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MASK AND PATTERN CHARACTERISTICS

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16. ABSTRACT

This document provides the individuals planning to use the mask and pattern facility with detailed information on equipment accuracy, limitations, and pattern-making capabilities. It also provides insight into potential areas of pattern applications, the sequence of mask making, as well as the possible inputs and outputs available to the user.

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MASK AND PATTERN CHARACTERISTICS

I. INTRODUCTION

Basic Capabilities

The mask and pattern facility of the Astrionics Laboratory, Marshall Space Flight Center, has the following capabilities:

1. Creation of fine or complex lines, shapes, and circle patterns. These are created with precision and excellent line edge quality.

2. A rapid turnaround time from program input to completed masks.

3. A rapid and easy method of creating data, arranging and formatting that data for use on the Mann (1600 and 2600 series) or the Gerber (100 and 2000 series) pattern generators (see Section II).

4. Shifting and repeating of a pattern (computerized step and repeat) (see Section III).

This facility has created masks or patterns for the following areas:

1. Monolithic masks for research and development microelectronic circuits.

2. Hybrid (electronic circuits) screening masks at final product size.

3. Microwave conductor patterns.

4. Optical grids and line patterns.

5. Holography patterns.

Basic Limitations

The quality of these patterns and lines is limited by the following:

1. The mechanical precision and the positional increments of the X and Y stages on the Pattern Generator (PG) and the Step and Repeat (S&R) Camera.

2. The transmitting optics of the two machines of item 1.

3. The emulsion of the photographic glass plate.

The basic or major limiting factor is the resolution of the optics (650 line pairs per mm). Further discussion of these limitations will follow.

II. PATTERN GENERATOR DETAILS

The function of the pattern generator is to respond to data commands such that an accurately sized and positioned rectangle will be exposed onto a photographic glass plate. The complex patterns and masks are created by a series of exposures, rectangle by rectangle.

The PG is limited in X and Y motion to a maximum of 10.16 cm (4000 mils). The generator is limited to positional increments in X and Y of 6.35 μm (0.25 mils). The minimum and maximum dimensions are 0 and 10.16 cm (4000 mils) in the X and Y directions.

Each rectangle will be positioned to within 0.25 μm (10×10^{-6} in.) relative to other exposures of that pattern. Absolute accuracy of placement will be 1.25 μm (50×10^{-6} in.) or better.

The rectangular height and width commands are limited to 12.7 μm (0.5 mil) increments, with a minimum size of 12.7 μm (0.5 mil) and a maximum size of 3048 μm (120 mils).

Each rectangle can be rotated through an angle (A) in increments of one degree. The accuracy of this angle is $\pm$10 minutes of arc. The two stages (X and Y) will move at right angles to each other to within 2 seconds of arc.

III. STEP AND REPEAT CAMERA SYSTEM DETAILS

The function of the step and repeat camera system is to accept a pattern on high resolution photographic glass plate and accurately aligned to a metal frame, to reduce that pattern image by a factor of 10, then step and repeat the image in a precise X, Y array. The X, Y array of images (after development processing) is the output of this system.

The step and repeat camera system is limited in X and Y motion to a maximum of 10.16 cm (4000 mils). The system is limited to positional increments of 25.4 μm (1 mil) for both X and Y steps. The minimum and maximum dimensions are 0 to 10.16 cm (4000 mils) in each direction.

Relative precision (one pattern to another) will be 0.25 μm (10×10^{-6} in.) or better. The X and Y stages will move at right angles to each other so as to be within 2 seconds of arc.

The step and repeat camera does not have the capability of rotating the pattern images.

The maximum image size that can be accepted by this system is limited by its optics and mechanics to 6.3 x 6.3 cm (2.5 x 2.5 in.). The maximum active area onto which the X, Y array can be placed is 6.3 x 6.3 cm (2.5 x 2.5 in.).

IV. OPTICS

The objective lens in the PG as well as the step and repeat camera are Ultra Mico Nikkor lens. They are capable of resolving a minimum of 650 line pairs per mm and are high resolution, flat field reduction lens with a 28 mm focal length and a f/1.8 is used.

V. AVAILABLE OUTPUTS (GLASS AND FILM)

Photographic Glass Sizes

The PG is now limited to two sizes of standard photographic glass plates 5.08 x 5.08 and 10.16 x 12.70 cm (2 x 2 and 4 x 5 in.). Due to holder

design, the active areas available for patterns are approximately 4 × 4 cm (1.6 × 1.6 in.) and 9.5 × 9.5 cm (3.75 × 3.75 in.), respectively.

The step and repeat camera system is limited to the standard 5.08 × 5.08 and 7.62 × 7.62 cm (2 × 2 and 3 × 3 in.) photographic glass plates. Due to holder design the active areas available for patterns are approximately 4 × 4 and 6.3 × 6.3 cm (1.6 × 1.6 and 2.5 × 2.5 in.), respectively.

Film Size

The PG and the step and repeat camera are limited to exposing glass plates. Contact prints of the patterns on the glass plates can be transferred to film 20 × 25 cm (8 × 10 in.) at a 1:1 ratio. Enlargements of the patterns can be made on film up to 20 × 25 cm (8 × 10 in.) also.

VI. SUMMARY OF SPECIFICATIONS

Pattern Generator

1.	Range of motion in X and Y	0 to 10.16 cm (4 in.)
2.	Positional increments in X and Y	6.35 μm (0.25 mil)
3.	Maximum rectangular height and width	3048 μm (120 mils)
4.	Increments of height and width	12.7 μm (0.5 mil)
5.	Increments of rotation	1 degree
6.	Accuracy of the angle of rotation	±10 minutes of arc
7.	Relative precision of patterns	0.25 μm (10×10^{-6} in.)
8.	Absolute accuracy of pattern positions	1.25 μm (50×10^{-6} in.)

9.	Motion of the two stages (X and Y) will be orthogonal to within	2 seconds of arc
10.	Maximum active area available for patterns	9.5 × 9.5 cm (3.75 × 3.75 in.)
11.	Resolution of the optics	650 line pairs per mm

Step and Repeat Camera System

1.	Range of motion in X and Y	0 to 10.16 cm (4 in.)
2.	Positional increments in X and Y	25.4 μm (1 mil)
3.	Image rotation not provided	
4.	Resolution of the optics	650 line pairs per mm
5.	Relative precision of patterns	0.25 μm (10×10^{-6} in.)
6.	Motion of the two stages (X and Y) will be orthogonal to within	2 seconds of arc
7.	Maximum input pattern image	6.3 × 6.3 cm (2.5 × 2.5 in.)
8.	Maximum array output area	6.3 × 6.3 cm (2.5 × 2.5 in.)

VII. MASK WORK FLOW DIAGRAM

The flow diagram (Fig. 1) will provide a better understanding of the mask-making process, the various inputs and outputs available to the user.

As shown in the figure, the following four types of inputs can be accepted:

1. Nine-track or seven-track magnetic tape with data commands capable of driving the Mann Pattern Generator (1600 series).

2. Punched paper tape (in ASC II code) capable of driving the Mann Pattern Generator.

3. Punched cards (using the EBCDIC code) formatted for the "MSFC Mask and Pattern Program."

4. A sketch (to scale) of the desired pattern.

Mask or pattern outputs can be provided on high resolution photographic glass plates, standard sizes 5.08 × 5.08, 7.62 × 7.62 cm (2 × 2, 3 × 3 in.) and 10.16 × 12.70 cm (4 × 5 in.) or on film of various sizes.

VIII. EXAMPLE

Figures 2 and 3 are examples of the work described in this document.

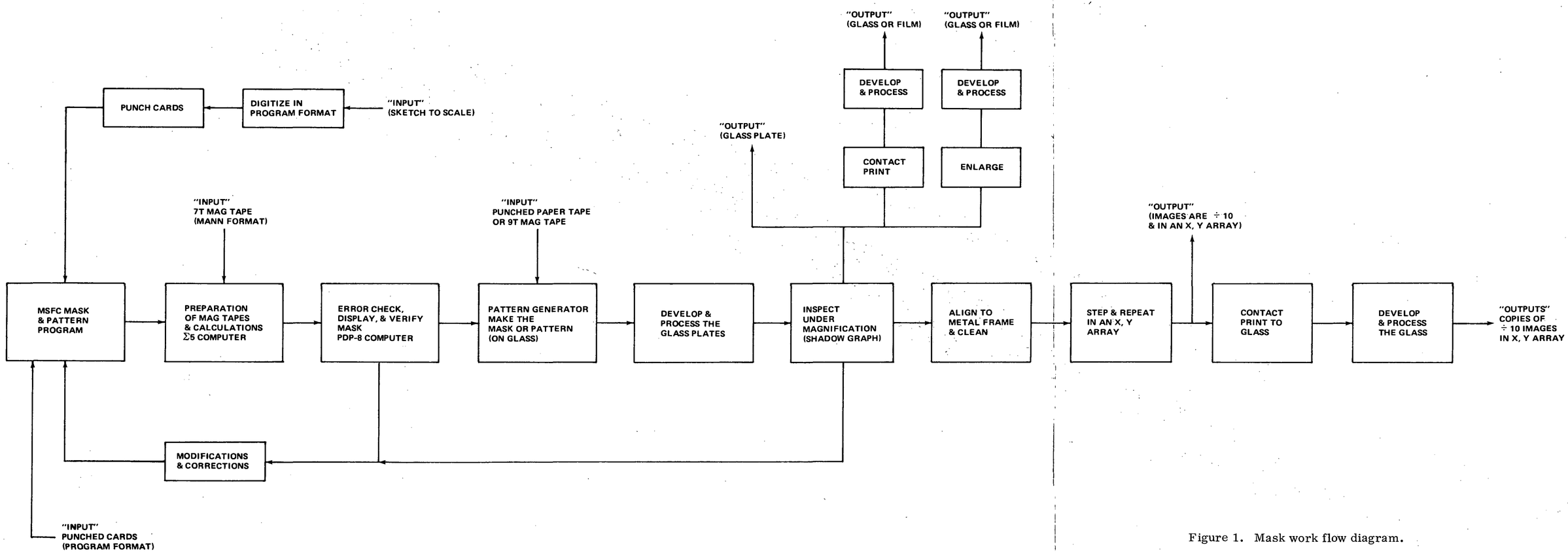

Figure 1. Mask work flow diagram.

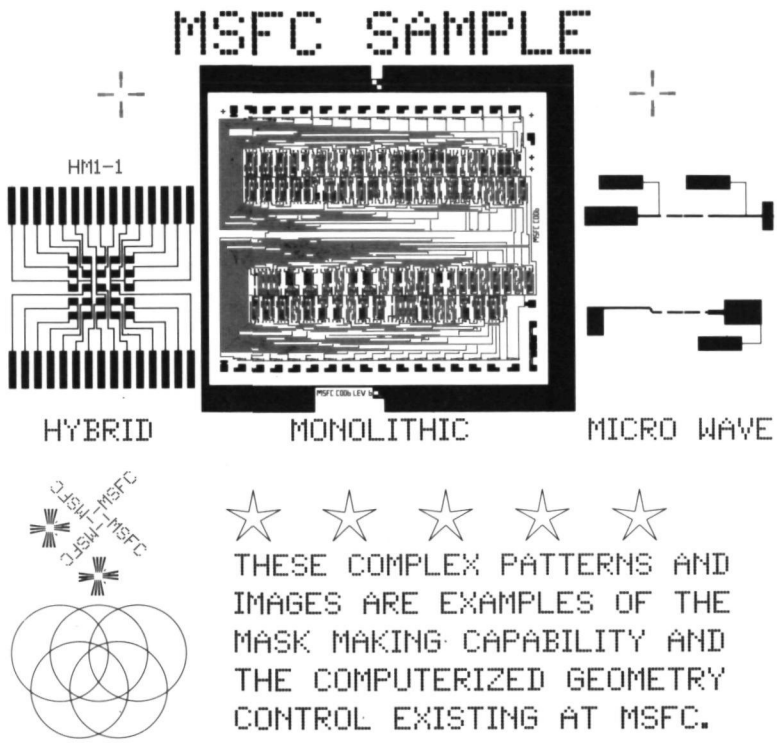

Figure 2. An example of the complex shapes and lines that can be created and reproduced.

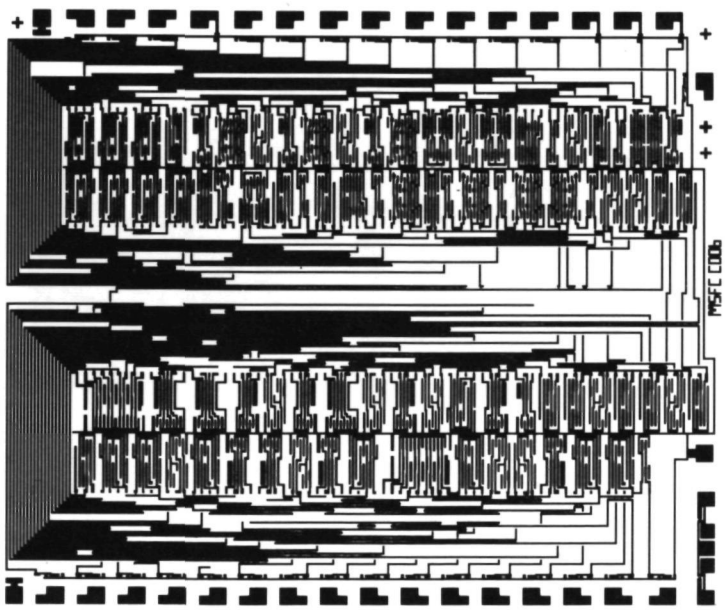

Figure 3. A CMOS monolithic mask enlarged and contact-printed.

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APPROVAL

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The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense or Atomic Energy Commission programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

This document has also been reviewed and approved for technical accuracy.

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