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Full Surface Testing of Grazing Incidence Mirrors

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Second Quarter Report

The major goal of the first two quarters of the Full Surface Interferometric Scanner (FSIS) project was the design of the optical, mechanical, and electrical/digital prototype. During this period, procurement, testing and the overall design of the mathematics, systems and algorithm development were also initiated.

The prototype design of the FSIS optical, mechanical, and electrical/digital system is complete following the schematic presented as fig. 1 in the first quarterly report of Dec. 5, 1990. Upon completion of the procurement and testing of the remaining mechanical components by the end of the third quarter, detailed drawings will be provided.

Prototype Mechanical Assembly

Figure 1 shows two views of a cylindrical optic material to be scanned relative to the optical head and resting on an automated mechanical stage which has been procured and tested. This stage has a 150 mm travel length and a step size of 0.001 mm (1 um). Testing found the maximum posistioning error over 144 mm of travel to be -0.00519 mm. This small amount of error is acceptable for our scanning method which will integrate overlapping subapertures. During the third quarter, the mechanical assemby for the optical head will be completed.

Prototype Optical Head Design

The optical head shown in Fig. 1 will be comprised of

1. A coherent light source which will include:

   a) low power stabilized He Ne laser,

   b) low power non-stabilized He Ne laser, and

   c) visible laser diodes.

2. Beam expanding and shaping optics with a beam splitter.

3. Grating type shearing device.

4. Beam forming optics composed of a collimating lens and a cylindrical lens which will create a reference cylindrical wave.

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The optical head illuminates the test cylindrical surface as shown in the perpendicular views (fig. 1). The beam is then reflected back into the system for a second pass and the interferogram of the surface is formed in the final image plane.

The test cylinder is mounted on a motorized assembly (see automated mechanical stage described above) to carry out full surface scanning, subaperture by subaperture. The motor control and scan sequence are computer controlled.

Electrical/Digital Assembly

The detection and acquisition system will be comprised of:

1. A CCD camera to capture interferogram images. A classical CCD array as well as a new square pixel CCD array will be evaluated.

2. An A/D converter and frame buffer will be used to digitize and store the interferogram data at video rates. The large amount of data resulting from the subaperture scans will require a frame buffer with 4 Mb of on board memory.

Software Design

The software systems design has been divided into six sub-systems projects.

1. Data acquisition software will define:

   a) camera sync status,

   b) image buffer format, and

   c) memory buffer size, startin address, and sequencing procedures.

2. A/D conversion and storage which will establish the

   a) CCD camera to A/D linkage and

   b) subaperture/interferogram to A/D converter to the #th buffer (from the captured sub-aperture interferograms).

3. Scanning controller software which will control the

   a) software driver for the stepping motor controller and

   b) software driver for the servo motor controller.

4. The data computation procedures will be further divided into eleven different functional sections or sub-programs which will compute and store:

a) Interferograms for each of the subapertures which are captured and stored in the assigned address buffers.

b) Phase measurements which will yield the x-y slope for each of the subapertures.

c) Digital integration which yields the wavefront shape for each of the subapertures.

d) Matching the full surface wavefront by least square fit on the overlap area among each adjacent sub-aperture.

e) Analysis of the surface wavefront shape in terms of the polynomial forms and the printout of each coefficient of the polynomial and the components of the aberration.

f) Comparison of the surface wavefront shape with theoretically designed functions or some other (external) measurement.

g) Extraction of the test parameters of the test object.

h) Signal averaging to reduce noise and improve accuracy.

i) Smoothing of both high and low pass filtering.

j) Data editing for scaling, rotation, and translation.

k) Data storage and transfer to other computers or devices.

5. Menu driven software will display in the following analytical results:

   a) 3-D isometric plots.

   b) Thin line (b&w or color) contour maps with an assigned level (calibration) in wavelengths or microns.

   c) Interactive section profile display.

   d) Solid modeling display.

   In addition, displays will present calculations of:

   a) Root-mean-square (RMS) values.

   b) Peak to valley (P-V) values.

   c) Histogram plotting.

   d) Polynomial fit coefficients.

   e) Aberrations.

6. The hard copy software will provide for the generation of:

   a) Interferograms taken from the TV monitor by polaroid camera.

   b) Interferograms printed by video printer.

   c) Display, tabulations and other numerical results printed by the laser printer.

The software design listings descibed in this section are a more detailed description of the heading presented in the flow chart (figure 2).

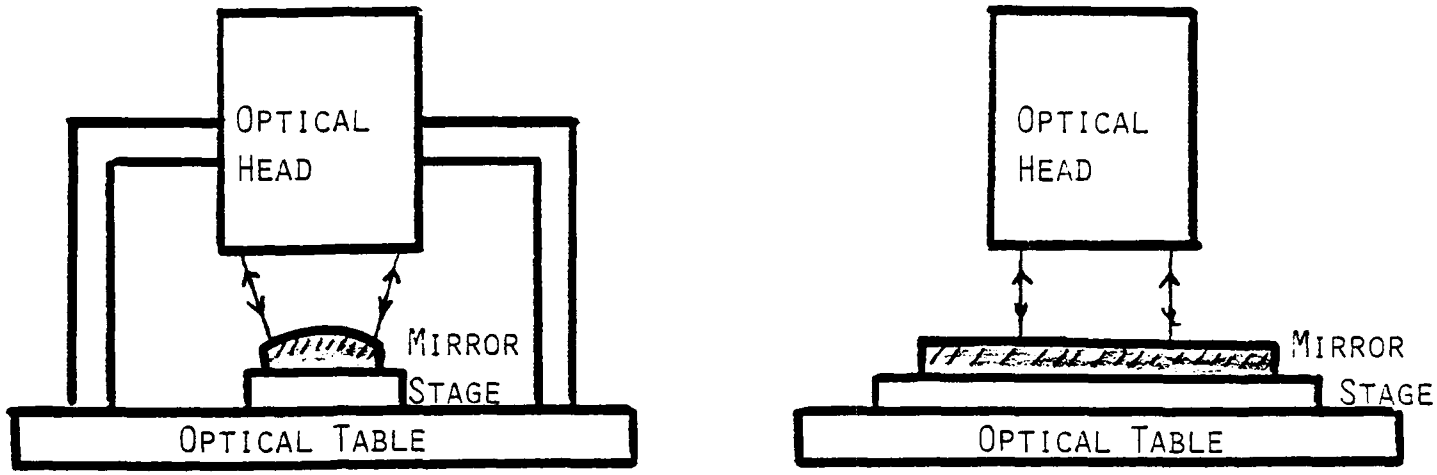
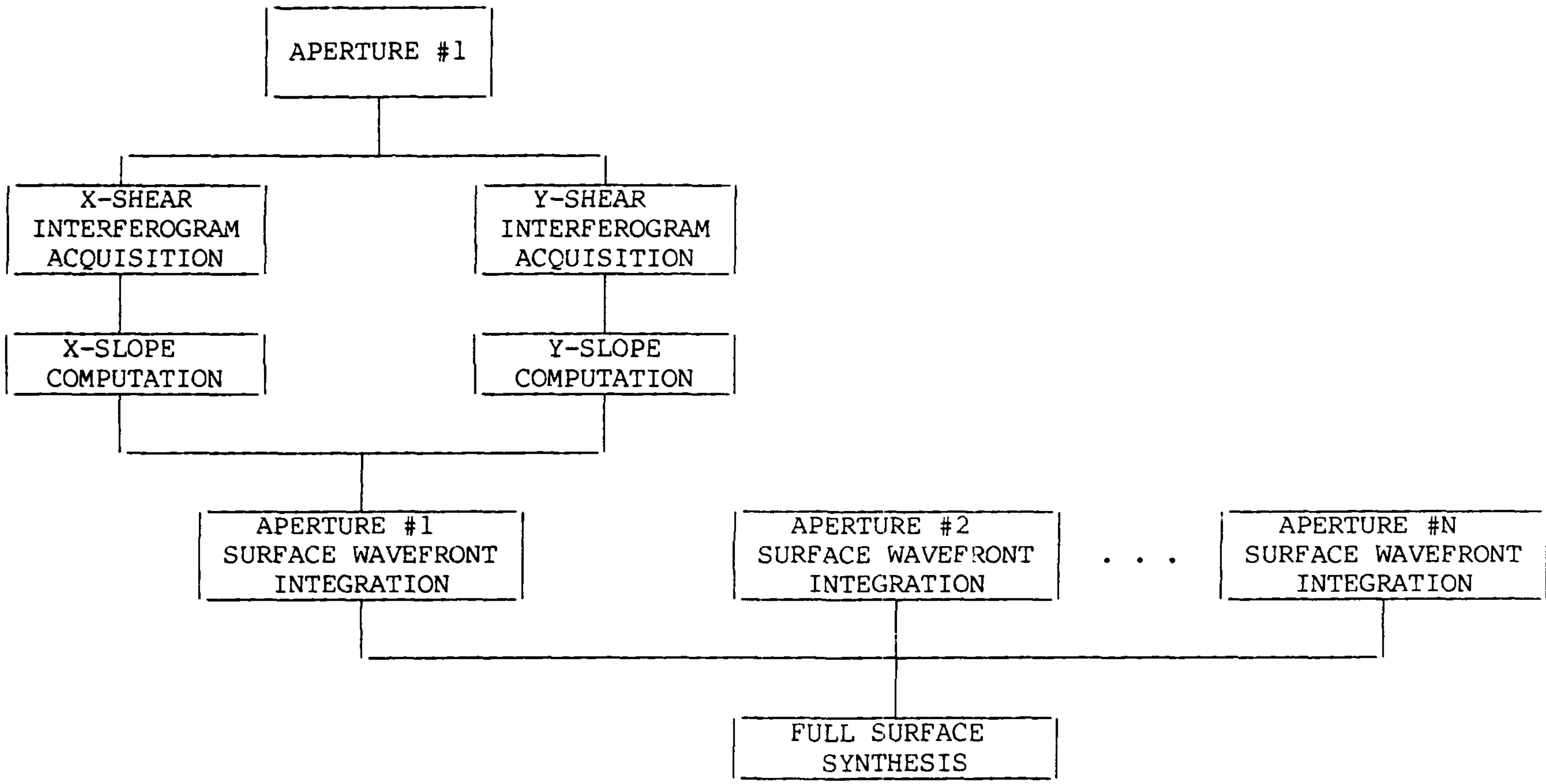


FIGURE 1: SCHEMATIC DIAGRAM OF THE COMPLETE SYSTEM



Flow chart of preliminary software.

Figure 2