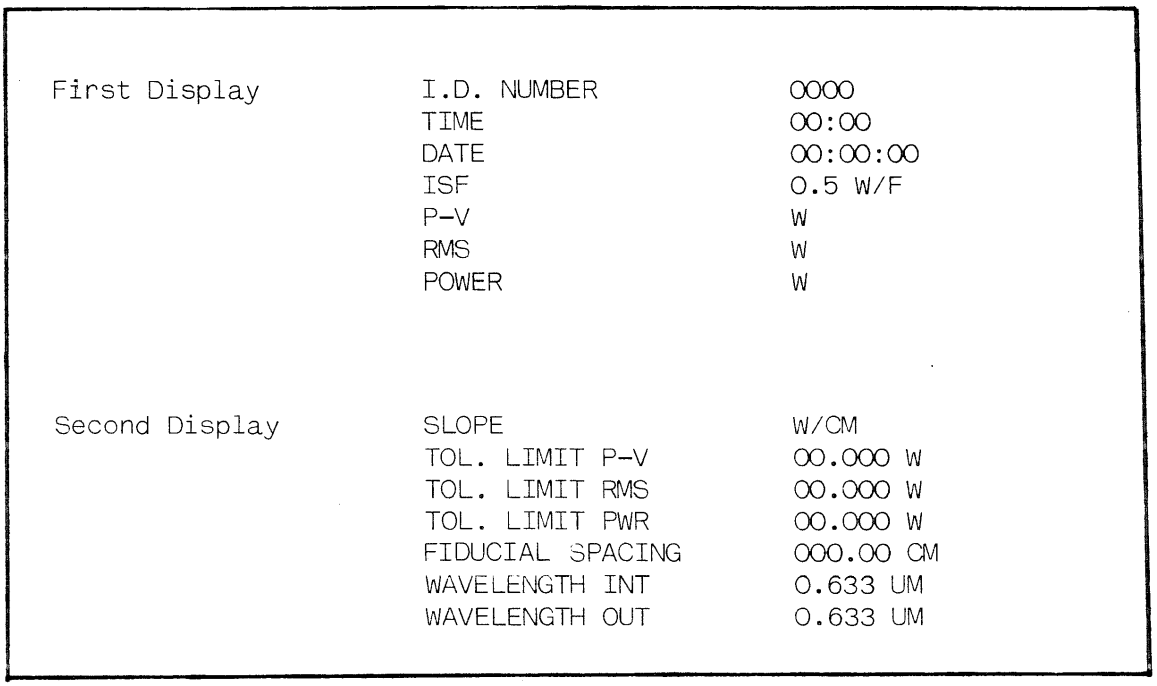


Figure 4.5.6-1 Output Format as Displayed on the Monitor

4.6 CONTROL TERMINAL -- MANUAL SECTION

The manual controls allow the operator to 1) erase or enter single points when in the automatic fringe center acquisition mode, or 2) manually acquire fringe centers for an entire pattern.

4.6.1 POINTER: The POINTER, an asterisk character, appears on the monitor's viewscreen when the BEGIN pushbutton is depressed while in the AUTO mode; or when the AUTO-MAN-FID three position toggle switch is in the MAN position. Using the controls described below, the POINTER can be positioned horizontally or vertically on the viewscreen.

4.6.2 BEGIN: Depressing the BEGIN pushbutton causes the following operations to take place.

1. In the AUTO acquisition mode the POINTER appears on the monitor viewscreen and single point insertion or erasure operations can be performed.

2. In the MAN acquisition mode the BEGIN pushbutton is depressed to clear all fringe centers from memory.

4.6.3 PUSHBUTTON ↑ : The ↑ pushbutton moves the POINTER incrementally up by 8 TV scan lines.*

4.6.4 PUSHBUTTON ↓ : The ↓ pushbutton moves the POINTER incrementally down by 8 TV scan lines.*

4.6.5 ← POINTER → : This three position center-off, momentary toggle switch moves the POINTER horizontally. A single contact of this switch causes a slow horizontal motion of the POINTER. A quick double contact of the switch causes a rapid horizontal motion. The horizontal motion is in increments of one resolution element.

4.6.6 ERASE: Depressing the ERASE pushbutton causes the following operations to take place.

1. AUTO acquisition mode: After BEGIN has been depressed, when the POINTER is moved to an incorrect data point and the ERASE pushbutton is depressed, the data point closest to the POINTER is erased.

*The POINTER is moved incrementally up or down by 10 TV scan lines in the 50Hz ZAPP systems.

2. MAN acquisition mode: When the POINTER is moved to a horizontal line of interest and the ERASE button is depressed, all data points on that horizontal line are erased. This permits only the insertion of data on that horizontal line. This mode can be terminated by pressing COMPLETE (Sec. 4.6.7).

4.6.7 COMPLETE: In the MAN mode, the COMPLETE pushbutton is depressed after each row of editing has been completed.

In the AUTO mode, the COMPLETE pushbutton is depressed when single point editing has been completed.

4.6.8 INSERT: The INSERT pushbutton is depressed each time the POINTER coincides with a fringe center that is to be entered into the microprocessor.

4.6.9 TOP: When the TOP pushbutton is depressed in the MAN mode, the POINTER returns to the top of the viewscreen, automatically increments the fringe order number, and is now ready to acquire the next fringe.

4.6.10 ALIGN: The ALIGN pushbutton is pressed to order the data points when the fringes have been misordered due to editing. However, if the fringe pattern is misaligned due to artifacts, the close proximity of fringe spacing, or slopes in excess of 45 degrees from the vertical, ZAPP will not be able to automatically reorder the fringes.

5. OPERATION

ZAPP has been designed to be equally useful for production, quality assurance and laboratory applications. The operating system is easily used to its full capability by an operator with minimal technical training. At the same time, it has also been designed to be a useful tool for the more sophisticated user.

When acquiring an interference pattern for evaluation by ZAPP, the user should obtain a sampling of data which is as uniform as possible over the clear aperture (pupil). An interference pattern with straight-line bias fringes provides the most uniform sampling of data. It is also useful to acquire well-defined patterns without closed fringes to eliminate ambiguity in numbering the fringes, i.e., assigning order numbers. Phase information is ascertained by specifying the location of the zero order.

ZAPP evaluates an interference pattern which has been transduced by a low geometric distortion CCTV camera by performing a least squares fit to an array of points located on the center of the fringes. The coordinates of the array of points located on the fringe centers are obtained either automatically or manually. The least squares fit calculates the fractional deviation of the interference pattern represented by the fringe centers from an ideal, best-fitting pattern. ZAPP is essentially a video fringe center coordinate digitizer with the numerical computational capability to do rapid, sophisticated analysis of the data. It provides an objective, powerful, essentially real-time interference pattern evaluation capability previously available at only a few facilities.

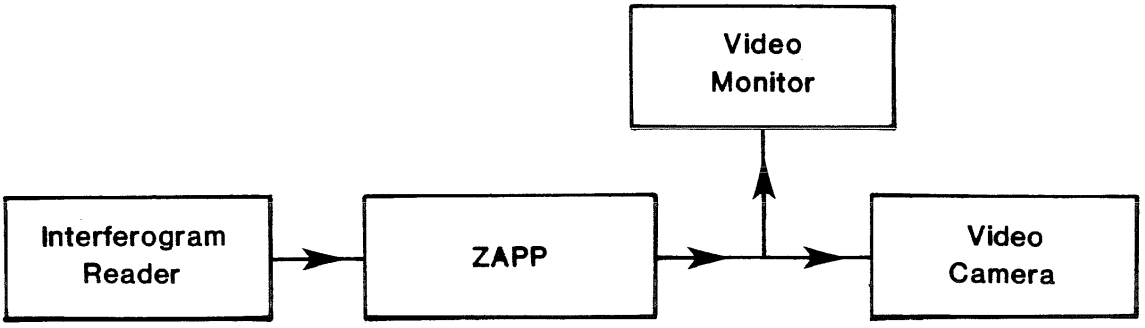
5.1 TWO MODES OF OPERATION

For one type of application, the mode of operation consists of placing the interferogram to be evaluated on the platen of the Interferogram Reader. The resulting pattern, which is displayed on the monitor, is stable since it is viewed from the original hard copy interferogram. Interferograms taken at different test facilities or at different times can be evaluated using a single ZAPP system. Figure 5.1-1(a) is a schematic of the video signal flow for this mode.

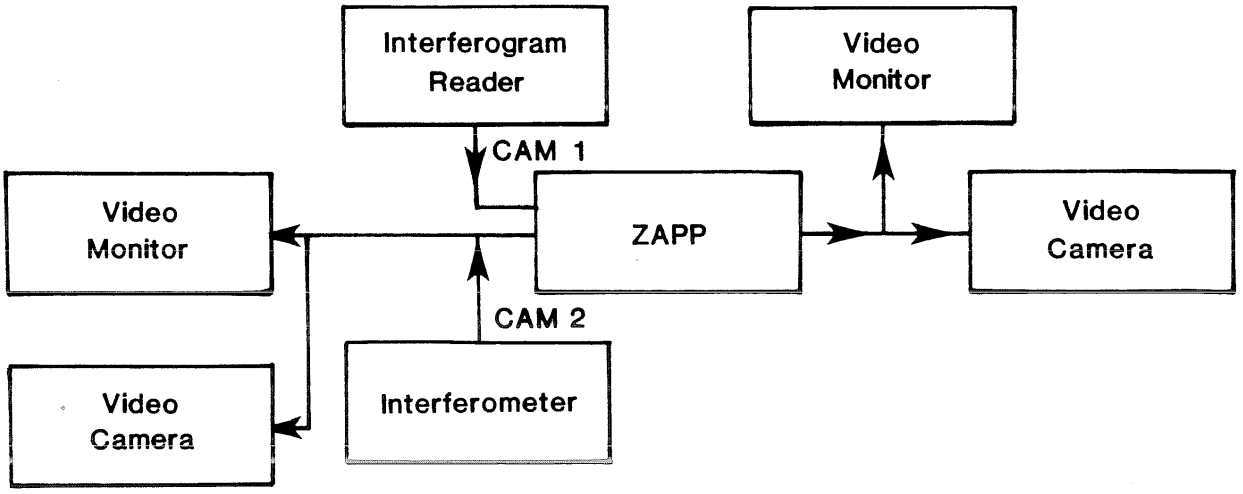
Alternatively, in the second mode of operation, a live interference pattern from an interferometer incorporating a CCTV camera is interfaced directly to the ZAPP system. This mode is feasible only when the interference pattern to be evaluated is stable and is not adversely affected by vibration and/or drifts in the interferometer setup. Figure 5.1-1(b) is a schematic of the video signal flow for this mode.

5.2 START UP

Activate the power switches on the Processor Module, Interferogram Reader, Video Camera, and the Video Monitor. Allow the Interferogram Reader and the Video Camera to warm-up for 30 minutes.



(a) Normal operation of ZAPP System



(b) Interferometer Interfaced with ZAPP System

Figure 5.1-1

CAUTION: To avoid damage to the Vidicon from overhead lights, keep the shield provided with the Interferogram Reader in place over the platen when the module is not in use.

5.3 SET-UP OPERATION

Since the evaluation of the interferogram requires a number of input parameters; since a number of operations or functions may constitute the evaluation desired; and since there are a number of outputs and formats for the outputs of the evaluation; it is necessary to provide a convenient, flexible means to accommodate this complex array of options.

5.3.1 Prompting Format: ZAPP accommodates these options by using the Control Terminal and the Video Monitor as a video terminal with which the operator can easily insert input information, select operations, and select outputs. Specifically, ZAPP uses a prompting format with software generated forms which appear on the Video Monitor. Figures 5.3.1-1, 5.3.1-2, and 5.3.1-3 illustrate the Input Information, Operation Information, and the Output Information.

5.3.2 Defaults: Since some parameters are encountered quite frequently, defaults are built into the system. Defaults are set in two ways in ZAPP: 1) in ROM, i.e., read only memory, in the Processor Module, and 2) via switches accessible from the Control Terminal. In either case, a default can be changed, if desired, via the controls on the Control Terminal during set-up. The defaults are set in ROM or switches in order to assure their nonvolatility.

5.3.3 Set-Up Procedure: Before executing the set-up procedure, turn on the Processor Module if the on/off switch is in the off position. As soon as the Processor Module is turned on, the system diagnostics program is automatically executed (for more details, see Section 7.1.3). While the system is performing the diagnostics procedures, the revision level of the software (e.g., REV E) will appear in the top left corner of the Video Monitor. Error codes or warnings may also appear below the software revision level on the monitor viewscreen (see Section 5.12). If any of these warnings occurs repeatedly, contact the Service Department. To continue system processing after a warning appears, depress the SKIP/RESTORE pushbutton to access the initial Input Information Form. If no problems are detected during the execution of the diagnostics program, the initial Input Information Form is automatically displayed on the Video Monitor.

When the Processor Module is already turned on, simply depress the START pushbutton to access the first Input Information Form. To change the default parameters on a prompting information page, move the pointer down to the line of interest by depressing the ENT key or up to the appropriate line by depressing the EXP key. The keypad may then be used to change the defaults and enter numerical data. Many of the default parameters can be

	Type of Default	Defaults	Format	Units
I.D. No.			XXXXXX	
Time			XX:XX	24-hr clock
Date			XX-XX-XX	
Apert.	Switch	E[2]	E or R[3]	
Units	Switch	λ	λ or F	
ISF[1]	ROM	0.5λ	X.XX	λ
Zero Order	Switch	L	L or R	
Tol. Limit P-V			X.XX	F or λ*
Tol. Limit RMS			X.XX	F or λ*
Tol. Limit PWR			X.XX	F or λ*
Fid. Spacing	ROM		655.35 max.	cm
λ_{int}	ROM	0.633	65.535 max.	µm
λ_{output}	ROM	0.633	65.535 max.	µm
Positive	Switch	Yes		

*Depends on units selected (on the Monitor, λ is represented by an L)

[1]ISF = Interferogram Scale Factor
[2]E = Ellipse
[3]R = Rectangle

Figure 5.3.1-1 Input Information Format

	TYPE OF DEFAULT	DEFAULTS
Subtract Power	Switch	No
Averaging	Switch	No
Number of Averages		
Measure Geometric Distortion	Switch	No
Number of Measurements		
Subtract Geometric Distortion	Switch	No
Transfer to Auxiliary Computer	Switch	No
Print OPDs	Switch	No
Obscuration	Switch	No
Slope	Switch	No
Manual Averaging	Switch	No

Figure 5.3.1-2 Operation Information Format

		PRINT	DISPLAY	FORMAT & UNITS
I.D. NUMBER		Yes	Yes	*
Time		Yes	Yes	*
Date		Yes	Yes	*
ISF		Yes	Yes	*
P-V		Yes	Yes	*
RMS		Yes	Yes	*
Power		Yes	Yes	*
Slope		Yes	Yes	*
Tol. Limit P-V		Yes	Yes	*
Tol. Limit RMS		Yes	Yes	*
Tol. Limit Power		Yes	Yes	*
Fiducial Spacing		Yes	Yes	*
Wavelength Int		Yes	Yes	*
Wavelength Out		Yes	Yes	*
	Type of Default			
OPDs	Switch	No	NA[1]	
3-D Plot	Switch	NA[1]	No	

[1] NA = Not Applicable

*Same as Input Information

Figure 5.3.1-3 Output Information Format

changed by simply depressing the YES or NO key (Table 5.3.3-1 and 5.3.3-2). Subsequent depression of the SKIP/RESTORE pushbutton causes the additional Input Information Form and the Operation Forms to appear on the Video Monitor. Again, the operator can change the default parameters as desired.

After the last Operation Form is displayed, the prompt "STANDARD DEFAULTS?" will appear on the Video Monitor. If the operator does not wish to continue to change the default parameters, the YES key is depressed. If instead the operator either wishes to reexamine or change the default parameters, the NO key should be depressed to cause the first Input Information Form to reappear. The SKIP/RESTORE pushbutton can be pressed to cycle through all of the prompting information pages. START may also be pressed at any time to cause the system to return to the first Input Information Form.

5.4 AUTOMATIC ACQUISITION

Place the interferogram to be evaluated on the platen of the Interferogram Reader, or interface directly to a real-time interference pattern. Place the mode switch in AUTO and turn the CURSORS ON-OFF switch to ON. Position the clear aperture cursors as described in Sec. 4.4. Figure 5.4-1 depicts the four clear aperture cursors superposed on an interference pattern. Note that the cursors are slightly inside the circular format shown. This insures that the data is reduced within the 80% low distortion region. (If necessary, the cursors can also be positioned outside the circular format to acquire data over the entire interference pattern.)

With the mode switch in AUTO, depressing the MEASURE pushbutton will cause the Processor Module to acquire and to display automatically on the video monitor's viewscreen the coordinates of an array of points falling on the fringe centers inside the clear aperture (Fig. 5.4-2). It takes ZAPP a fraction of a second to measure the X,Y coordinates of up to approximately 500 fringe centers.

If the automatically acquired fringe centers are not satisfactory, the operator can either 1) edit by erasing and inserting a few fringe centers using the single point erase mode, 2) edit an entire row, or 3) digitize the entire pattern manually if a few edit corrections are not feasible.

If the automatically acquired data is satisfactory, depressing the COMPUTE pushbutton causes the Processor Module to perform the least squares analysis. The results of the computation, namely, the peak-to-valley (P-V), root-mean-square (RMS), and accept/reject (if applicable) are displayed on the Video Monitor's viewscreen in three seconds (Figure 5.4-3).

If the operator wishes to change the defaults, but use the same data points, pressing the SKIP/RESTORE button will cause these points to be redisplayed after prompting.

During a number of repeated MEASURE and COMPUTE cycles, the RMS value should remain reasonably constant for modest changes in peak-to-valley values. These changes occur during any measurement process due to the statistical nature of the process. If the RMS value does not change sub-

INFORMATION REQUIRED	DEFAULTS TO BE ENTERED	DEPRESS
Identification Number	Enter via keypad	ENT
Time	Enter via keypad	ENT
Date	Enter via keypad	ENT
Aperture	E = Elliptical or R = Rectangular To retain the displayed default To change the default	 Yes No
Units	W = Wavelength or F = Fringes To retain the displayed default To change the default	 Yes No
Interferogram Scale	Retain scale factor Enter new scale factor via keypad	ENT ENT
Zero Order	L = to the left or R = to the right To retain displayed default To change default	 Yes No
Tolerance Limit-- Peak-to-Valley	W or F depends on units selected Enter via keypad	 ENT
Tolerance Limit-- Root-Mean-Square	W or F depends on units selected Enter via keypad	 ENT
Tolerance Limit-- Power	W or F depends on units selected Enter via keypad	 ENT
Fiducial Separation	Enter via keypad in cm	ENT
Wavelength--Interferometer	Retain wavelength Enter new wavelength via keypad	ENT ENT
Wavelength--Output	Retain wavelength Enter new wavelength	ENT ENT
Positive	Input material in Reader To retain display default To change default	ENT Yes No

Table 5.3.3-1 ZAPP Prompting Format for First and Second Display

INFORMATION REQUIRED	DEFAULTS TO BE ENTERED	DEPRESS
Subtract Power?	To subtract power To not subtract power	YES NO
Averaging?	To obtain averaging To not average	YES NO
Number averaged	Enter 1, 2, 4, 8, or 16 via keypad To retain the default	ENT ENT
Measure Geometric Distortion?	To measure geometric distortion To not measure geometric distortion	YES NO
Number Measured	Enter 1, 2, 4, 8, or 16 via keypad To retain default	ENT ENT
Subtract Geometric Distortion	To subtract geometric distortion To not subtract	YES NO
Transfer to Auxiliary Computer	To transfer to auxiliary computer To not transfer	YES NO
Print OPDs	To print OPDs To not print OPDs	YES NO
Obscuration	To activate the obscuration mode To not activate the obscuration mode	YES NO
Slope	To calculate slope To not calculate slope	YES NO
Manual Averaging	To average manually To not average manually	YES NO

Table 5.3.3-2 ZAPP Prompting Format for Third and Fourth Display

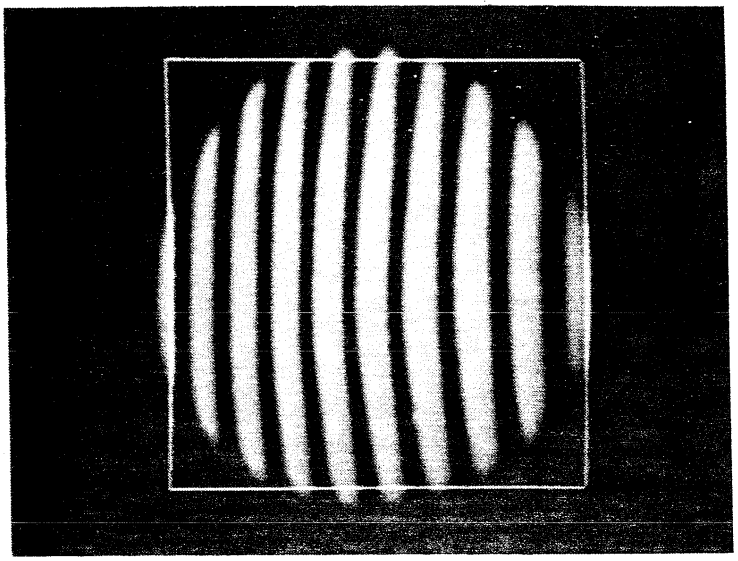


Figure 5.4-1
Clear Aperture Cursors

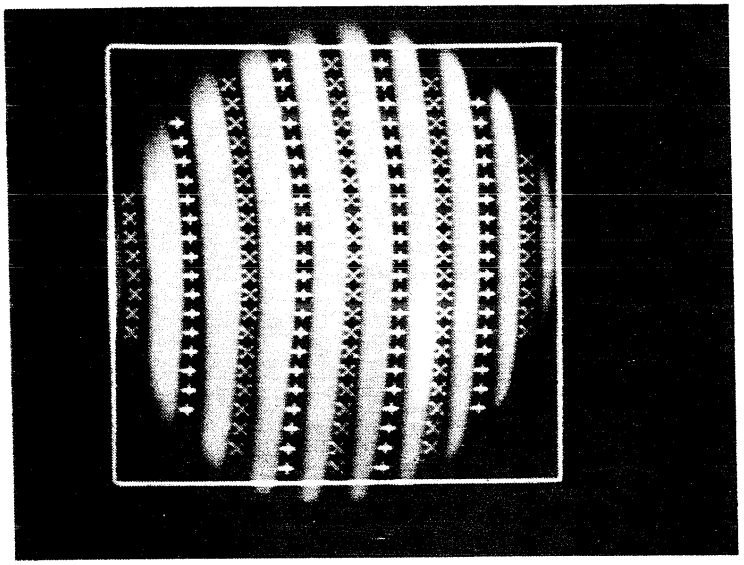


Figure 5.4-2
Fringe Centers

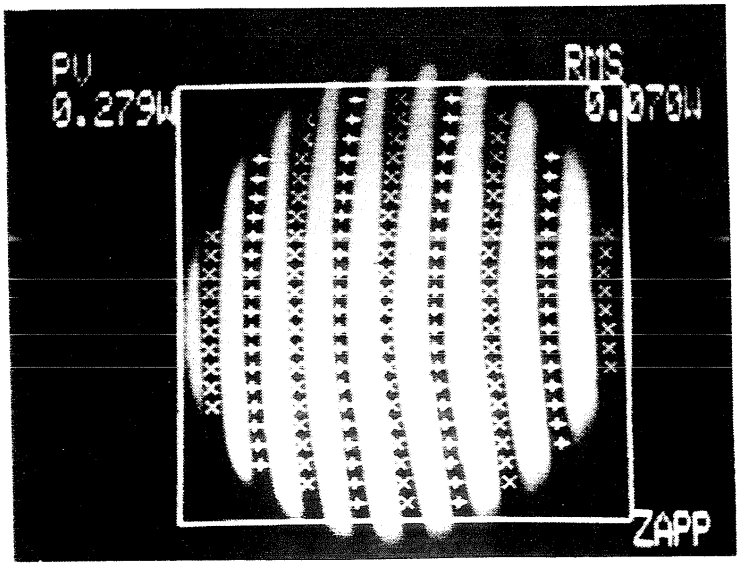


Figure 5.4-3
Data Reduction

stantially through a number of MEASURE and COMPUTE cycles, it can generally be assumed that the data is being acquired properly. If the RMS value changes by approximately 25% or more, the operator should check for misacquired data points.

5.5 EDITING

Because of a variety of effects, e.g. artifacts, gaps in fringes, large variations in fringe widths, etc., the results of the automatic acquisition may lead to: 1) spurious data points, 2) missed data points, and 3) improperly ordered data. The video display of the results of the automatic acquisition provides a quick and convenient means by which the operator can assess the presence of any of these problems.

5.5.1 Single Point Editing: This mode of operation is utilized for editing isolated points; however, an entire fringe pattern can be edited if desired (see Sec. 5.5.4). With the toggle switch in AUTO, depressing the BEGIN pushbutton causes the POINTER to appear on the monitor's viewscreen.

5.5.1.1 Single Point Erasure--Move the POINTER so that it is superposed on an incorrect data point to be erased. See Sec. 4.6 for operation of POINTER controls. Depressing the ERASE button erases the data point closest to the POINTER on that row.

5.5.1.2 Single Point Insertion--Move the POINTER to the fringe center to be inserted. Depressing the INSERT pushbutton enters the data point into the microprocessor. NOTE: New data points cannot be entered on vacant lines. This type of operation is performed in the MANUAL editing mode only.

5.5.1.3 Complete--When the Editing has been completed, depress the COMPLETE pushbutton to exit the single point edit mode.

5.5.2 Misordering of Data Points: If there are one or more problem data points which have caused a misordering of subsequent data points, it is necessary only to edit the point(s) causing the problem (as described previously). After the editing operation is completed, place the mode toggle switch in the AUTO position and depress the ALIGN pushbutton to reorder the subsequent data points. Next, the COMPLETE pushbutton must be depressed, before a COMPUTE can be executed.

5.5.3 Editing a Line of Data Points: To edit a line of problem data points or to insert points on a vacant row the AUTO-MAN-FID toggle switch is placed in the MAN position. In this mode, the POINTER appears on the monitor's viewscreen. To erase the line of data points, move the POINTER to the line of interest and depress the ERASE pushbutton.

To insert the edited points, the POINTER is moved horizontally left-to-right from fringe center to fringe center. Each time the POINTER coincides with a fringe center, the INSERT pushbutton is depressed. The integral fringe order number is displayed and is increased by one each time the INSERT pushbutton is depressed. Upon completion of the edit, the COMPLETE pushbutton is depressed and the toggle switch returned to the AUTO position before a data reduction can be requested by depressing COMPUTE.

After COMPUTE is depressed, the first point entered on the line of data points may not appear on the fringe pattern. This may occur since ZAPP does not count the fringe order in this mode. If the first point on the line does not appear, a few dummy points must be entered outside the fringe pattern. To enter the dummy points, move the toggle switch back to the MANUAL position, enter two or three points from left to right, and depress the COMPLETE pushbutton. (Do not depress ALIGN.) The dummy points may then be removed using single point editing (see Sec. 5.5.1) before COMPUTE is depressed.

5.5.4 Editing a Complete Pattern: In order to acquire fringe centers manually for an entire pattern, place the mode toggle switch in the MANUAL mode. The BEGIN pushbutton is then depressed to place the POINTER in the upper left-hand corner of the monitor's viewscreen. The pointer is moved using the aforementioned controls until it is centered on the top-most part of the left-most fringe. Once the pointer is centered, the INSERT pushbutton is depressed. Pushing the INSERT pushbutton causes 1) the coordinates of the pointer to be placed in the memory of the Processor Module and 2) the pointer to increment down 8 TV lines* so that it can be moved horizontally to coincide with another fringe center. This process is repeated until the entire first fringe is digitized. Then the TOP pushbutton is depressed to return the pointer to the top of the monitor's viewscreen. This also increments the fringe order internally. The process followed for the first fringe is repeated until the entire set of fringes is digitized. The acquisition mode switch is then placed in AUTO so that the fringe center data can be processed when the COMPUTE pushbutton is depressed.

5.5.5 Obscuration Editing Mode: This optional mode provides a method by which obscured fringe patterns may be measured using semiautomatic or manual editing methods. This mode is entered through the standard defaults by pressing YES to answer the question "OBSCURATION?".

In order to measure an obscured pattern (Fig. 5.5.5-1) the user sets up an interferogram in the standard way and presses MEASURE. In addition to obtaining the fringe centers, this operation may also pick up spurious points within and around the edges of the obscuration (Fig. 5.5.5-2). Furthermore, the fringes in general will not be properly aligned. To perform the alignment, the user must press BEGIN (as in the single point edit mode) and insert data points for every line of data in the obscured region (Fig. 5.5.5-3). These points serve to connect artificially the fringes on either side of the obscuration. Other spurious points should be edited at this time also.

*The pointer is moved down 10-TV lines in the 50Hz ZAPP systems.

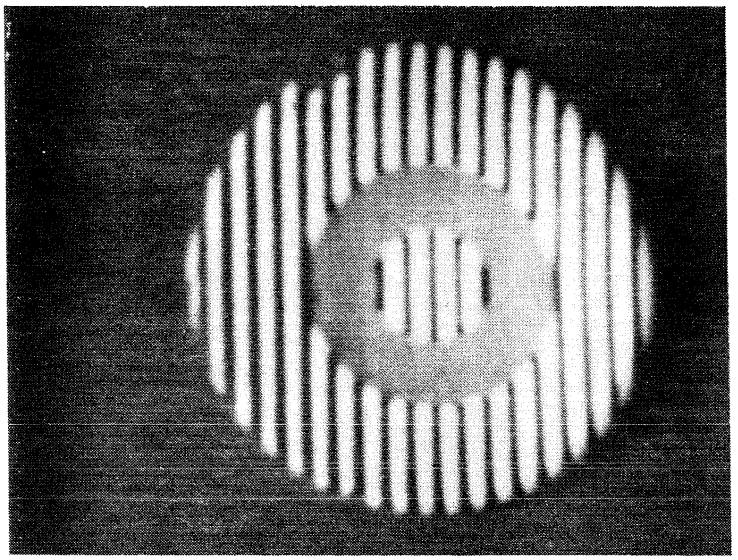


Fig. 5.5.5-1
Obscured fringe pattern to be measured.

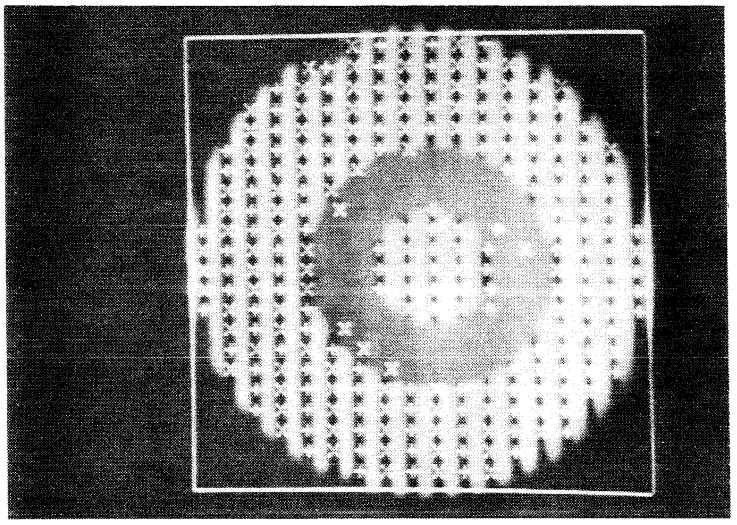


Fig. 5.5.5-2
Automatically acquired fringe centers may pick up spurious points within and around the edges of the obscuration.

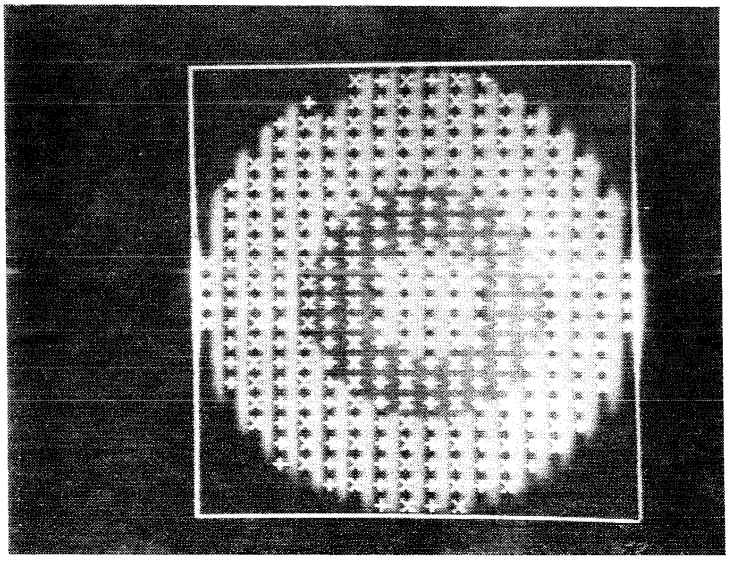


Fig. 5.5.5-3
To properly align the fringes, data points must be inserted for every line of data in the obscured region.

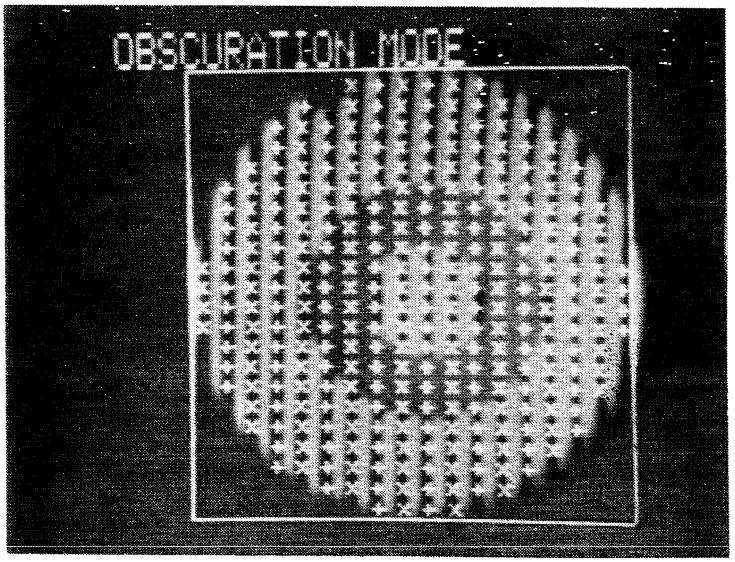


Fig. 5.5.5-4
Pressing COMPUTE activates the Central Obscuration Mode.

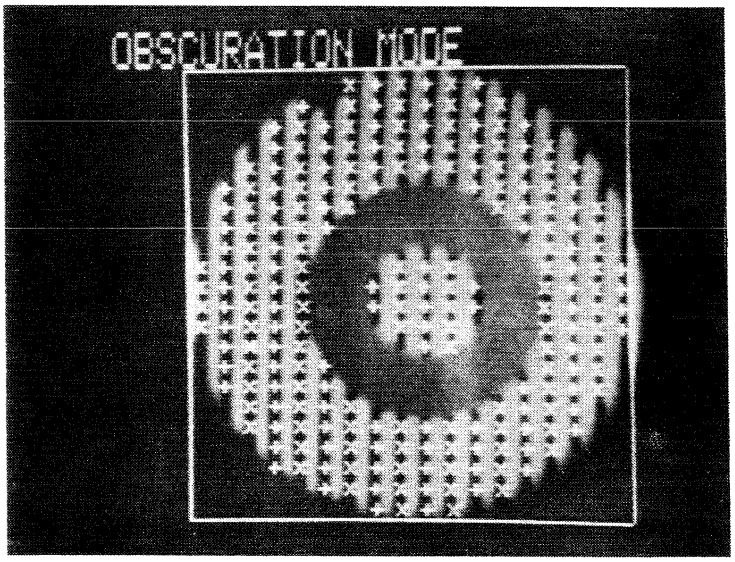


Fig. 5.5.5-5
Erase each point within the obscuration by means of single point editing.

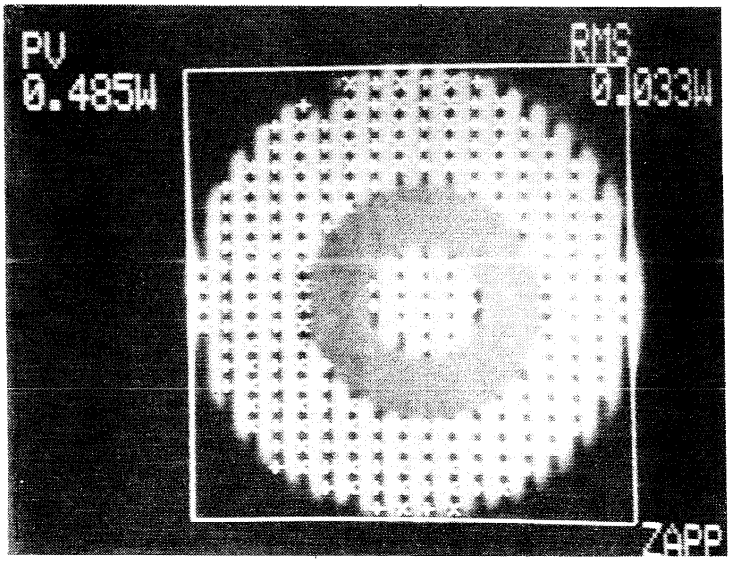


Fig. 5.5.5-6
When the editing is complete, pressing COMPUTE causes ZAPP to calculate the peak-to-valley and root-mean-square.

When the editing is accomplished, press COMPLETE and then press ALIGN to properly order each fringe. After alignment, carefully examine all data points to be sure they are correct. If they are not satisfactory, edit them again at this time and align if necessary.

When the editing is satisfactory, press the COMPUTE button to activate the obscuration mode and cause the words "Obscuration Mode" and a pointer to be displayed on the top of the screen (Fig. 5.5.5-4). The pointer can be moved in the same manner as in single point editing. It should be moved to the left-most x or + for any row of data within the obscuration. Pressing ERASE will erase the point nearest the pointer. Continued pressing of ERASE will erase points successively to the right of the first point erased (Fig. 5.5.5-5). Step the pointer through each row as required and erase all data points within any obscured area in the field. When the editing is complete, press COMPUTE again to cause ZAPP to calculate the peak-to-valley and RMS on the remaining data points (Fig. 5.5.5-6).

5.6 CALIBRATION

The Calibration mode allows the user to measure, store, and subtract the system geometric distortion from interference data. This is accomplished using a precise artificial interferogram (calibration grid) which is provided with the ZAPP System. The system must be calibrated prior to using transmission spheres in the interferometer accessory receptacle. For measurements not requiring a transmission sphere, the system should be calibrated to acquire interference patterns in the tenth to twentieth wave range. Whenever parts with errors greater than $\lambda/10$ are measured, the amount of system distortion is relatively small compared to the error in the part. It is perfectly acceptable, however, to calibrate the ZAPP System for any measurement.

5.6.1 Measurement of the Calibration Grid: The Calibration mode is entered via prompting by: (1) changing the "UNITS" default to "F" to request measurements in fringe units, (2) changing the "MEASURE G.D.?" default to YES, (3) entering the desired number of measurements (1, 2, 4, 8 or 16)*, and (4) changing the "SUBTRACT G.D.?" default to YES. After these steps are completed, place the calibration grid on the reader platen and adjust the clear aperture cursors as previously described for an interferogram. (Place a white card over the grid so that the illumination is uniform.) Next, depress the MEASURE pushbutton to obtain the fringe centers. When the fringe centers are displayed, remove the calibration grid and place an interferogram on the reader platen. Adjust the ZOOM control so that all of the interferogram's fringes are within the area of the previously acquired fringe centers.

To perform the first measurement in the calibration mode, replace the interferogram on the reader platen with the calibration grid and the white card. Center the grid within the clear aperture cursors positioned during the previous procedure, and depress MEASURE followed by COMPUTE. Check the P-V error when it appears on the Video Monitor. The maximum value of this number should be less than or equal to 1% of the number of grid lines in the clear aperture. For example:

*For maximum accuracy, 16 measurements should be requested during prompting.

1) If 10 grid lines are visible in the clear aperture, then the approximate P-V value should be 1% of 10, or .100 F.

2) Whenever 15 grid lines are in the clear aperture, the approximate P-V value should be 1% of 15, or .150 F.

If the displayed P-V value, in fringes, is considerably greater than the 1% approximation, look for any obviously mislocated data points and either correct them using the single point editing mode or press MEASURE followed by COMPUTE once again. A useful tool for a careful calibration is to press STORE OPDs and PLOT after each MEASURE and COMPUTE cycle. Single error points are prominent in the displayed plot and can be edited accordingly. Each line in the plot corresponds to a data line from the bottom up.

When a valid calibration measurement has been obtained, depress the ENT key to store the data in the special calibration storage array. After ENT is depressed, the measurement number is displayed on the Video Monitor. Each subsequent measurement may be acquired in the same way, except that the calibration grid should be shifted slightly following each measurement to obtain better smoothing of the average distortion. The average distortion correction of each measurement is stored in the calibration array.

CAUTION: 1. Calibration is not retained in the memory when the Processor Module is turned off or when RESET is depressed.

2. A new calibration procedure will be required any time the interferometer zoom position is changed.

3. If the cursors are moved out from the positions where the calibration data was acquired, "WARNING I" appears on the Video Monitor. This warning indicates that the current calibration is invalid.

5.6.2 Measurement Automatically Subtracting Distortion: After the calibration grid is measured and the data is stored for the last time, pressing COMPUTE subtracts the average correction from the last measurement. This difference provides the user with the residual system error remaining after the calibration mode. Once the calibration has been completed, the "MEASURE G.D.?" default will revert to the value of NO. As long as the calibration light is on, the system distortion will automatically be subtracted from subsequent interferograms.

5.6.3 Measurement Without Subtracting Distortion: Interferograms may be measured directly without subtraction of distortion in the calibration mode by going to the prompting mode and pressing NO to the "SUBTRACT G.D.?" question. Pressing YES to the same question returns the system to the original calibration condition. If, after calibrating the system, recalibration is desired, pressing YES in response to "MEASURE G.D.?" will erase the stored array upon leaving the prompting mode. The procedure outlined in Section 5.6.1 can then be repeated to recalibrate the system.

5.6.4 Calibration Using Real-Time Fringes: ZAPP can be calibrated using the ZYGO Adjustable Parallelogram as a real-time calibration grid. Refer to the Zygo Interferometer System Operation-Maintenance Manual (OMP-0055) Section 5.8, for details concerning how to set up the Interferometer System. After the interferometer is set up, position a two-axis adjustable mount with a 4% or 90% reference flat approximately 12" from the interferometer's accessory receptacle. Align the reference flat, then place the adjustable parallelogram a few inches away from the 2-axis mount between the mount and the interferometer. The grid lines on the parallelogram must be perpendicular to the interferometer output beam and vertical. After the parallelogram is positioned, the grid line shadows should appear on the Video Monitor. Adjust the grid spacing to obtain the maximum number of lines over the entire aperture for a given zoom position. Proceed as described in Sections 5.6.1, 5.6.2, and 5.6.3.

5.7 AVERAGING INTERFEROGRAMS

The purpose of the Averaging mode is to enable the user to obtain a more representative value of the real peak-to-valley errors in an optical sample rather than one extreme high or low value. Either 2, 4, 8 or 16 interferogram measurements can be averaged manually or automatically.

Automatic averaging averages measurements from a single real time or hard copy interferogram. Manual averaging allows the user to average measurements representing a real time interference pattern and/or one or more hard copy interferograms from an optical sample fixed in the same position. During manual averaging, the user can also select the individual measurements to be averaged. Generally, automatic averaging is more appropriate for real time measurements, and manual averaging can be used to average measurements from a number of hard copy interferograms.

Because of the statistical nature of the measurement process, the user should never take singular peak-to-valley measurements as the true result. ZAPP minimizes the RMS value in a least squares sense and this value will remain relatively constant for a number of repetitive singular measurements, while the peak-to-valley value may fluctuate. Before entering the Averaging mode, the user should run through a series of MEASURE and COMPUTE cycles to establish a mean peak-to-valley value. After a mean value is established, the Averaging mode can be entered using a measurement close to this value. In order to prevent ZAPP from including very poor measurements during automatic averaging, error limits have been included as shown in Fig. 5.7-1. These limits also indicate for the user the reasonable spread which can be expected in the peak-to-valley values when conducting repetitive singular measurements.

NOTE: Averaging real time data should not be performed when the fringe positions are being altered by excess vibration or thermal changes.

5.7.1 Automatic Averaging: To initiate automatic averaging, the Averaging mode is entered via prompting by changing the "AVERAGING?" default to YES and entering the number of averages desired.

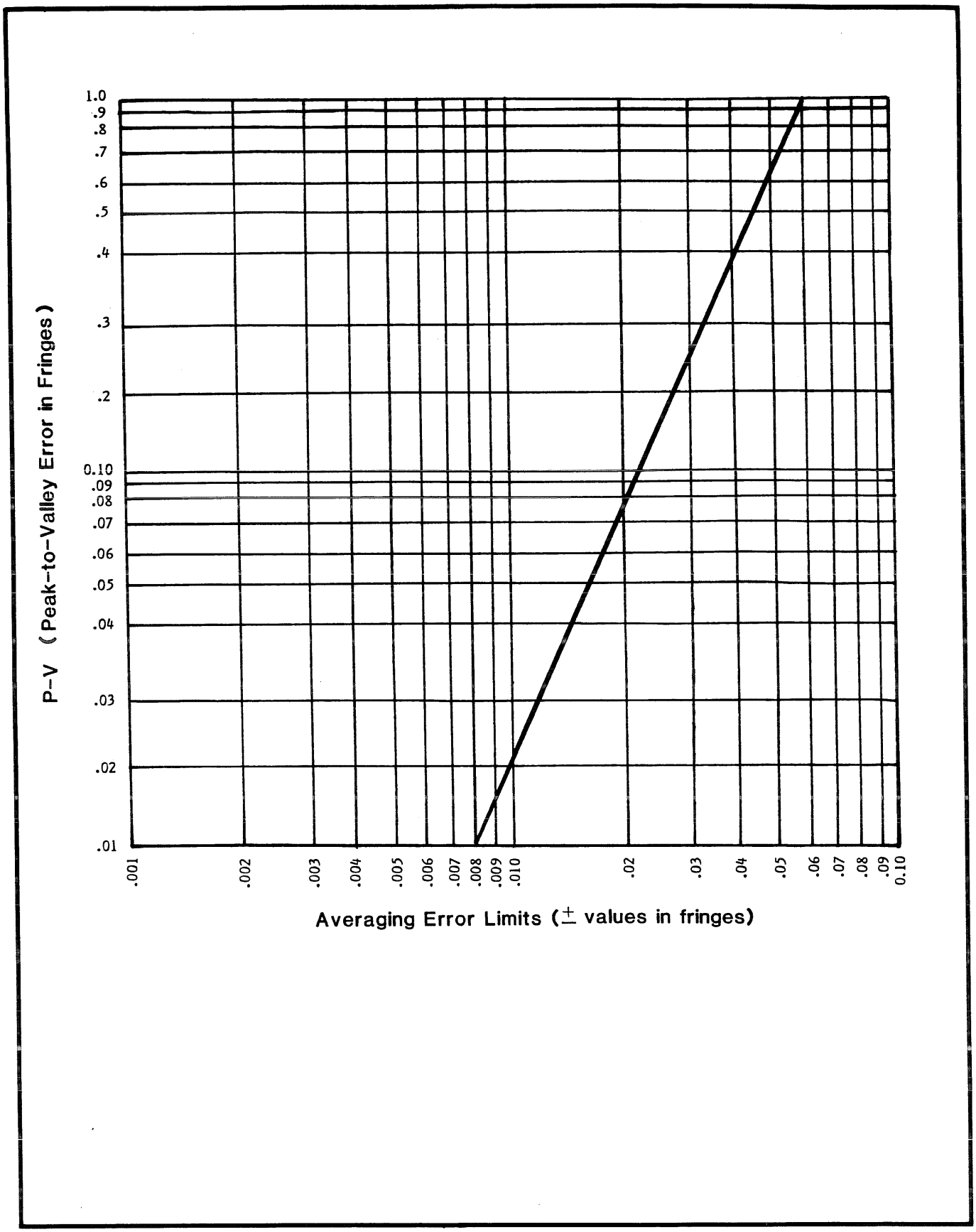


Figure 5.7-1 Averaging mode error limits indicate what reasonable spread might be expected when conducting a series of repetitive, singular measurements.

NOTE: If a number other than 2, 4, 8 or 16 is entered for the number of averages, ZAPP will automatically assume a default value. The default will either be 2, 4, 8 or 16 depending upon which number is closer to and lower than the number of averages entered.

After entering the prompting information, the operator can measure a real time or hard copy interferogram in the AUTO mode by depressing MEASURE and then COMPUTE. If the data is satisfactory, pressing ENT executes the selected or default number of averages with no further operator interaction and displays the result.

ZAPP automatically performs the following process to obtain the average peak-to-valley and RMS values.

1. The fringe center data are acquired and a least squares computation is performed for each measurement.

2. The OPDs for each each measurement are transferred to a uniform grid.

3. After all the measurements have been taken, the OPDs on the uniform grid are summed and divided by the number of averages.

4. The peak-to-valley and RMS values are extracted for the averaged OPDs on the uniform grid.

If one of the measurements calculated during automatic averaging does not meet the error limit requirements (Fig. 5.7-1), Warning #K is flashed on the display screen. If three consecutive measurements are unacceptable, the automatic averaging process is aborted. To correct this problem, the user should establish a more accurate mean peak-to-valley value before re-entering the Averaging mode.

5.7.2 Manual Averaging: To initiate manual averaging, the Averaging mode is entered via prompting by changing the "AVERAGING?" default to YES; entering either 2, 4, 8 or 16 for the number of averages or manual measurement cycles desired (see the NOTE in Sec. 5.7.1); and by changing the "MANUAL AVERAGING?" default to YES.

The first measurement of a real time or hard copy interferogram is performed in the AUTO mode by depressing MEASURE and then COMPUTE. If the data is satisfactory, pressing ENT automatically enters the measurement for averaging and redisplays the fringe centers to start a new manual measurement cycle. At this point, the operator can either: (1) reposition the cursors and/or manually edit the fringe centers or (2) prepare another interferogram for measurement (center the new interferogram within the existing cursors).

To cause ZAPP to perform the next measurement, the operator should again depress MEASURE followed by COMPUTE. ZAPP automatically displays the calculated values and a number at the bottom left corner of the screen (Fig. 5.7.2-1), representing the number of the current measurement cycle.

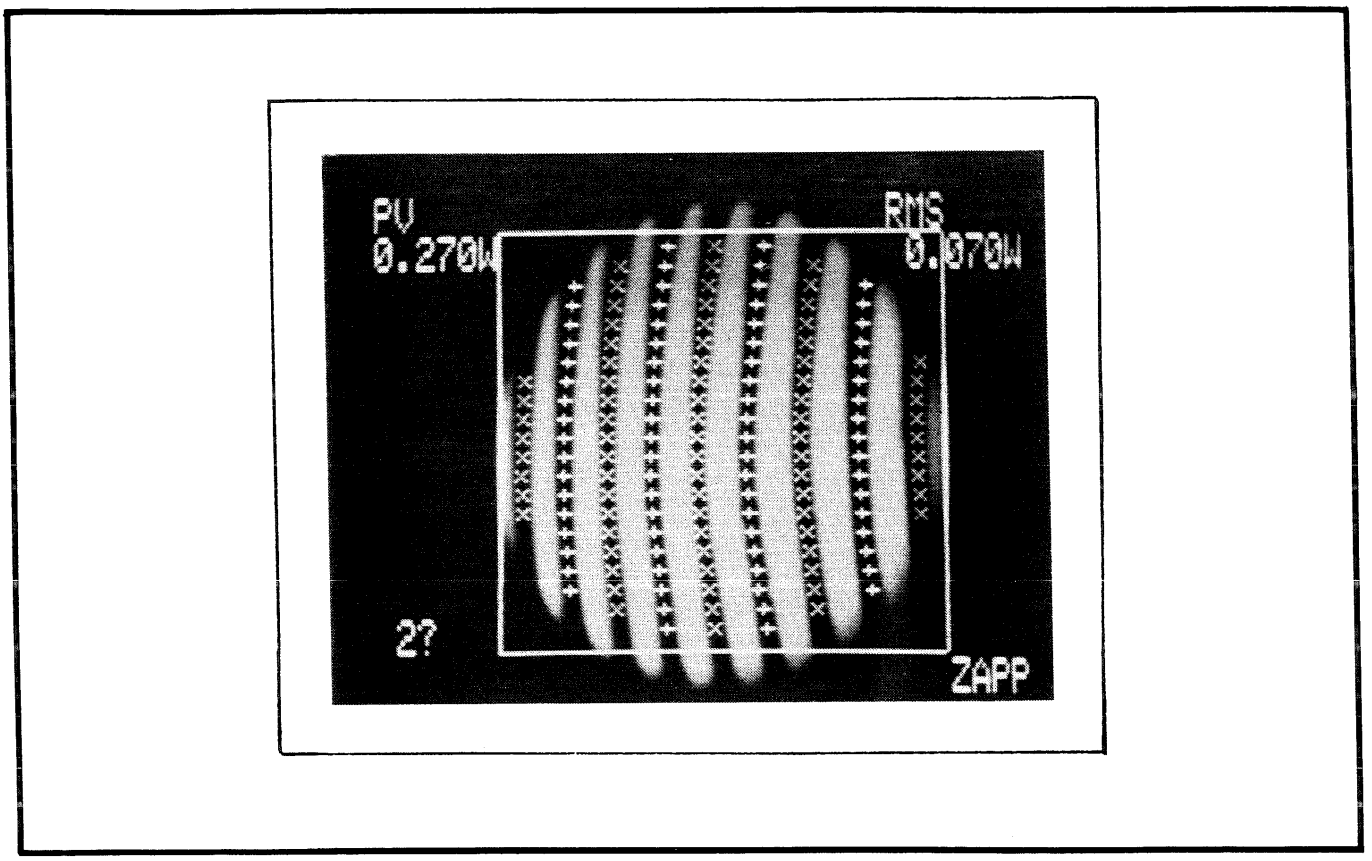


Figure 5.7.2-1 Manual averaging display showing the measurement cycle number in the bottom left corner of the screen.

The operator can either accept the calculated values by depressing YES or reject the values by pressing NO. The fringe centers are redisplayed after either response is entered. Following a NO response, the current measurement cycle can be rerun; if YES is entered, a new cycle should be started. The entire manual averaging process can also be aborted by depressing START after either YES or NO. If START is depressed, ZAPP will return to the prompting mode. Whenever the final measurement cycle is completed with a YES response, ZAPP will calculate and display the average of all the measurements. ZAPP calculates the average of the measurements by executing the following steps automatically:

1. The OPDs common to all the measurements are transferred to a uniform grid.

2. The OPDs on the uniform grid are summed and divided by the number of measurements.

3. The peak-to-valley and RMS values are extracted for the averaged OPDs on the uniform grid.

5.8 ISOMETRIC PLOTS

The 3-D PLOT provides an isometric view of the OPD data. It is scaled to a constant height equal to the maximum P-V for any data greater than 0.004 fringes.

Measurement of the interferogram is performed by pressing MEASURE and then COMPUTE. If the measurement is satisfactory, STORE OPDs is depressed to store the OPDs in the microprocessor memory.

Depressing the PLOT pushbutton causes ZAPP to display the isometric view of the OPD data from the bottom up (Fig. 5.8-1). Depressing PLOT a second time causes ZAPP to display the reciprocal of the OPD data (Fig. 5.8-2). Depressing PLOT a third time exits the instrument from the 3-D plot mode. Depressing SKIP/RESTORE will also exit this mode. If the ZERO ORDER default is set to "L" when it should actually be "R", the second plot is the correct representation of the part.

In the Averaging mode, depressing the STORE pushbutton is not required since the OPDs are already in the uniform grid. When averaging is completed, simply depress PLOT.

To view a 3-D plot with OPDs subtracted, depress PLOT after SUBTRACT. DO NOT DEPRESS STORE. After subtracting, the OPDs are already on the uniform grid and consequently depressing STORE will give erroneous results.

5.9 SUBTRACTING OPDs

The SUBTRACT OPDs pushbutton enables the operator to subtract the OPDs in an original interferogram from the OPDs in a second interferogram.

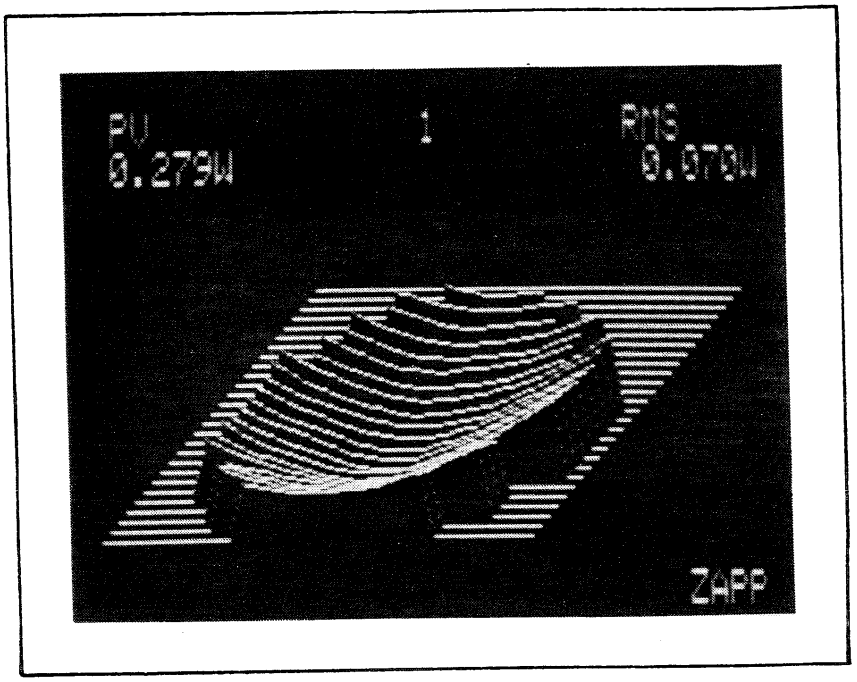


Figure 5.8-1 Isometric View of the OPD Data

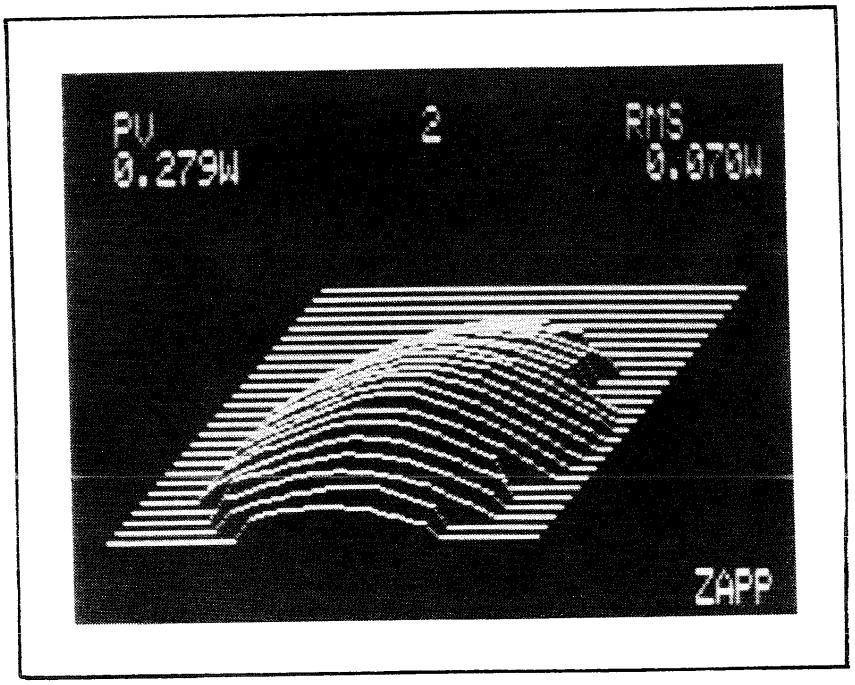


Figure 5.8-2 Reciprocal of the OPD Data

5.10.2 Electrical Specifications: ZAPP will transmit to an external computer the required data needed for further computations. The ZAPP interconnections to the computer are through a standard RS-232C connector (Fig. 5.10.2-1). Interface connector pin assignments are shown in Table 5.10.2-1.

5.10.3 Transmitted Data Specifications: Transmitted data includes alpha-numeric characters in ASCII code. The bits for each character including eight data bits and one stop bit (no parity) are transmitted serially at a 9600 baud rate. The data format is shown in Table 5.10.3-1.

I.D. NO., DATE, TIME	All on one line so the FRINGE Program will recognize this line as a title.
ZAPP	This signifies to FRINGE that the data has been transmitted by ZAPP.
TILT	As required by FRINGE to indicate fitting the best fit plane to the data.
FOCUS	As required by FRINGE to indicate subtracting power from the data.
WVLI, WVL	Wavelengths as defined by FRINGE will be entered in ZAPP in the prompting mode.
WEDGE	As defined by FRINGE containing the ISF and zero order data entered in ZAPP in the prompting mode. A negative value will be given by a "minus" character followed by a number.
ELLIPSE (or RECT)	This signifies to FRINGE that the data has been measured for either a rectangular or an elliptical test aperture as defined by ZAPP in the prompting mode.
P-V	The computed peak-to-valley value in units selected from prompting.
RMS	The computed RMS value in units selected from prompting.
	NOTE: If COMPUTE is not pressed before PRINT/TRANSFER, both the RMS and the P-V entries will be blank.
SUBGD	As required by FRINGE to indicate subtracting the ZAPP system geometric distortion from the data.
FIDS	Fiducials will include eight numbers separated by a space corresponding to the four fiducial XY coordinates defined by the cursors. The odd places will include X values. (NOTE: XY coordinates of the ZAPP System are defined in a plane rectangular coordinate system with the origin at the lower left-hand corner of the monitor screen. The abscissa is X and the ordinate is Y.) The even places will include Y

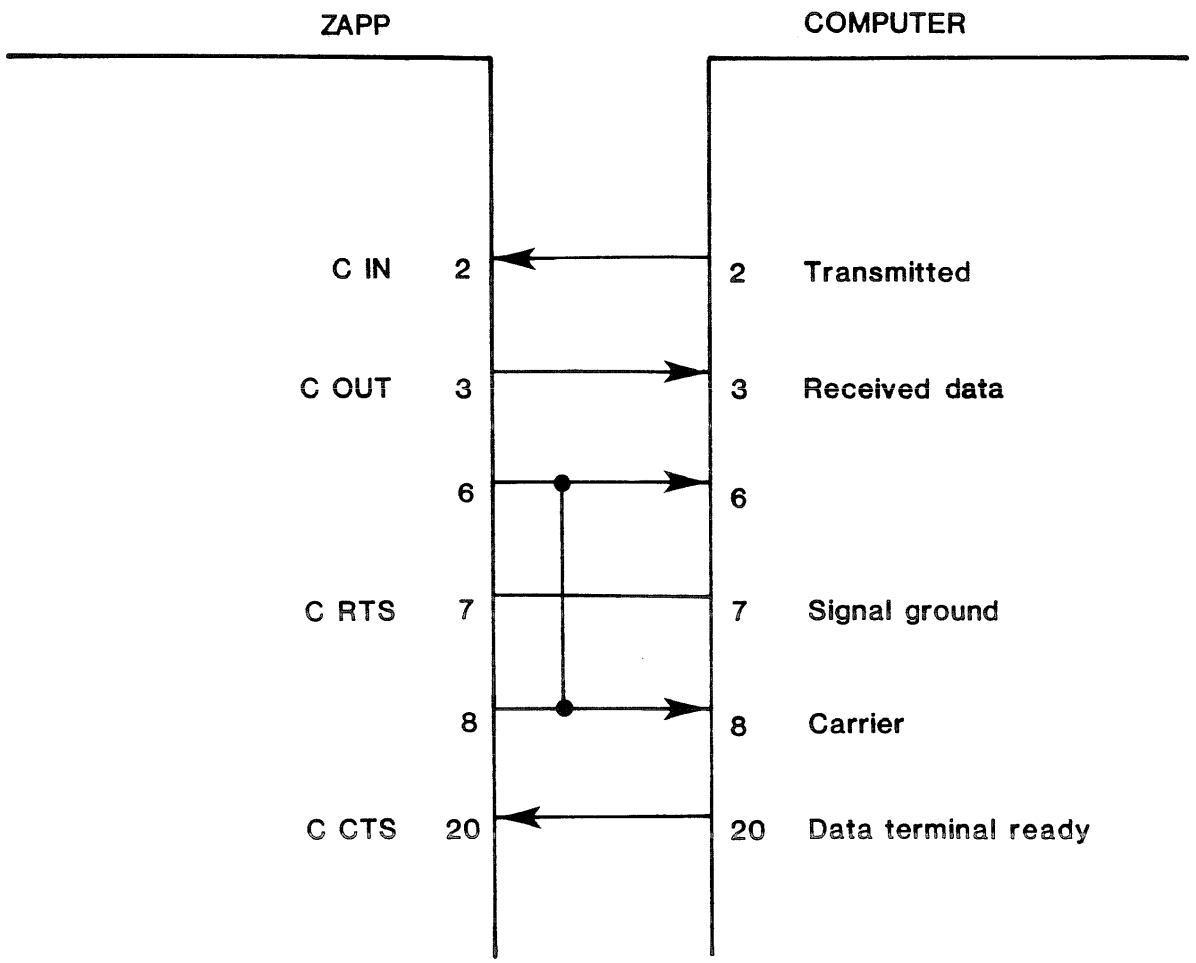


Figure 5.10.2-1 Interface Connector Pin Assignments

PIN	CIRCUIT	EXTERNAL COMPUTER	ZAPP
2		Transmitted data	C IN (the line of received data)
3	BB	Received data	D OUT (ZAPP output). The line of transmitted data. -V = 1 = Mark, +V = 0 = Space (+V = any voltage > +3 volts; -V = any voltage < -3 volts)
7	AA	Signal ground	
8*	CF	Carrier	C RTS (request computer to send) Whenever ZAPP transmits a character, this line goes to +V
20	CD	Data terminal ready	C CTS (computer clear to send) Tied to +5VDC for I/O compatibility +V in this line enables ZAPP to transmit a character

*NOTE: Pins 6 and 8 are connected internally.

Figure 5.10.2-1 Interface Connector Pin Assignments

START OF TEXT

```
ID: OMP 23 G  *  TIME     9:26 -   *  DATE    2-9-81
ZAPP
TILT
WVLI   0.633
WVL    0.633
WEDGE  0.5
ELLIPSE
P-V=     0.163 W
RMS=     0.044 W
SUBGD
```

DATA ARRAY

```
FIDS 656 945 656 158 208 551 1104 551 END
201  1 511  2 653  3 781  E
239  1 513  2 655  3 781  4 900  E
278  0 364  1 514  2 658  3 782  4 902  E
316  0 361  1 517  2 663  3 786  4 904  E
355  0 360  1 520  2 660  3 786  4 909  5 1023  E
393  0 364  1 521  2 660  3 788  4 910  5 1024  E
431  0 364  1 522  2 657  3 791  4 913  5 1026  E
470  0 366  1 522  2 655  3 788  4 916  5 1026  E
623  0 360  1 515  2 648  3 788  4 915  5 1031  E
662  0 358  1 515  2 651  3 790  4 914  5 1030  E
700  0 353  1 513  2 655  3 789  4 914  5 1027  E
739  0 347  1 508  2 652  3 785  4 908  5 1026  E
777  0 343  1 503  2 649  3 783  4 906  E
815  0 342  1 497  2 644  3 777  4 905  E
854  1 495  2 642  3 777  4 904  E
892  1 491  2 640  3 775  E
931  2 640  3 776  E
END
```

CALIBRATION ARRAY

```
201  1 8180  2 10463  3 12511  E
239  1 8219  2 10504  3 12514  4 14409  E
278  0 5814  1 8225  2 10540  3 12527  4 14428  E
316  0 5748  1 8256  2 10606  3 12570  4 14441  E
355  0 5746  1 8324  2 10579  3 12594  4 14535  5 16323  E
393  0 5809  1 8338  2 10578  3 12620  4 14546  5 16332  E
431  0 5805  1 8355  2 10523  3 12663  4 14594  5 16361  E
470  0 5848  1 8366  2 10505  3 12629  4 14660  5 16381  E
623  0 5743  1 8260  2 10396  3 12632  4 14639  5 16443  E
662  0 5703  1 8258  2 10439  3 12662  4 14617  5 16431  E
700  0 5623  1 8220  2 10504  3 12643  4 14617  5 16383  E
739  0 5519  1 8130  2 10450  3 12570  4 14509  5 16348  E
777  0 5454  1 8045  2 10399  3 12531  4 14484  E
815  0 5448  1 7940  2 10314  3 12434  4 14521  E
854  1 7915  2 10286  3 12441  4 14457  E
892  1 7853  2 10252  3 12406  E
931  2 10239  3 12406  E
END
```

END OF TEXT

Figure 5.10.3-1 Transmitted Data Format (example)

values. The order in which fiducial coordinates are given is: top, bottom, left, right. Additional fiducial coordinates may be determined in the manual mode, but may not be transmitted automatically to an auxiliary computer. The word END is transmitted at the end of the fiducial row.

E — Signifies to FRINGE the end of each line of data.

END — Signifies to FRINGE the end of data transmission. If both row and calibrated points are transmitted, the two arrays are separated by the word END.

DATA ARRAY — The data array will include the fringe center coordinates in the following format:

Y m X

where

Y = Y coordinate

X = X coordinate

m = fringe number 0 to 31

Each line corresponding to a particular scan line Y will be followed by pairs of m and X. The numbers will be separated by a space.

CALIBRATED ARRAY — The calibrated array will be given if the calibration procedure is performed. The array will be transmitted in the same order as described for the data array. The X coordinates of this array will represent the corrected values for the corresponding data array values (after calibration); multiplied by 16.

ESC — 27 (ASCII code) to assign end of data (ESC: Escape).

5.10.4 Graphics Data Input to ZAPP: An optional graphics mode allows the use of ZAPP's graphic capability to display contour plots generated by an external computer. ZAPP and the external computer are interconnected through the RS-232C connector described in Sec. 4.2.5.

NOTE: The standard ZAPP System is configured to transmit data for the FRINGE Program over the RS232C connector as described in the preceding sections. As an option, instead of this capability, the user may choose to have a ZAPP System configured to accept graphics data input.

5.10.4.1 Mode of Operation--The external computer will send an interrupt to ZAPP before it begins transmitting. This voltage on the Data Terminal Ready line (Pin-20) will make a positive transition. The computer can interrupt ZAPP at any time except when transmitting data through the I/O port or when transmitting data to the printer.

Upon receipt of the interrupt, ZAPP will clear the 256 x 256 display array and set up to receive the data. The external computer will transmit xy coordinates of the points required to get the desired plot. The end of transmitted data will be recognized when x and y coordinates have the value 255.

Depressing the SKIP button will cause ZAPP to terminate this routine and return to the main program.

5.10.4.2 Transmission Characteristics--The data will be transmitted in the following order:

$$x_1y_1\ x_2y_2\ \ldots\ldots\ldots x_ny_n$$

where x and y are the coordinates of a point on the screen that has to be turned on. The coordinate values will be in binary form. Each coordinate will be included in one transmission byte. The characteristics of the transmitted byte will be:

1200 baud rate

8 data bits

1 stop bit

no parity

5.10.4.3 Range of Coordinates--Due to hardware limitations, not all the points of the 256 x 256 memory array are seen on the screen. The range of coordinates will be:

$$0 \leq x \leq 255$$

$$11 \leq y \leq 242$$

5.11 CODES

If certain conditions exist which preclude successful fringe acquisition or analysis, a code is flashed onto the video monitor. Listed below are the codes and their interpretations.

Measurement of the original interference pattern is performed by pressing MEASURE and then COMPUTE. If the measurement is satisfactory, STORE OPDs is depressed. If ZAPP is in the Averaging mode, ENT is pressed.

Measurement of the second interferogram is performed by depressing MEASURE and then COMPUTE. If the measurement is satisfactory, depress SUBTRACT OPDs to subtract the OPDs of the original interferogram, stored in the uniform grid, from those of the second interferogram.

The data can now be displayed, plotted, or transferred to a printer. (Fig. 5.9-1)

5.10 DATA AVAILABLE FOR AN AUXILIARY COMPUTER

The following information, suitably formatted, is provided on a bidirectional port for use by an auxiliary computer:

1. The coordinates of the centers of the fringes, either acquired automatically or manually
2. The coordinates are ordered, i.e., they are grouped for each fringe with an assigned fringe number
3. The calibration data
4. The coordinates of the clear aperture cursors represented by eight fiducial readings
5. The computed P-V and RMS values
6. Pertinent input prompting information.

In addition, output from the auxiliary computer can be displayed on the ZAPP Video Monitor using the same port.

5.10.1 Transfer Operation: Data can be transferred to an auxiliary computer by presetting the prompting mode default "TRANS TO AUX. COMP" to YES. Transfer of raw data points will occur each time the PRINT/TRANSFER button is depressed. During the time that the data is being transferred, ZAPP will flash on the monitor screen the words, TRANSFER IN PROGRESS.

The calibrated array can also be transmitted to the auxiliary computer. To do this, the prompting mode default, "SUBTRACT G.D.?" must be preset to YES, and the instrument properly calibrated (see Sec. 5.6 for Calibration procedure). To transmit the array, the operator first depresses COMPUTE. After COMPUTE is depressed, ZAPP will stop in the middle of the computing routine and wait for the operator to depress PRINT/TRANSFER to transfer all the data including the calibrated data array. The COMPUTE routine will be completed after the transfer has occurred. If necessary, the operator can get out of the waiting state by depressing START which brings the instrument back to the prompting mode.

```
ID NUMBER              102180
TIME                    15:11
DATE                 10-21-80
ISF                       0.5 W/F
P-V                     0.038   W
RMS                     0.008   W
POWER                   0.021   W
SLOPE                           W/CM
TOL. LIMIT P-V            0.1   W
TOL. LIMIT RMS            0.2   W
TOL. LIMIT POWER          0.3   W
FIDUCIAL SPACING       000.00   CM
WAVELENGTH INT          0.633   UM
WAVELENGTH OUT          0.633   UM
ACCEPT
```

Figure 5.9-1A Print Ticket of Output Information

```
07    0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
      0.000  -0.006  -0.007  -0.008  -0.009  -0.010  -0.011  -0.012
     -0.014  -0.015  -0.016  -0.017   0.000   0.000   0.000   0.000
      0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
08    0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
      0.000  +0.002  +0.002  +0.003  +0.003  +0.003  +0.003  +0.001
     -0.000  -0.002  -0.004  -0.006   0.000   0.000   0.000   0.000
      0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
09    0.000   0.000   0.000   0.000  +0.003  +0.002  +0.001  -0.000
     -0.001  -0.002  -0.003  -0.002  -0.002  -0.002  -0.002  -0.002
     -0.001  -0.001  -0.001  -0.001  +0.001  +0.003  +0.004  +0.005
     +0.007   0.000   0.000   0.000   0.000   0.000   0.000   0.000
10    0.000   0.000   0.000   0.000  +0.011  +0.009  +0.007  +0.005
     +0.003  +0.002  +0.002  +0.005  +0.007  +0.009  +0.011  +0.011
     +0.011  +0.011  +0.011  +0.011  +0.009  +0.006  +0.003  +0.001
     -0.002   0.000   0.000   0.000   0.000   0.000   0.000   0.000
11    0.000   0.000   0.000   0.000  +0.010  +0.009  +0.009  +0.008
     +0.008  +0.007  +0.007  +0.008  +0.009  +0.010  +0.010  +0.01
     +0.013  +0.014  +0.015  +0.016  +0.011  +0.004  -0.002  -0.009
     -0.016   0.000   0.000   0.000   0.000   0.000   0.000   0.000
12    0.000   0.000   0.000   0.000  -0.001  -0.001  -0.002  -0.002
     -0.003  -0.004  -0.003  -0.002  -0.002  -0.001  -0.000  +0.002
     +0.003  +0.005  +0.007  +0.009  +0.008  +0.007  +0.005  +0.004
     +0.002   0.000   0.000   0.000   0.000   0.000   0.000   0.000
13    0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
      0.000  -0.022  -0.019  -0.017  -0.014  -0.011  -0.009  -0.005
     -0.002  +0.002  +0.006  +0.009  +0.013   0.000   0.000   0.000
      0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
14    0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
      0.000   0.000   0.000   0.000   0.000   0.000  -0.020   0.000
      0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
      0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000

THE MINIMUM OPD VALUE IS IN ROW 13
THE MAXIMUM OPD VALUE IS IN ROW 11
```

Figure 5.9-1B Stored OPDs print ticket. Follows the output information when the "PRINT OPDs?" default is answered by pressing YES.

NOTE: Signed (-0.000) is small OPD. Unsigned (0.000) is no data. 9.999 indicates areas where obscuration exists.

CODE #1 Unable to perform reduction. Caused by:

1. Erratic or wild points on screen
2. Carelessness in ordering fringes in a manual correction
3. Memory Board not installed

CODE #2 No points read. Caused by:

1. No fringes in field
2. Fringes too thin or light
3. Hardware failure

CODE #3 OPD is too large

Not currently used

CODE #4 Too many fringes. Caused by:

1. Too many fringes
2. Residual values in RAM; press RESET to clear

CODE #7 Fringes too close. Most common error. Caused by:

1. Fringes too close (approx. 1/50 width of monitor)
2. Dirt on picture is picked up as a fringe that is too close
3. Analog thresholding circuitry not properly adjusted (too sensitive)

NOTE: Point on screen giving the error message will usually be shown as a pointer.

CODE #8 Cannot transfer to computer or printer (device off-line).

CODE #9 Less than 3 data points. Caused by:

1. Less than 3 data points in compute
2. Points not being transferred from displayed matrix to working matrix

5.12 WARNINGS

Warnings are flashed for certain operational conditions which do not always halt the analysis of a pattern. Listed below are the warnings and their interpretations.

WARNING #A — Filled up OPD space (too many points)

WARNING #B — Change in OPDs too sudden on uniform grid (error too large)

WARNING #C — OPD location in 32 x 32 array is out of range

WARNING #D — COMPUTE must be pressed before entering calibration data

WARNING #E — Too much tilt in calibration

WARNING #F — Error too large to calibrate--use calibration grids only

WARNING #G — Calibrating in power--calibration should be performed NOT subtracting power

WARNING #H — Overflow in adding OPDs in calibrate--should never occur if using calibration grids

WARNING #I — Coordinate on the uniform grid does not have corresponding error correction--show by asterisk. This warning may be exited by pressing SKIP resulting in an incorrect calculation.

WARNING #J — Illegal fringe entry caused by:

1. In the MAN (data editing) mode, a point was entered to the left of an existing point on that row.
2. Entering a point too close to an existing fringe center.

WARNING #K — Readings do not fall within acceptable limits (in averaging).

WARNING #L — In the single point mode a fringe center may not be entered or erased on an empty row. Use Manual mode.

WARNING #M — Error in entering either the wavelength IN, wavelength OUT, ISF, Tolerance Limits, P-V, RMS or Power.

WARNING #N — Error in defining an aperture obscuration.

WARNING #P — At least one of the OPDs is greater than the limit of 7.999; 9.999 is displayed.

WARNING #Q — Power subtracted is too great to display.

WARNING #R Error in inability to display maximum slope error. Could be due to scaling in "Fiducial Spacing" prompting.

WARNING #S Broad fringes cannot be acquired in the negative mode. (NO is entered for POSITIVE during prompting.)

The following warnings apply to the system diagnostic tests executed after system power up (initiated by the Processor Module on/off switch) or system reset (using the RESET button). If a diagnostic test fails, a warning will be displayed on the Video Monitor. The Zygo Service Department should be contacted if a warning occurs repeatedly. After a warning appears, depressing the SKIP/RESTORE pushbutton will proceed to the initial Input Information Form.

CTRL Control Terminal pushbutton and/or toggle switch shorted

ROM MPU Board, Read Only Memory (ROM) checksum error

MPU MPU Board, Random Access Memory (RAM) read/write error

FCB Fringe Center Board, RAM read/write error

AUX Auxiliary Memory Board, RAM read/write error

5.13 SLOPE

The Slope mode is an optional ZAPP program. The slope is defined as the value of the maximum gradient between two adjacent data points along the fringes of an interferogram. It is activated by utilizing spacing and slope defaults. The fiducial spacing input allows the spacing between adjacent data lines to be determined in centimeters. Pressing MEASURE and COMPUTE displays the slope calculation in waves or fringes per centimeters. The pointer flashes a few times to identify the location of the maximum slope (Figure 5.13-1).

5.14 SUBTRACT POWER MODE

This mode allows the operator to subtract spherical power from the interference pattern (Figure 5.14-1). The Subtract Power mode should be used primarily for testing spherical surfaces. When it is requested for testing other types of surfaces (i.e., plano, cylindrical, or aspheric surfaces) the system evaluation of the interference pattern will always subtract only a best-fitting sphere from the wavefront.

The Subtract Power mode is entered by responding YES to the "SUBTRACT POWER?" default on the second Input Information Form. Pressing PLOT in this mode displays the isometric view of the OPDs with power removed (Fig. 5.14-2). Pressing PLOT again displays the reciprocal (Fig. 5.14-3).

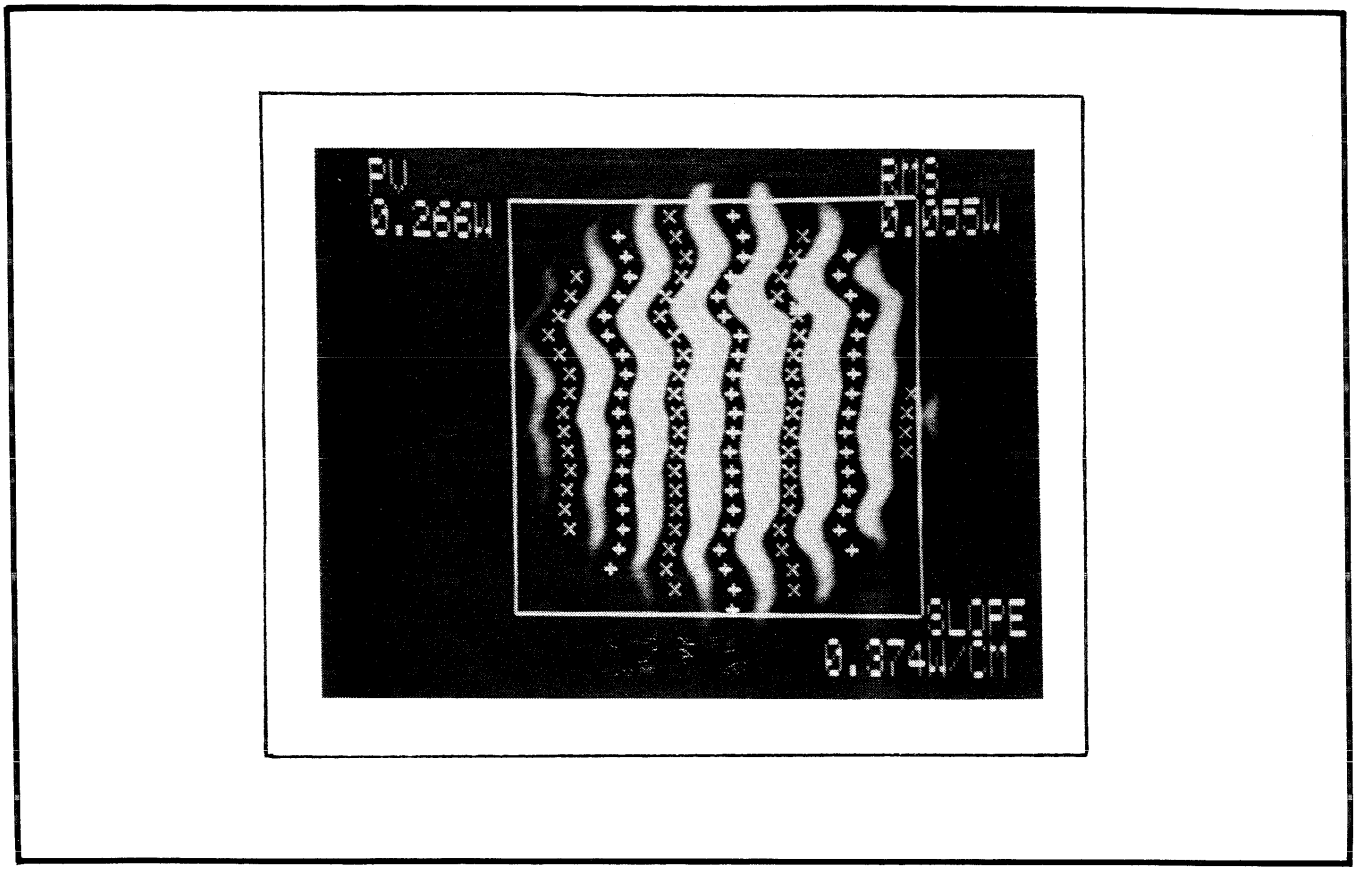


Figure 5.13-1 Slope indicated by asterisk (upper right) with calculation shown in lower right corner.

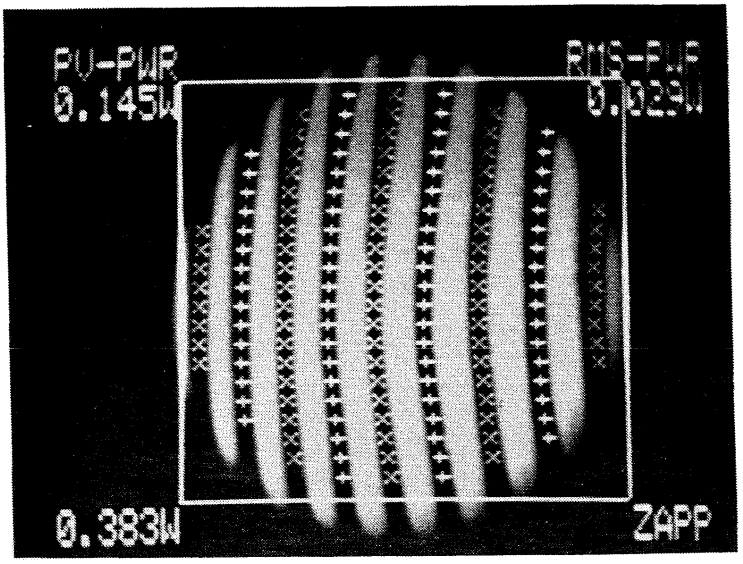


Figure 5.14.1
Data Reduction with spherical power subtracted.

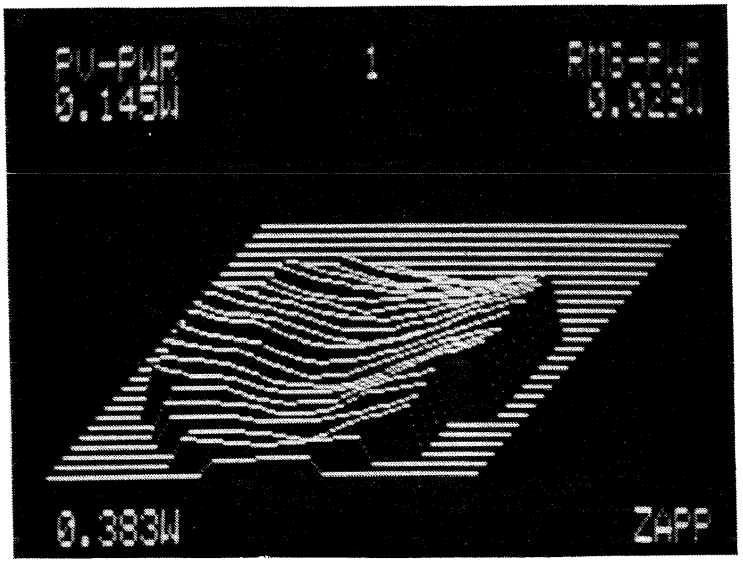


Figure 5.14-2
Isometric view of OPD data with power subtracted.

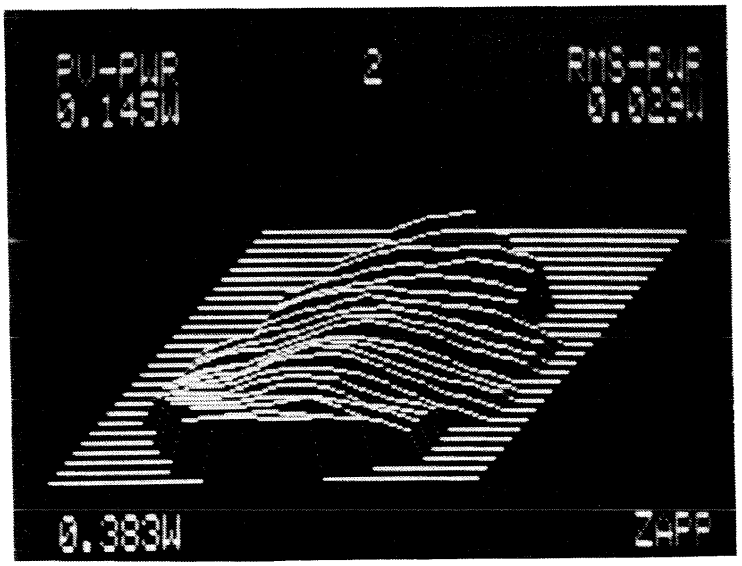


Figure 5.14-3
Reciprocal of OPD data with power subtracted.

5.15 ACCEPT/REJECT MODE

The Accept or Reject mode is activated via the keypad by entering the tolerance limit for P-V, the tolerance limit for RMS and/or the tolerance for POWER. Pressing MEASURE and COMPUTE displays on the video monitor the results of the data reduction and the symbol ACC if all the limits which were entered are in tolerance (Fig. 5.15-1). REJ is displayed if any limit is out-of-tolerance with an asterisk pointing to the out-of-tolerance limit(s) on the fringe pattern. ACCEPT or REJECT is also displayed with the output information on the line above the tolerance limit for P-V.

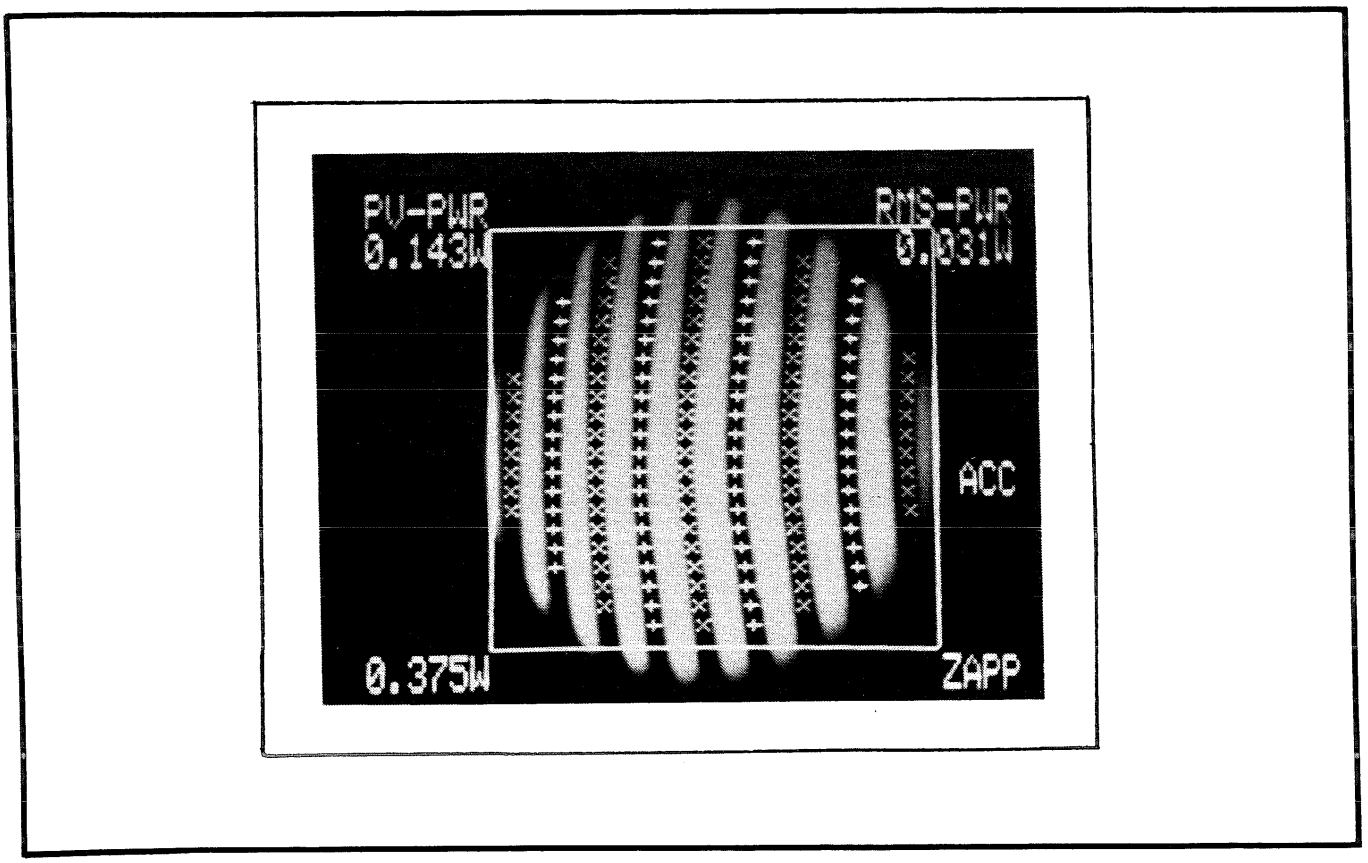


Figure 5.15-1 Accept (ACC) indicates the data is within the preset limits.

6. MAINTENANCE

The ZAPP System is virtually a maintenance free instrument. However, it should be treated with care and kept in a clean environment.

6.1 USE AND MAINTENANCE OF CB-101 POLAROID CAMERA BACK

See OMP-0048, ZYGO Video Camera Model VC-2A, Operation-Maintenance Manual, Sec. 4.2.

6.1.1: Before loading film, examine the two steel rollers. It is important to keep these rollers clean. Use a damp cloth or tissue to remove any specks or deposits on the rollers and film exit door. Solvents other than water do not work as well and are not recommended. For more details see the Polaroid booklet "How to Use the Polaroid Model CB-101 Land Camera Back." Read the CAUTION instructions on the packing slip supplied with each roll of Polaroid film in reference to the caustic jelly used in processing the film.

6.1.2: Use dry air or an air syringe (bulb) to blow out any accumulated dust inside the camera back.

6.2 INTERFEROGRAM READER PLATEN

6.2.1: The platen may be cleaned periodically with a mild spray cleaner such as "Fantastik." Do not spray on too much cleaner as the platen does not have a watertight seal.

6.2.2: If the platen becomes scratched to an objectionable extent, a new one may be installed. See Sec. 9.1. Ordinarily multiple small scratches will not be visible on the interferogram, but care should be taken to avoid scratching the platen.

6.3 CLEANING

The desk top and instrument cases may be cleaned with a soft cloth and a commercially available, mild furniture polish, such as "Pledge."

6.4 SPARE PARTS

If a downtime of one week is intolerable, it is recommended that all the following spare parts be purchased ahead of time so that they will be on hand if needed.

	DESCRIPTION	REPLACEMENT PART NUMBER
1.	Replacement Video Monitor (Less riser bracket)	VM-2
2.	Replacement TV Camera (Includes Lens)	CCTV-IR
3.	Illumination Lamps	Chicago Miniature #137
4.	Replacement Platen	6303-1004

6.5 FUSE SCHEDULE

INSTRUMENT	MODEL		
	Domestic	Europe	Japan
PM-2	2-1/2 Amp	3/4 Amp	1-1/2 Amp
IR-1	1-1/2 Amp	3/4 Amp	1-1/2 Amp
VC-1A	1/2 Amp	1/2 Amp	1/2 Amp

All fuses are Type 3AG, Slo-Blo, 250 V.

7. TROUBLESHOOTING

The following procedures should help solve most of the problems which may arise with the ZAPP System. Before any of the troubleshooting procedures are initiated (Sections 7.2 through 7.17), the entire preliminary checkout procedure (Section 7.1) should be performed. If any problems arise which cannot be solved in the field, refer to the Warranty (Section 8) in the Manual for information on contacting the Zygo Service Department.

CAUTION: Removal of the console panel will result in exposure to high voltages. Any adjustments necessary should be performed by qualified service personnel.

7.1 PRELIMINARY CHECKOUT PROCEDURE

7.1.1 Power Requirements: The ZAPP System will not operate properly unless certain requirements are met for supplying electrical power to the system. All of the power switches for the ZAPP modules listed in the table below must be in the "ON" position and the corresponding indicator lights must be lit. If one of the switches is in the "ON" position and the appropriate indicator light is not on, check the power connections and the fuses before proceeding. If for some reason the problem cannot be corrected, contact your Zygo service representative.

POWER SWITCH	INDICATOR LIGHT
Processor Module (PM-2)	Light on the switch face
Interferogram Reader (IR-1)	Green Pilot Lamp
Video Camera (VC-1A)	Green Pilot Lamp
Mark II Mainframe	Green Emission Indicator
Video Monitor (VM-2)	Red Pilot Light

7.1.2 Wiring Connections: Verify the connections shown in Fig. 7.1.2-1 (the flat ribbon cable from the "CONTROL TERMINAL" connector on the Processor Module must be connected to the 37 pin connector of the Control Terminal). If a ZAPP system includes an optional digital printer, the printer's 25 pin "D" connector must be connected to the "PRINTER" jack on the Processor Module. For ZAPP systems with an auxiliary computer, the computer's 25 pin "D" connector (RS-232 serial interface) must be connected to the I/O Port on the Processor Module.

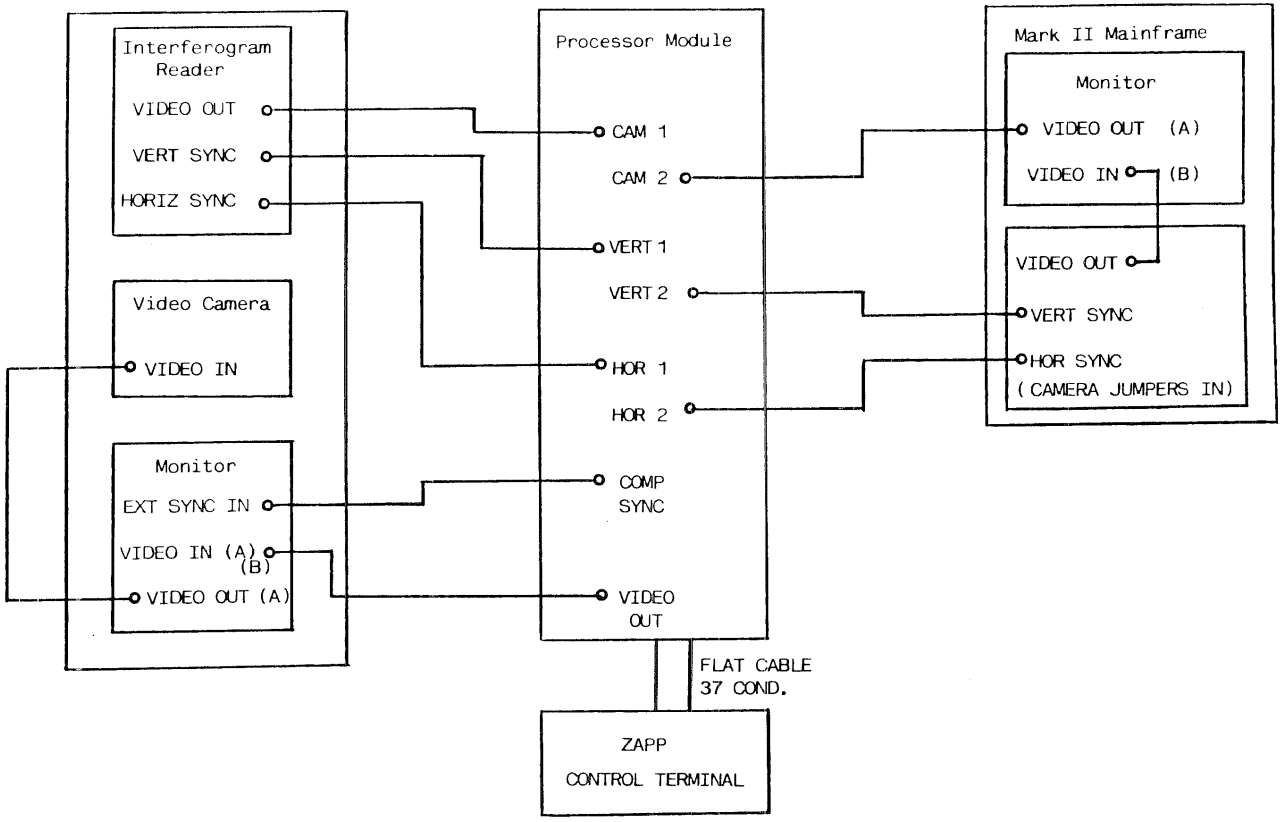


Figure 7.1.2-1 Wiring Diagram

7.1.3 System Diagnostics Program

The ZAPP diagnostics program automatically performs the following trouble-shooting procedures:

1. Checks the Control Terminal switches
2. Performs a checksum operation on the system software
3. Tests all volatile memory

This program is automatically activated when the system is turned on or each time the RESET pushbutton is depressed. A system diagnostics display will immediately appear on the Video Monitor giving the revision level of the software (e.g., REV E), followed by specific warning messages if any problems are detected. All of the warnings which may appear are described in Section 5.12.

If no problems are detected by the diagnostics program, the ZAPP System will automatically display the initial Input Information Form. Whenever one or more warnings appear, the system will display the initial input form if the SKIP/RESTORE pushbutton is depressed. When a warning occurs repeatedly, the Zygo Service Department should be contacted.

7.2 POWER ON FAULTS

If no prompting information or random pattern appears on the Video Monitor after power is supplied to the system, check the flat ribbon cable connecting the Processor Module to the Control Terminal. Both ends of this cable should be firmly seated in the appropriate connectors. If this malfunction cannot be corrected, contact the Zygo Service Department.

7.3 LOSS OF POWER

7.3.1: Check that proper electrical power is being supplied to the system.

7.3.2: Check the fuses on the connector panel at the rear of the console.

7.3.3: If the wiring connections have not been verified, check all the connections shown in Fig. 7.1.2-1.

7.4 VIDEO IMAGE OUT-OF-ROUNDNESS

7.4.1:

PROBLEM	CORRECTIVE PROCEDURE SECTION
Video Monitor and Video Camera out-of-round	Section 9.3, CCTV Camera Roundness Adjustment
Only Video Monitor out-of-round	Section 9.4, Video Monitor Adjustment
Only Video Camera out-of-round	Section 9.3, then Section 9.4

7.5 NO VIDEO IMAGE ON MONITOR

If no video image from either the Interferogram Reader or the Interferometer appears on the Video Monitor, perform the steps described below.

7.5.1: Check the CAM 1/CAM 2 switch on the Control Terminal.

7.5.2: Push RESET button on Control Terminal.

7.5.3: If the wiring connections have not been verified, check all the connections shown in Fig. 7.1.2-1.

7.5.4: Check that the CCTV camera in the Interferogram Reader is turned on.

7.5.5: If this malfunction cannot be corrected, contact Zygo.

7.6 NO VIDEO IMAGE FROM INTERFEROGRAM READER

When no video image from the Interferogram Reader appears on the Video Monitor (images from the Interferometer do appear), remove the console side panel. Verify that the camera power switch on the rear of the CCTV camera is in the "ON" position and check the internal power connections. If this malfunction cannot be corrected, contact Zygo.

7.7 NO CHARACTER INFORMATION ON MONITOR

If a video image is displayed on the Video Monitor but no character information appears, the analog board is probably defective. Contact Zygo for a replacement board.

7.8 NO CURSORS ON MONITOR

In instances where the video image and character information are visible on the Video Monitor but no cursors are displayed, verify that the cursor on/off switch is in the "ON" position. If this switch is on and no cursors appear, the cursor board is probably defective. Contact Zygo for a replacement board.

7.9 MONITOR BRIGHTNESS CHANGE (MARK II/ZAPP SYSTEM)

Should the brightness of the Video Monitor change when moving the CAM 1/CAM 2 toggle switch between the CAM 1 (Interferogram Reader input) and the CAM 2 (Interferometer input) position, check that the switches on the rear chassis panel of the Video Monitor are in the correct positions (See Fig. 7.9-1).

7.10 VIDEO IMAGE ROLLING OR OUT-OF-SYNC

If the video images from both the Interferogram Reader and the Interferometer are out-of-sync, perform the steps described below.

7.10.1: Push RESET button on Control Terminal.

7.10.2: Check that the Video Monitor sync cable is connected.

7.10.3: Check all sync cables for proper connection. See Wiring Diagram, Fig. 7.1.2-1.

7.10.4: Check that the Video Monitor sync switch is on "EXT".

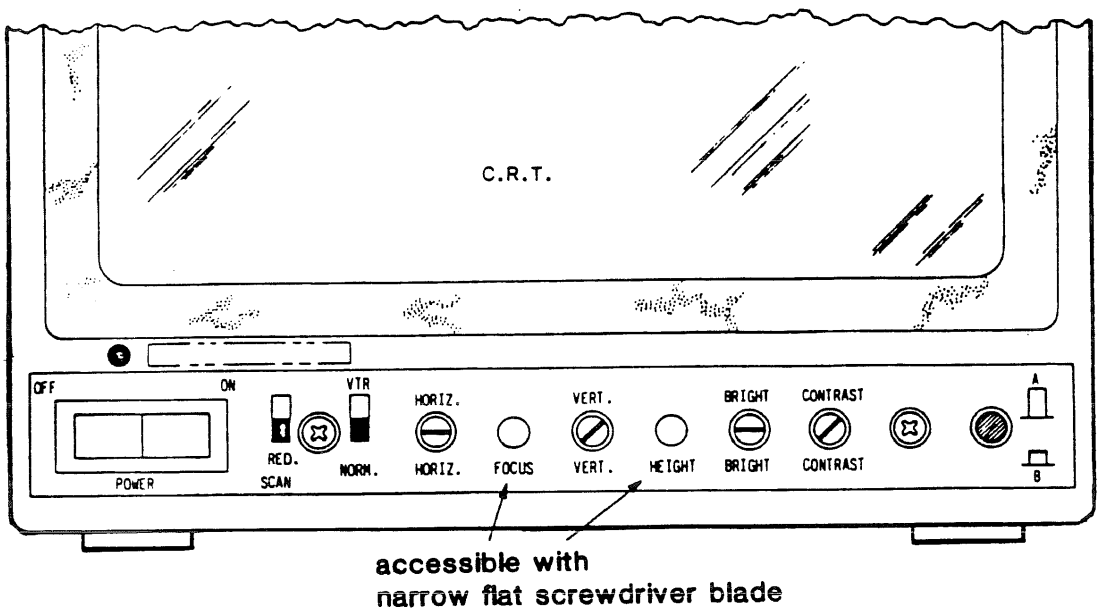
7.10.5: Check V HOLD and H HOLD controls on the front of the monitor.

7.10.6: If a Mark II Mainframe is used with the ZAPP System, check the position of the two jumpers in the Mark II camera (see Section 10.3).

7.11 VIDEO IMAGE FROM INTERFEROMETER OUT-OF-SYNC (MARK II/ZAPP SYSTEM)

If only the video image from the Mark II Mainframe is out-of-sync, verify that the A/B switch on the Processor Module is in the "B" position and check the positions of the two jumpers in the Mark II camera (see Section 10.3).

FRONT CONTROL PANEL VIEW



REAR CHASSIS PANEL VIEW

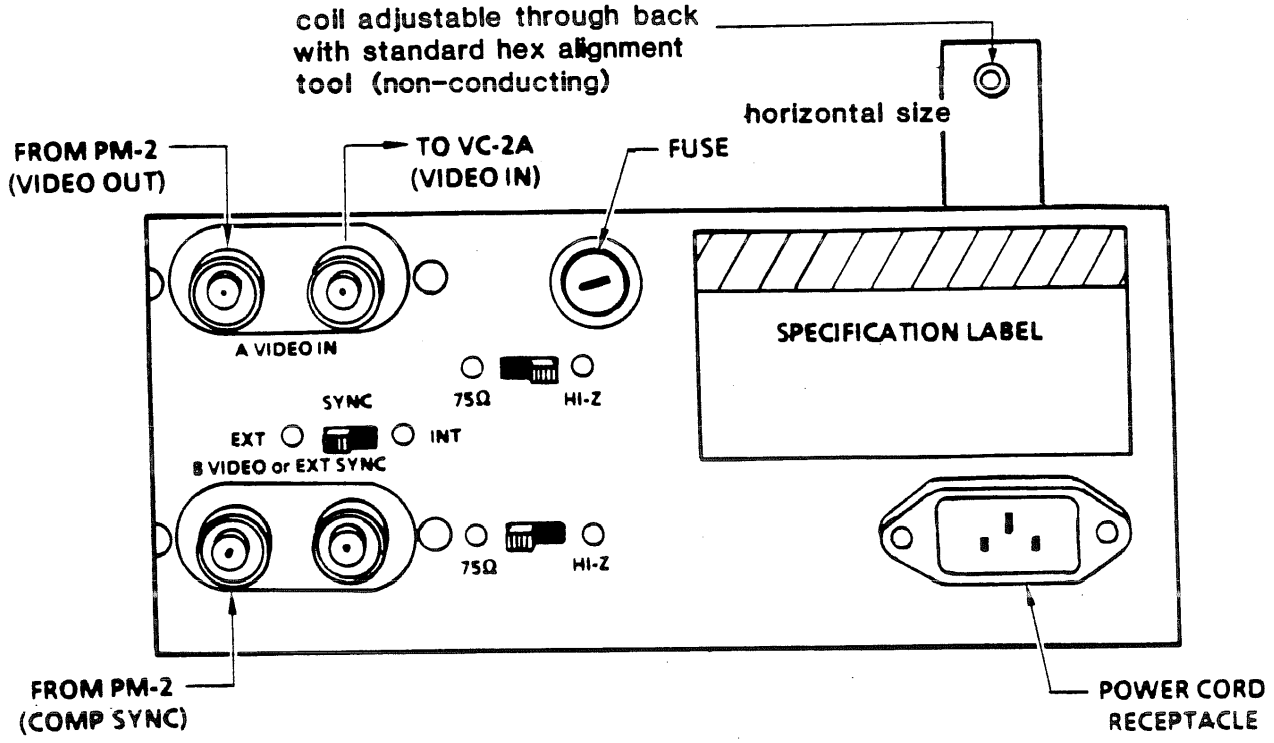


Figure 7.9-1 Video Monitor Control Panel & Rear Chassis Panel

7.12 PROMPTING, PLOT, AND DISPLAY INFORMATION OUT-OF-SYNC

Whenever the prompting, plot, or display information is out-of-sync on the Video Monitor (the video image and video with superposed data are stable), verify that the "SYNC" switch on the rear chassis panel of the monitor is in the "EXT" position.

7.13 VIDEO IMAGE FROM INTERFEROGRAM READER OUT-OF-FOCUS

Whenever this condition occurs, adjust the zoom lens focus. See Section 9.5.

7.14 NO MOVEMENT OF POINTER IN PROMPTING FORMAT

If the first page of the prompting format appears on the Video Monitor but the pointer cannot be advanced or the second page accessed, press the RESET button on the Control Terminal. If the condition persists, contact Zygo.

7.15 NO EXPOSURE POSSIBLE

7.15.1: If the film for the Video Camera is not exposed during photography, remove the unused film pack. Place your head close to the open camera back so that one eye is centered in the opening and can observe the center of the lens diaphram. See if light can be observed through the lens aperture when the shutter is activiated. If an image can be seen, then the film is defective or was improperly loaded. If no light is observed at any setting, proceed to next section.

7.15.2: Remove the four screws which secure the console side panel and remove the panel.

CAUTION: Removal of the side panel will result in exposure to high voltages. Any adjustments necessary should be performed by qualified service personnel.

Check to see if a lens cap is over the lens.

Check that the coaxial cables that provide the horizontal and vertical sync to the rear panel are properly connected and that both horizontal and vertical sync pulses are present.

Locate the BNC connectors on the monitor mounting bracket and check to see that these connections are secure. If these connections are secure, check the connections on the inside of the rear connector panel where the horizontal, vertical sync and video signals come into the unit to see if there is any obvious damage.

7.16 POOR CONTRAST

There may be test conditions which require more latitude for exposure of the Video Camera film. If so, remove the cover as described in Section 9.3. Locate the f/stop control lever on the lens. This setting has been pre-set to f/5.6. Usually, only a slight adjustment of 1 stop in either direction is all that is required to improve the exposure.

7.16.1: If there are white streaks on the photos, clean the rollers in camera back and try a new film pack.

7.16.2: When the photos lack contrast and the video image on the monitor is washed out, check the position of the top 75Ω/HI-Z switch on the rear chassis panel of the monitor. If a Mark II Mainframe is used in conjunction with the ZAPP System, this switch should be in the HI-Z position.

7.17 EXCESS GEOMETRICAL DISTORTION

Using the procedure given in Section 5.6, the system quality can be ascertained. If there is an excess distortion as measured with the ZAPP System, then the CCTV camera in the Interferogram Reader may need replacement. If the test pattern appears distorted on the Video Monitor, then the Video Monitor is the most likely source of the problem.

8. ZYGO PRODUCT WARRANTY

Zygo Corporation provides this warranty to protect its customers from defects in product workmanship or product materials. This warranty covers all products manufactured by Zygo Corporation.

Zygo warrants that the equipment purchased will be free from any defects in material and/or workmanship under normal operation conditions for a period of 1 year from the date of shipment.

WARRANTY SERVICE

Zygo's responsibility under this warranty shall be limited to the repair or replacement (at Zygo's option) of defective equipment at no cost to the buyer, except for transportation, cleaning, and recalibration charges.

Zygo will perform warranty service by: (1) Sending replacement parts with appropriate installation instructions to the buyer after the buyer has returned his defective part to Zygo or; (2) Repairing the product at a Zygo repair facility after it has been returned to Zygo freight prepaid or; (3) Dispatching a service representative to the buyer's facility. The buyer shall pay Zygo's travel and living expenses.

Defective products or parts will be repaired or replaced with new or like-new parts. These replacement parts will be warranted for a period of 90 days after they are shipped, or for the remainder of the original warranty period, whichever is longer.

Warranty service will be performed only if the buyer notifies Zygo within 14 days of discovering any defects. Equipment or parts that are to be returned to Zygo must be issued a Return Authorization number. This number can be obtained by contacting the Zygo Service Department. Should Zygo's subsequent inspection reveal that the parts were not defective, all expenses incurred by Zygo shall be charged back to the buyer. Defective equipment that is replaced shall become the property of Zygo.

Warranty period begins when the product is shipped from Zygo In the case of new systems, the warranty period is 12 months.

Replacement parts, service workmanship, used equipment, and refurbished equipment are warranted for a period of 90 days.

EXCLUSIONS

The above warranty applies only to equipment that is an integral part of a Zygo manufactured product. It does not apply to peripheral equipment manufactured by others such as computers, printers, vibration isolation tables, etc.

In such cases, the warranty of the original manufacturer will apply.

In addition, warranty service does not include or apply to any product or part which, in Zygo's judgement:

a. Has been repaired by others, improperly installed, altered, modified, or damaged in any way.

b. Malfunctions because the customer has failed to perform maintenance, calibration checks or good operation procedures.

c. Is expendable or consumable (such as panel lights, fuses, batteries, windows and filters) if such items were operable at the time of initial use.

d. Requires replacement because of poor facility, operating conditions or utilities.

Other than expressly described above, Zygo makes no express or implied warranties, including any regarding merchantability or fitness for a particular purpose relating to the use or performance of the equipment. Zygo will not be liable for personal injury or property damage (unless caused solely by its own negligence), loss or profit or other incidental or consequential damages arising out of the use or inability to use the equipment. Nor does this warranty apply to any equiment which has been (A) subject to misuse, neglect, or accident; or (B) has been repaired or altered by other than service representatives qualified by Zygo.

9. SERVICE PROCEDURES

9.1 PLATEN REPLACEMENT

In the event the platen becomes damaged it may be easily removed and a new one installed.

Step 1 Remove the twelve #4-40 flat head screws securing the platen retainer assembly to the front panel and remove the assembly.

Step 2 Lift out the old platen and install the new one.

Step 3 Replace the retainer assembly and the twelve screws.

9.2 BULB REPLACEMENT

The twelve light bulbs used to illuminate the interferogram are rated at 6.3 VAC, 0.25 amp, with a 5000-hour lifetime. The type used is Chicago Miniature #137. They may be replaced as follows:

Step 1 Remove the platen (see Section 9.1, PLATEN REPLACEMENT)

Step 2 Remove the dead bulb by pushing it down, turning counterclockwise and pulling up. Install new bulb by inserting, pushing down, and turning clockwise.

Step 3 Replace platen.

9.3 VIDEO MONITOR ADJUSTMENT

Step 1 Turn the equipment on and let it warm up for 30 minutes or more before proceeding.

Step 2 Figure 7.9-1 shows the Video Monitor control panel and rear chassis panel. Locate the Horizontal size control on the rear chassis panel and the Height control on the front panel.

Step 3 Install the target provided on the Interferogram Reader platen. Adjust the zoom control until the target edges are just clearly visible in the view monitor. Center the target if necessary.

Step 4 With a short nonconducting coredriver, adjust the Horizontal size to make the width of the image as measured on the face of the monitor 110mm $\pm$ 1.0mm.

Step 5 With a nonconducting screwdriver, adjust the Vertical size until the image height is equal to the image width.

Step 6 Repeat *Steps 4* and *5* until both the height and the width are equal to the same dimension $\pm$ 1.0mm with no further adjustments.

Step 7 Turn off the equipment.

NOTE: As an alternative to using the video image for the roundness adjustment, depress the RESET pushbutton on the Control Terminal to display the four clear aperture cursors on the Video Monitor. The distance between both the horizontal lines and the vertical lines should be approximately 110 mm ± 1.0 mm.

9.4 CCTV CAMERA ROUNDNESS ADJUSTMENT

The roundness adjustment for the Interferogram Reader CCTV Camera should be performed only after the Video Monitor Adjustment procedure is completed (Sec. 9.3).

Step 1 Turn the equipment on and let it warm up for 30 minutes or more.

Step 2 While the equipment is warming up, remove the four Phillips head wood screws securing the right-hand panel to the console. Remove the panel.

CAUTION: Removal of the side panel will result in exposure to high voltages. Any adjustments necessary should be performed by qualified service personnel.

Step 3 On the cover of the CCTV Camera, locate the access holes for the camera size controls. (The user should not adjust the horizontal size or the centering controls.)

CAUTION: The access holes for the camera controls permit access to high voltages. All adjustments to these components should be made only by qualified Television Service Personnel.

Step 4 Install the target provided on the Interferogram Reader platen. Adjust the zoom control until the target edges are just clearly visible in the view monitor. Center the target if necessary.

Step 5 Find the VERT SIZE access hole on the side of the CCTV camera cover and insert a non-conducting screwdriver to adjust the vertical size control. Adjust the control to make the image height equal to the image width within ± 1/3 mm as measured on the face of the Video Camera monitor with no further adjustments. (The image should be approximately 63 mm in diameter.)

Step 6 Temporarily replace the console side panel and take a picture at a low intensity setting (about 3). Check the roundness of the image on the photograph, and readjust the vertical size if necessary to acheive roundness within ± 1/4 mm.

Step 7 Replace the console side panel.

9.5 CCTV CAMERA REPLACEMENT

Replacement of the RCA TC-1005 CCTV camera incorporated in the Interferogram Reader will be necessary in the event that it fails to function properly and if no adjustments can be made to correct it.

CAUTION: The RCA TC-1005 CCTV camera and zoom lens have been prealigned together. They should be replaced as a set. Do not loosen the three screws securing the threaded mounting flange to the zoom lens.

The replacement procedure is as follows:

Step 1 Remove the Interferogram Reader from the console. (See Section 9.7.)

Step 2 Unplug the TV camera's black 3-conductor power cord and the three coax cables.

Step 3 Loosen the socket-head set cap screws (3/32 Allen wrench) securing the zoom shaft bearing plate to the slotted angle bracket. This relieves tension on the belt.

Step 4 Loosen the socket-head set screw (5/64 Allen wrench) in the plastic pulley, slide the pulley off the shaft, and remove the belt.

Step 5 Remove the two 1/4-20 socket-head cap screws (3/16 Allen wrench) holding the camera to the frame. Remove the camera/lens assembly. Replacement is the reverse of removal, paying attention to the following:

Step 6 Before tightening the 1/4-20 screws under the camera, temporarily connect all the cables (the Interferogram Reader may sit horizontally on the floor or a low stool for this adjustment) and energize the console.

CAUTION: Some AC line voltage may be accessible while the equipment is operating in this manner. To avoid electric shock be careful not to touch any terminals or cables.

Step 7 Move the camera side-to-side within the limits of the bolt-hole clearance to center the image of the aperture on the monitor. Tighten the two 1/4-20 screws.

Step 8 While warming-up the equipment for 1/2 hour, install the zoom belt and pulley. Adjust the bearing plate for proper belt tension (approximately 1/8-inch deflection at mid-span).

Step 9 Set the f/stop on the zoom lens to 4. Place a piece of paper with printing on it against the platen. Turn the zoom knob all the way counterclockwise (to the 75mm zoom position), and adjust the focus sleeve on the zoom lens for the sharpest image.

Step 10 After the warm-up period, check the roundness of the image and adjust the TV camera if necessary (see Section 9.4).

Step 11 When you are certain the equipment is operating satisfactorily, disconnect the console from its power source and reinstall the Interferogram Reader.

9.6 VIDEO CAMERA SERVICE

The Troubleshooting Section 7 and the Video Camera Operation-Maintenance Manual (OMP-0048) describe all of the service that may be performed in the field on the Video Camera. In the event of a malfunction that cannot be remedied by those procedures, it will be necessary to return the Video Camera module to the factory (see Section 8, Warranty). Section 9.7 describes the procedure for removal of the module from the console.

9.7 REMOVAL OF INTERFEROGRAM READER OR VIDEO CAMERA FROM THE CONSOLE

In the event that service is required for either the Interferogram Reader or Video Camera that cannot be performed *in situ* , or if one of the units must be returned to the factory, its removal from the console may be accomplished as follows:

Step 1 Disconnect the entire ZAPP Console from its power source.

Step 2 Remove the four Phillips head wood screws securing the side panel to the console, and remove the panel. Remove the rear upper louver panel (eight screws) to gain easy access to the inside of the connector panel.

Step 3 Disconnect all the cables from the unit to be removed at the connector panel.

Step 4 Remove the two #10-32 socket-head cap screws (5/32 Allen wrench) securing the upper angle bracket to the instrument frame. Also remove the single bolt and nut securing the lower brace to the instrument frame.

Step 5 With the aid of an assistant lift the unit free of the console. CHECK TO BE SURE ALL CABLES ARE DISCONNECTED.

Step 6 Replacement is the reverse of the removal steps.

10. INSTALLATION INSTRUCTIONS

10.1 UNPACKING AND HANDLING

10.1.1: This instrument and its modules should be unpacked in a clean area only.

10.1.2: To remove it or its modules from the shipping containers, do not lift by pulling on the instrument covers. Two people (one at each end) should grasp on the underside of an instrument to lift it out of the shipping box.

10.1.3: Besides the modules and a copy of the Operation-Maintenance Manual and Warranty, the shipping box normally contains:

1. Desk Top Console
2. Processor Module and Control Terminal
3. Video Monitor and Gimbal Bracket
4. Riser Bracket and Hardware; Remote Shutter Switch; BNC "T"s if needed; VPG Power Cord; and six (6) Coax Cables.

Do not discard the reusable shipping containers until it is certain that all items have been removed.

10.1.4: It is recommended that the shipping containers be retained until it is found that the system is in good operating condition.

10.1.5: When transporting the instrument from one location to another, use a suitable shock absorbing material under the instrument.

10.1.6: Do not subject the instrument to harsh shocks.

10.2 ZAPP SYSTEM ELECTRICAL POWER AND CABLE INTERCONNECTIONS

Step 1 Connect all BNC cables to the appropriate receptacles as shown in Figure 7.1.2-1.

Step 2 Check to see that the INT/EXT switch on the Video Monitor is in the EXT position and both HI-Z/75Ω switches are in the correct position (Table 10.2-1).

MODULE	SWITCH	SETTING
ZAPP Processor Module	A/B-SYNC	B position
ZAPP Monitor	Top 75Ω/HI-Z	HI-Z
	Bottom 75Ω/HI-Z	75Ω
	INT/EXT	EXT
Mark II Monitor	Top 75Ω/HI-Z	HI-Z
	Bottom 75Ω/HI-Z	75Ω
	INT/EXT	INT
External Monitor	Top 75Ω/HI-Z	HI-Z
	Bottom 75Ω/HI-Z	75Ω
	INT/EXT	EXT

Table 10.2-1 Video Switch Settings

Step 3 Plug into an electrical power source as specified on the instrument electrical power label.

Step 4 Activate the power switches on the Interferogram Reader, Video Camera, Processor Module, and the Video Monitor.

CAUTION: Keep the shield provided over the platen of the Interferogram Reader when it is not in use to avoid damage to the Vidicon from overhead lights.

Step 5 Allow the Interferogram Reader and the Video Camera to warm-up for 30 minutes.

NOTE: Federal regulations require inclusion of the following statement in this manual.

CAUTION: This equipment generates, uses, and can radiate radio frequency energy and if not installed and used in accordance with the instructions manual, may cause interference to radio communications. As temporarily permitted by regulation it has not been tested for compliance with the limits for Class A computing devices pursuant to Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference. Operation of this equipment in a residential area is likely to cause interference in which case the user at his own expense will be required to take whatever measures may be required to correct the interference.

10.3 ZAPP SYSTEM/MARK II INTERCONNECTIONS

When the Mark II Mainframe is to be used in conjunction with the ZAPP System allowing real-time interferogram reduction, the CCTV camera in the Mark II Mainframe must be "slaved" to the camera in the Interferogram Reader. This is accomplished by changing the positions of two jumpers in the Mark II camera.

The Mark II Mainframe is normally shipped with its CCTV camera jumpers set for operation without the ZAPP System, unless it is shipped on the same order with a ZAPP System. In order to convert the camera for use with the ZAPP System, perform the following steps.

Step 1 Remove the six #8-32 screws securing the top cover of the Mark II Mainframe and lift off the cover.

CAUTION: Removal of the top cover of the Interferometer will result in access to the Laser Power Supply. The high voltage connectors attached to this power supply carry 7,500 volts. Do not disconnect them.

Step 2 Find the CCTV camera at the rear of the instrument.

Step 3 Follow the diagram on the camera cover to change the jumper positions to slave the camera to external sync. (The jumpers should be moved to the EXT and HI-Z positions.)

Step 4 Replace the top cover of the mainframe.