NASA TECHNICAL MEMORANDUM

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USER'S MANUAL FOR MSFC MASK AND DISPLAY PROGRAM

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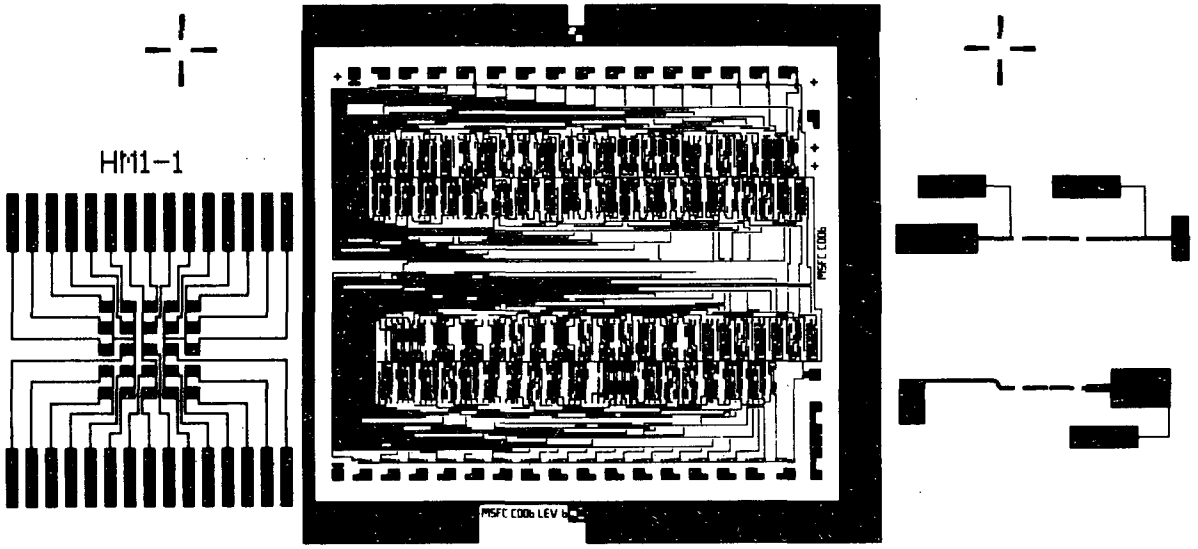
August 15, 1972

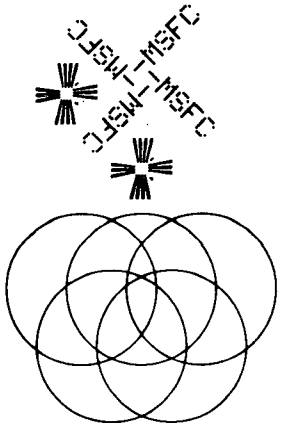
NASA

George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama

MSFC SAMPLE



HYBRID MONOLITHIC MICRO WAVE



THESE COMPLEX PATTERNS AND IMAGES ARE EXAMPLES OF THE MASK MAKING CAPABILITY AND THE COMPUTERIZED GEOMETRY CONTROL EXISTING AT MSFC.

EXAMPLE OF PROGRAM CAPABILITY

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*Employee of Sperry Rand Corp.

16. ABSTRACT

This report is intended to serve as the User's Manual for the MSFC Mask and Display Program. All program options and a detailed definition of the format of each input card (with examples) are given. Output options and their applications are detailed. A listing of the main program is provided and all update points are explained. All information required for a designer/draftsman (for program use) is provided, and it will not be necessary to become intimately familiar with the internal operations to effectively use the extensive capability it has to offer.

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I. INTRODUCTION

A. Objective and Advantages

The program objectives have been to provide the circuit or mask designer with a method of generating artwork data. These data are used by MSFC to drive the Mann Pattern Generator (MPG) for creating masks on those special devices not covered by the MSFC Banning Computer Aided Design System. The computer is an excellent vehicle for performing the calculation, data arranging, and tape preparation required to drive the pattern generator.

The advantages provided to the mask designer are as follows:

1. Provides the device and/or mask designer with a rapid and easy method of creating data, and arranging and formatting those data for use on the Mann (1600 series) or the Gerber (1000 and 2000 series) Pattern Generators.

2. Rapid turnaround time from data cards to completed masks.

3. Capability of creating complex lines, shapes, circles, and alphanumeric characters.

4. The capability of shifting and repeating a pattern (computerized steps and repeat).

This program has found application in the following areas:

1. Monolithic masks for research and development devices.

2. Hybrid screening masks at final product size (1X).

3. Microwave conductor patterns.

4. Grids and line patterns.

B. Program Intent

The Programers intended to allow the individuals preparing the data cards the utmost flexibility and simplicity to achieve the desired patterns. The designer's capability to produce various shapes and lines is limited only by the physical constraints of the pattern generator and the photographic emulsion that is exposed to create the images.

The data cards as called for by this report are intended to be used with the MSFC Mask and Display Program. This program has been written for the XDS Σ 5 Computer and is written in the modified (Σ 5) Fortran IV language. A program of this nature is dynamic and subject to revisions; the writer should be contacted for the latest revision.

II. GENERAL INFORMATION

A. Outputs

The present program outputs are magnetic tapes and a computer listing:

1. Nine-track Mann tape - This tape contains the pattern information used to expose the high-resolution glass plates. The format of this tape will be accepted by the Mann pattern (1600) system computer.

2. Seven-track Mann tape - This tape contains pattern information and is used to display the mask geometries on a Tektronix 611 CRT. This is done to check patterns before making the mask on the MPG.

3. Seven-track Gerber tape - This tape contains the pattern information as in 1. and 2. above and is used as a display tape. This tape can also be used to drive a Gerber (1000 and 2000 series) artwork generator.

4. The computer listing provides a card-by-card listing of the main program and the data cards.

As a final output, two types of mask images are produced. A preliminary set of expended mask images are produced (from one of the 7-track magnetic tapes) from the display on a CRT. A paper copy of the mask [approximately 15.24 by 17.98 cm (6 by 7 in.)] can be produced by copying the face of the CRT. This provides a preliminary geometry and alignment check prior to producing the glass masks. Finally, the glass mask set is exposed on the MPG and processed to produce the desired images.

B. Limitations of the MPG

The MPG is limited to exposing various height and width rectangles. All shapes will be created by incremental rectangular segments.

The MPG is limited in X-and-Y motion to a maximum of 10.16 cm (4 in.). The generator is limited to positional increments of 0.00064 cm (0.25 mil) (X1076.25, Y2000.50). The data cards may call for any decimal placement position; however, the program will round to the nearest 0.00064-cm (0.25-mil) position.

The angle (A) of rotation is limited to 1-deg increments. The data cards may call for any decimal parts of a degree; however, the program will round to the nearest full degree.

The height (H) and width (W) commands are limited to 0.00127-cm (0.5-mil) increments. The data cards may call for any decimal number; however, the program will round to the nearest 0.00127 cm (0.5 mil).

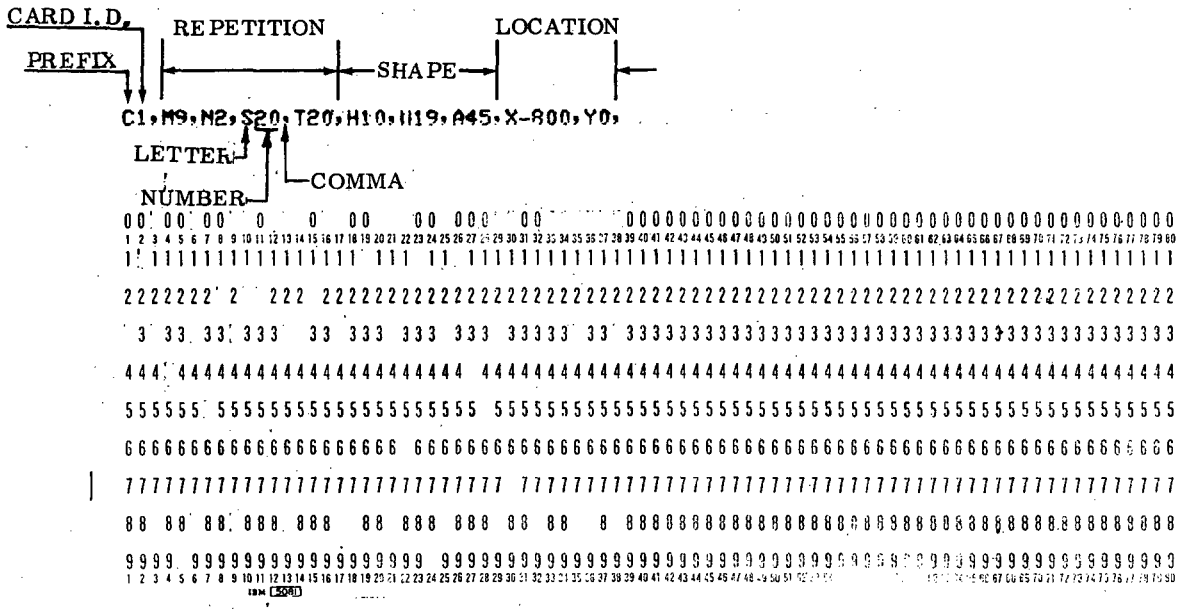
The MPG is now limited to two sizes of photographic glass plates: 5.08 by 5.08 and 10.16 by 12.7 cm (2 by 2 and 4 by 5 in.). Because of holder design, the active areas available for patterns are approximately 4.06 by 4.06 cm (1.6 by 1.6 in.) and 9.53 by 9.53 cm (3.75 by 3.75 in.).

The MPG will produce a mirror image of the data given. This must be given consideration when calling for a mirror or true image.

C. General Data Card Information

The punching of the data cards must be done with a card punch which uses the EBCDIC code. Six distinct groups of data cards exist. Each group is identified with a letter (A through F) which is used as a prefix to all cards belonging to that group. The data for each card must begin in column no. 1. The variables of each pattern command (groups C, D, E and F) may be seperated into three basic categories for conceptual understanding: repetition, shape, and location. Each command (groups C, D, E, and F) will consist of a letter, number, and comma, and in that order. The number following the prefix is for card identification, and the user can assign any number he desires. For reference purposes, this is usually 1 through (sequently) the number required to identify all cards. Imbedded blanks may not be included except between the letter and the number. The first card of each data group should be used to initialize all variables of that group. With the following exception; if an angle of zero is desired, then A need not be utilized, and if repetition is not desired, the variables M, N, S, and T need not be initialized until repetitions are required.

Example: Pattern and Data Commands



The data groups and the basic functions performed are as follows:

Data Group	Function
A	Adds a TTY text message to the Mann tape. This message is displayed to the operator of the pattern generator before exposing the plates. All unit or device identification information and special instructions for processing should be included here.
B	Specifies the scale factor, center of the mask, border, and true or mirror image.
C	Data that will create patterns by either the modified Mann format or the strip (lines capable of changing directions at right angles) format.
D	Data that will describe and create either patterns of lines at any angle (rounded to nearest degree) or arcs and circles.

Data Group	Function
E	Data that will describe and create alphanumeric characters to be put on the mask.
F	Data that will describe and create a standard flare-out pattern. (See Dwg. GC 362330.)

The range or limitations on the size of the numbers used for dimensions are not program limited; however, they are limited by the constraints of the MPG to:

10.16 cm [4 in. (4000 mils)] X motion

10.16 cm [4 in. (4000 mils)] Y motion

1-deg angles (A) increments

0.00127 cm (0.5 mil) height (H) and width (W) increments

0.00064 cm (0.25 mil) X and Y increments

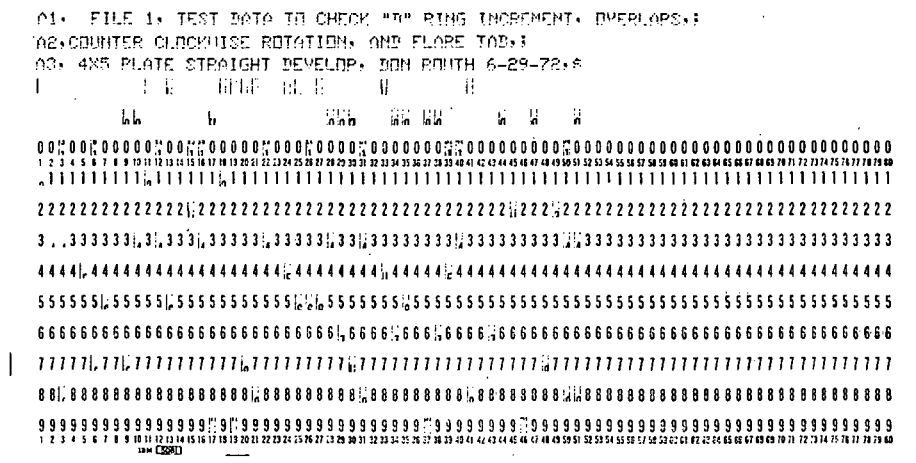
III. PREPARATION OF THE DATA CARDS IN SPECIFIC GROUPS

A. Group "A" Data (TTY Message on Magnetic Tape)

The message on the group A data cards will be written on the first record blocks of the magnetic tape and will be typed by the teletype just before exposure or during editing of that tape. It should be used to identify the forthcoming mask, for any special processing instructions needed, and to identify the magnetic tape file if so desired.

1. Data Cards. Each card begins with the card identification A1, A2, etc., followed by the message for the mask maker. The data cards end with a comma and semicolon (, ;). The last card in a data group ends with a comma and dollar sign (,$). The number following the A prefix is a card identifier, any value can be used, and this is typical for all card groups.

Example:



B. Group "B" Data (Scale Factor, Center Coordinate, Mirror Image, and Border)

1. Card Identification. Only one card is necessary in the Group B data, and it starts with the card identification B1, or B2, ... etc.

2. Scale Factor (SF). SF is a number relating input size (in drawing units) to output size (mil units).

The data unit for the MPG is a mil (1/1000 in.). However, any drawing unit can be used with the proper SF. SF is calculated such that the product with drawing units yields output in mil unit; i.e.,

Drawing Unit	Scale Factor
0.1 mil	0.1
mil	1
inch	1000
mm	39.370079 (= 100/2.54)
cm	393.70079 (= 1000/2.54)

3. Center Coordinate (XC and YC). The center coordinate (XC and YC is located at the center of the pattern arrangement and determined by the X and Y dimensions from the drawing origin. The center coordinate is required for the program to shift and place the mask center in the desired location on the active Mann plate [10.16 by 10.16 cm (4 by 4 in.) area].

To obtain XC and YC, draw the border line of the pattern as shown in Figure 1, and calculate the center coordinate of the border lines.

The values for XC and YC can also be obtained by superimposing the drawing of the mask over the 10.16 by 10.16 cm (4 by 4 in.) area (representing the MPG active field). XC and YC (Fig. 2) are the directed distances (in drawing units) from the drawing origin to the center of the 10.16 by 10.16 cm (4 by 4 in.) field.

Negative values for XC and YC will result in the center of the mask being positioned to the right and above the center of the active Mann area.

4. Image (MR). The image generated by the MPG will be either a true or mirror image, depending on the sign of MR.

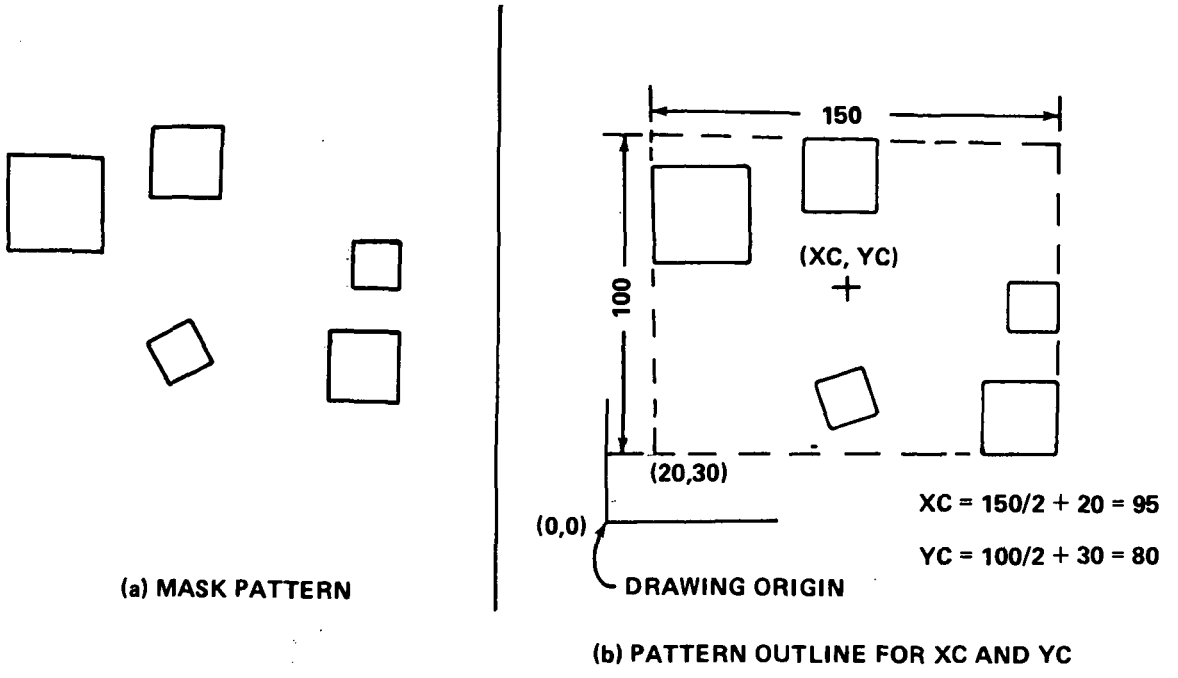


Figure 1. Center coordinate (XC and YC).

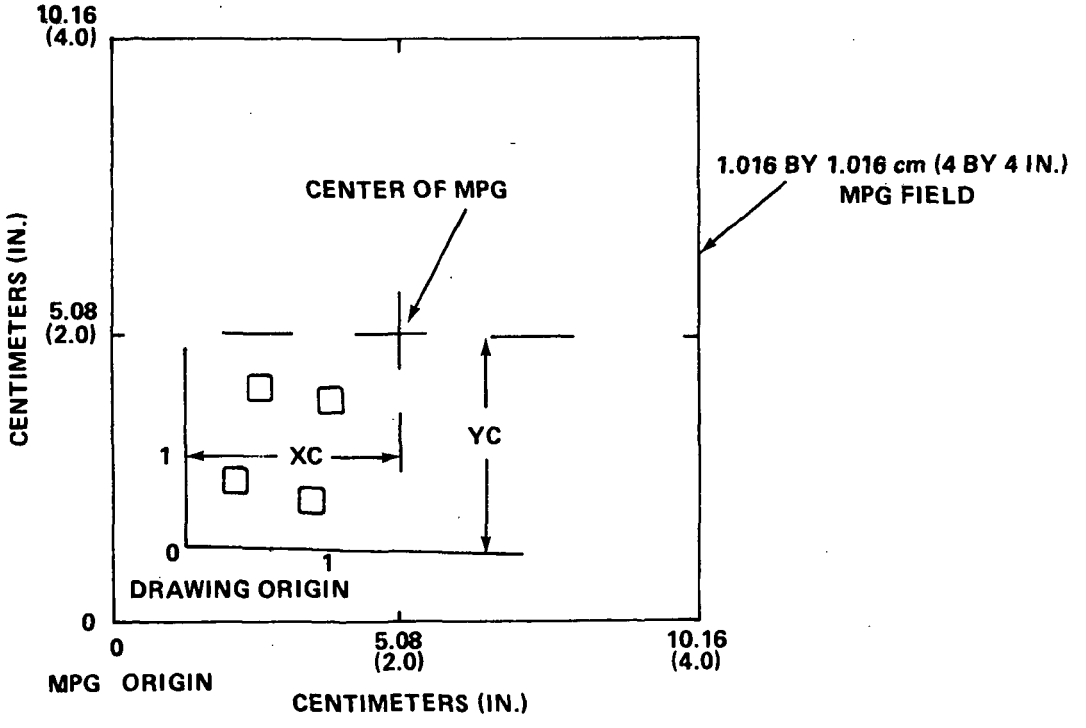


Figure 2. XC and YC.

If MR $\geq$ 1 (MR+1), the pattern on the plate will be identical to the drawing (true image) with the emulsion down and when transferred to the monolithic wafer, or MR with the emulsion up.

If MR $\leq$ -1 (MR-1), the pattern on the plate will be the MR of the drawing with the emulsion down, or the pattern will be identical to the drawing with the emulsion up.

4. Border. If the absolute value of the number assigned to the MR callout $\geq$ 3 (MR-3 or MR+3), a border will be exposed around the mask. If MR-3 is used, a mirror image of the data will be created and a border called for. If this feature is used, an instruction should be added to the A data group defining the inside height and width of the border in drawing units. The outside will be a square and only one dimension (in mil units) is required. The inside height and width should be given in drawing units and the outside dimension in mil units. A set of fiducial marks will be added, centered on the plate and with a separation distance of 4.064 cm (1600 mils). For Figure 3, SF is ten (10), W = H = 100 and S = 1400 mils.

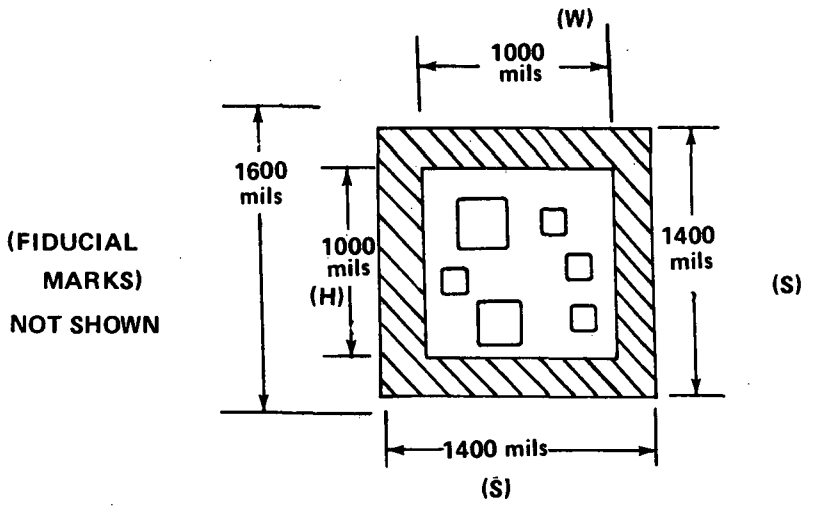
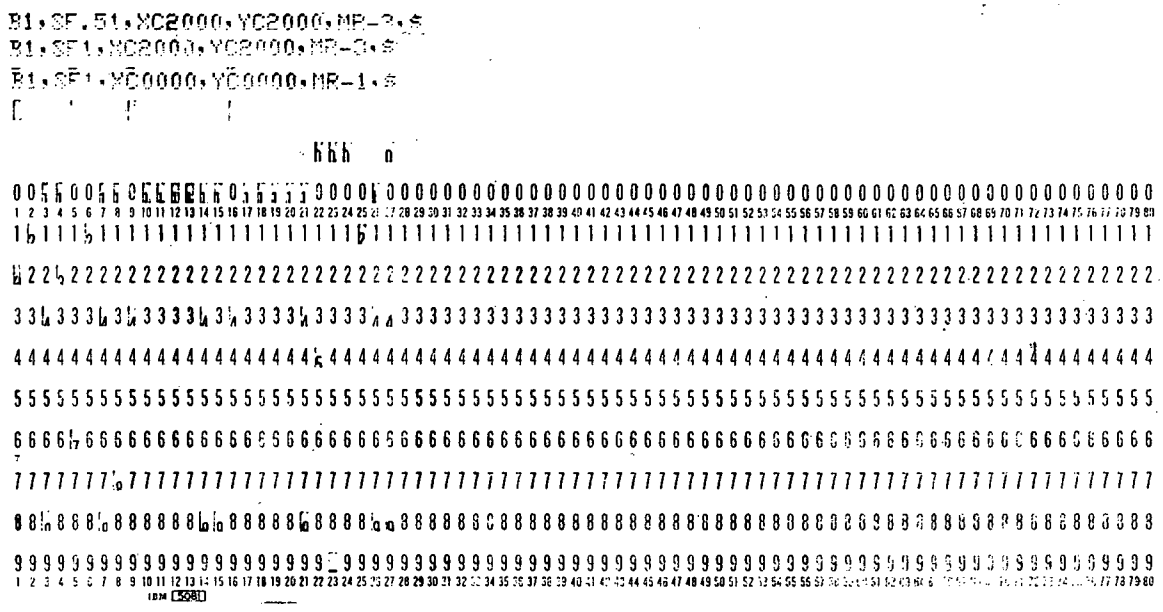


Figure 3. Example of a border.

Examples of Group B Data Cards:



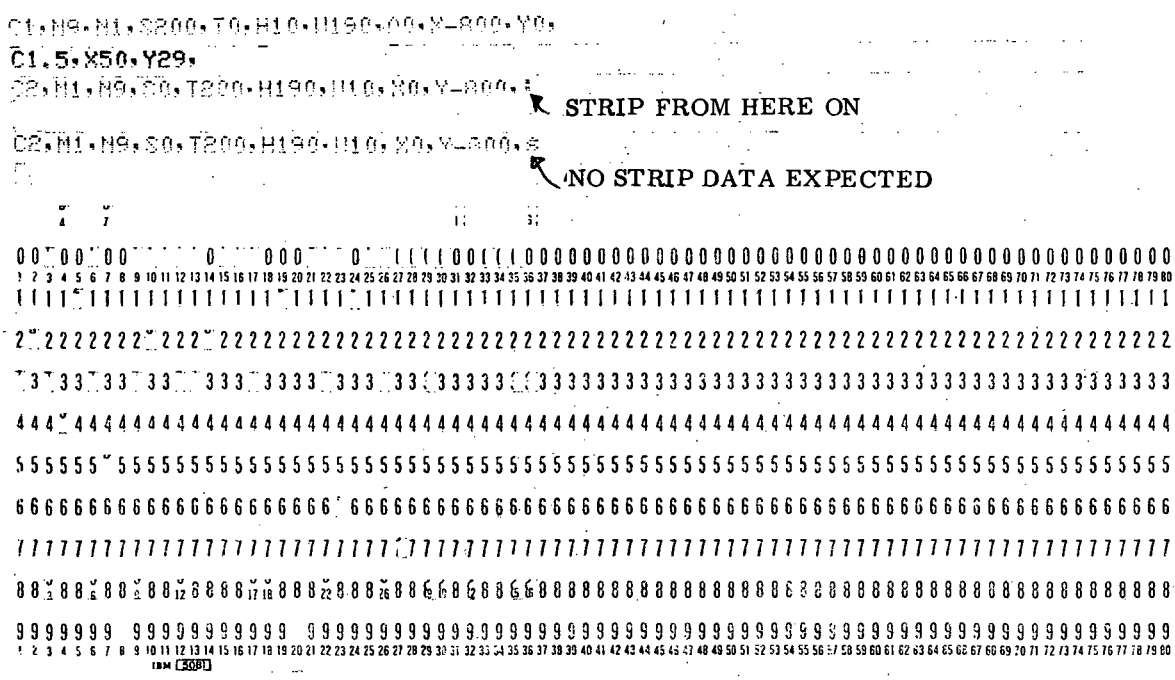
C. Group "C" Data (Modified Mann and Line Data for Patterns)

Each card begins with the card identification, C1, C2, C3, ... etc. The basic "C" group is composed of two types of pattern data: the extended Mann data and the line or strip data. These two types must be separated by a comma and semicolon (, ;). The last card of the "C" group ends with a comma and dollar sign (, $).

The data in this group can be extended to more than one card if so desired. When this is accomplished, any character A through F, any of the punctuations, or the variables cannot be used to identify the card (this is typical for all data groups). Several card identifiers may be put on one card if so desired. Any of the nine variables used in this format will carry forward from the last pattern if it is not stated. While the program provides considerable flexibility regarding the sequence of variables, it is recommended that the first card example on page 5 be used. Note that the sequence of data in the recommended format is repetition, shape, location.

1. Extended Mann Data. The first card must include the five variables (X, Y, A, H, and W) and if repetition is desired, the remaining four (M, N, S, and T) must be assigned values. Again, the "A" need not be utilized if an angle of zero (0) is desired. The last card of this subgroup should end with a comma and semicolon (, ;). The semicolon is a program flag used to indicate strip or line data cards expected from there on.

Examples:



If extended Mann data are not desired and strip data are forthcoming, then

C1, ;

(X, Y) are the center coordinate of the pattern, W and H are side lengths of the rectangle, and A is the rotation of the pattern as shown in Figure 4.

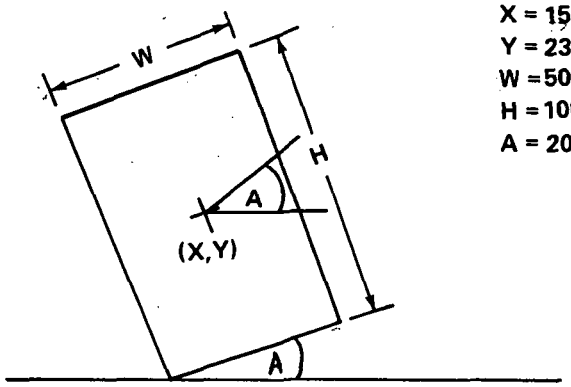


Figure 4. General single pattern in extended Mann format.

X, Y, W, H, and A are the simple Mann data of the lower left corner rectangle, and

M = number of patterns in X direction

N = number of patterns in Y direction

S = shift in X direction (drawing units)

T = shift in Y direction (drawing units)

An array of 3 by 2 repetitive rectangular patterns shown in Figure 5 can be produced with a single data card as,

M3, N2, S80, T150, AO, H100, W90 , X1500, Y2300,

The above example can be generalized for any number of repetitions if the patterns are within the range.

2. Strip or Right Angle Line Data. The first card in this format should include the update of the seven variables M, N, S, T, W, X, and Y (no H or A commands) or the variables will be carried forward from the modified Mann assignments. The initial X and Y values given will establish the starting point (an R or L and U or D command may be used). Following this, each X, Y, R, L, U, or D command will create a new line segment in the direction indicated. Any combination of the X, Y, R, L, U or D commands may be used to create an image. For the next pattern, each variable not restated will carry forward as a command; exception: the last values of X or Y will not carry forward.

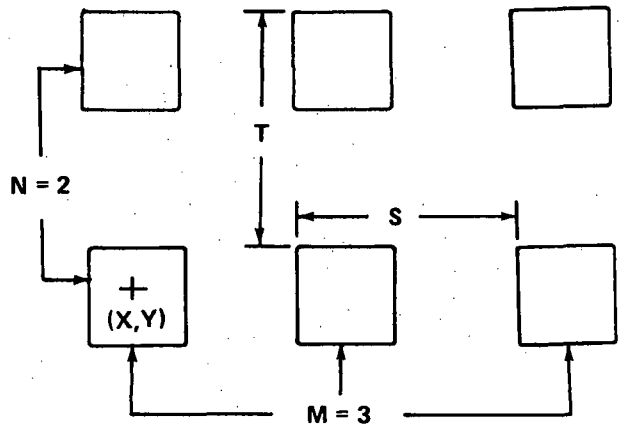


Figure 5. Repetitive patterns of 3 by 2 array.

Examples:

```
C7,M2,N2,S100,T100,U10,R500,U500,R200,U450,R400,D450,L300,
C8,X1000,Y750,R100,U100,X100,D100,$
```

The X and Y commands are absolute values; i.e., if X20 is commanded, the line will run horizontally to the point X20 from its previous point. However, if R20 is commanded, the line will be extended 20 units to the right. The following two cards (for the C data group) will create a pattern as given in Figure 6.

```
C1,;
C2,W10,X100,Y100,R300,U200,L300,D100,R200,$
```

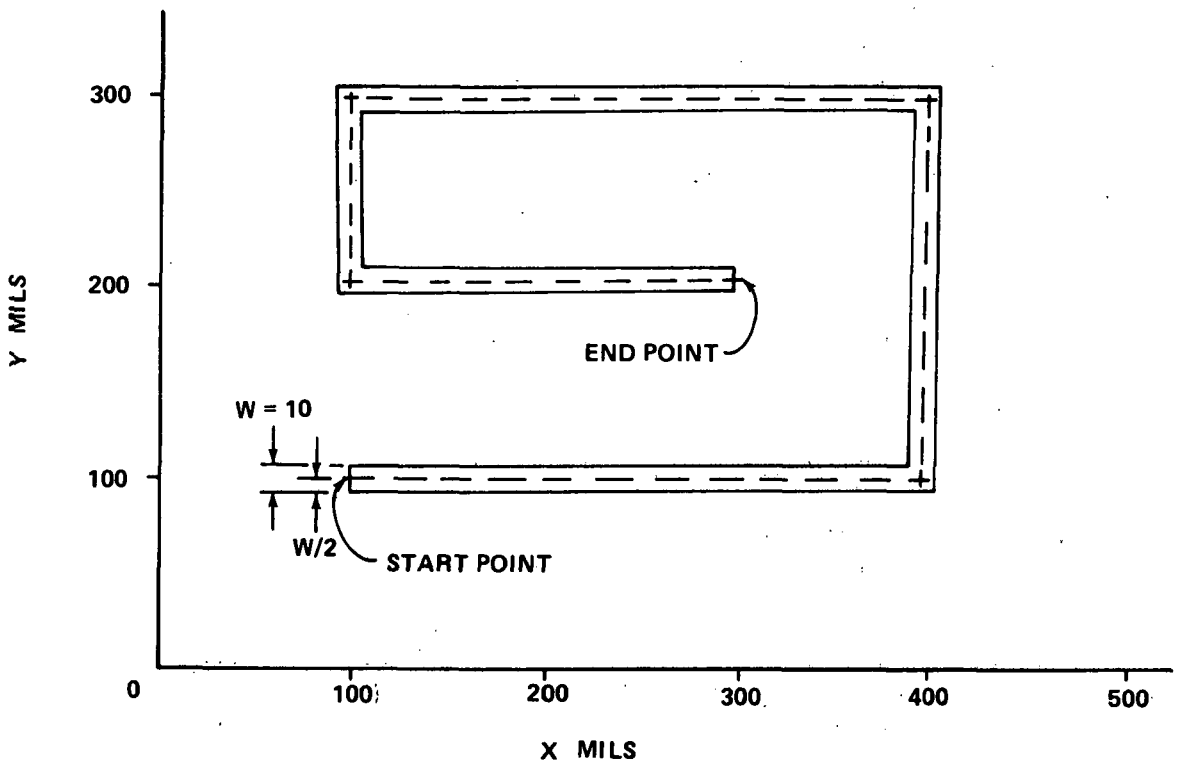


Figure 6. Strip pattern.

D. Group "D" Data (Strap or Lines at Any Angle and Arc or Circle)

Each card begins with the card identification, D1, D2, D3 .... etc. The strap format and the circle format are separated by the comma and

semicolon (, ;), and the last card is terminated with a comma and dollar sign (, $). With this data group, very complex figures and shapes can be simulated and produced with a high degree of detail and accuracy.

1. Strap (Lines at Any Angle). The standard M, N, S, T, and W commands are required and are followed by X and Y pairs. The X and Y pairs are the point-to-point information necessary to direct the line. While any angle can be specified by the X and Y data pairs, the angle and line data will be rounded to the nearest degree by the program. The program will calculate and position a rectangle at the junction of consecutively command lines for acute angles (Fig. 7). Obtuse angles are smoothed as shown by B-B in Figure 7. It will not perform this function for either end point. Data may extend to more than one card, or several D identifiers may appear on one card.

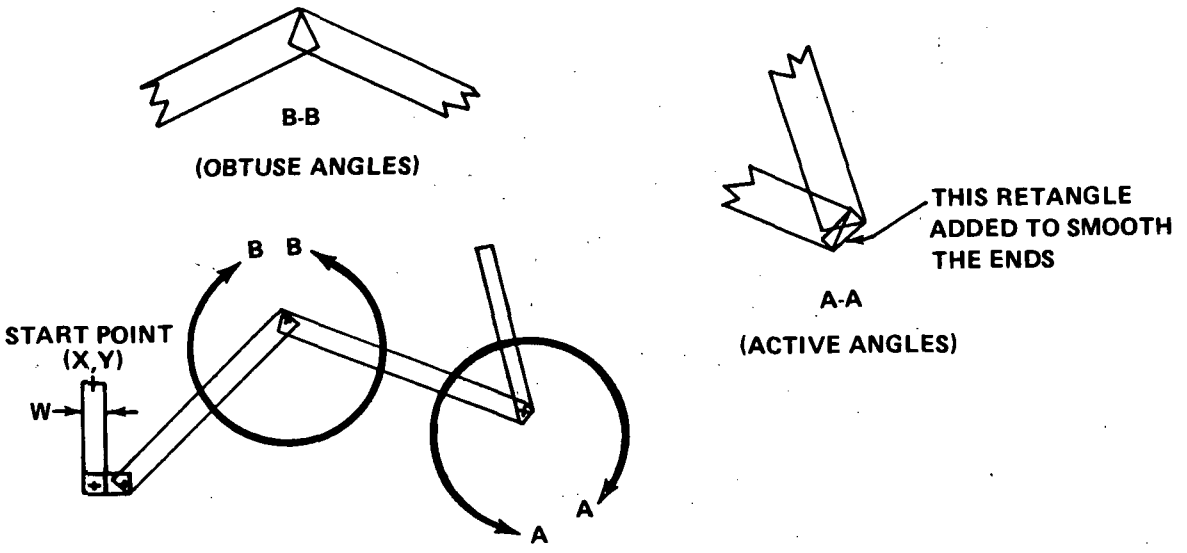


Figure 7. Acute and obtuse angles of strap data.

Examples:

```
D1,X110,Y1120,Y2980,X1150,Y2720,
D2,X530,Y2330,X510,Y2250,X480,Y2280,X430,Y2220,X750,Y2030,X750,Y2160,X510,Y2250,
D3,X490,Y2190,X180,Y1550,;
```

2. Ring or Circular Arc. To approximate an arc or circle, the additional commands of R, A, B, and I must be satisfied. If I is not specified, an increment of 5 deg will be used. Remember that Figure 8 is created with a counterclockwise rotation starting from A progressing to B.

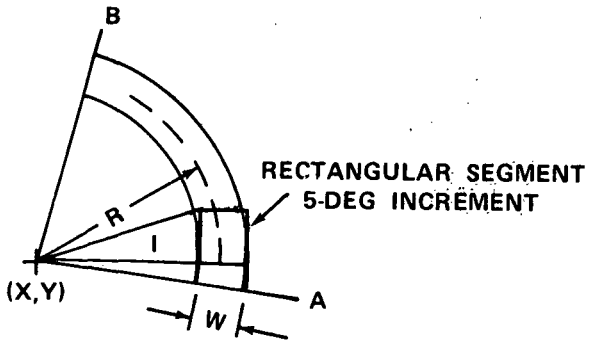
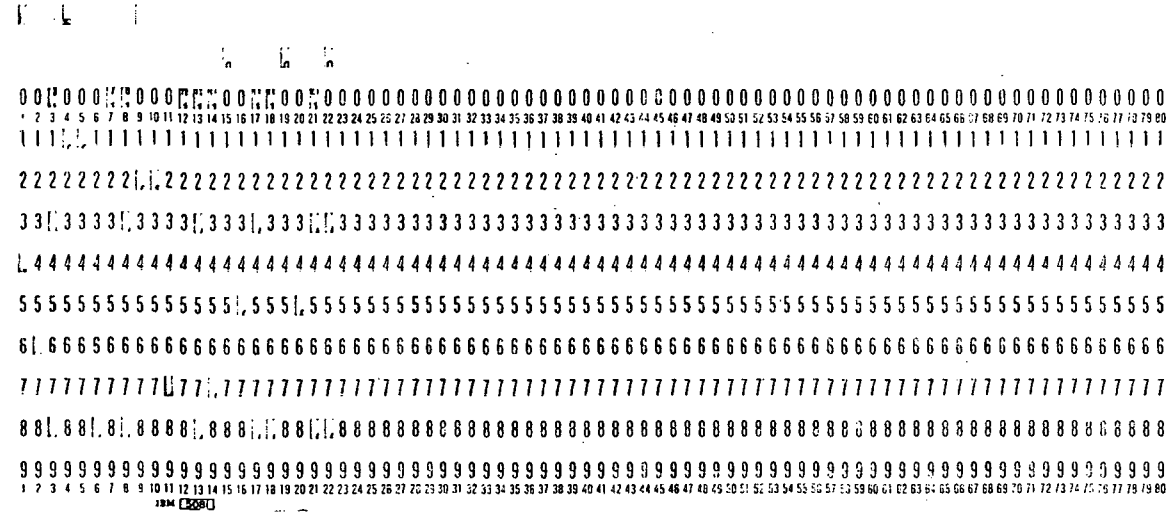


Figure 8. Circular arc.

Examples:

```
D4,M1,N1,S0,T0,W10,A0,B90,R180,X5,Y5,
D5,R300,
D6,A180,B270,X-5,Y-5,$
```



E. Group "E" Data (Alphanumerics)

Data group "E" starts with the card identification E1, E2, E3, . . . , etc., followed by M, N, S, T, W, A, X, Y, ' and the message to be added to the mask, then a comma and semicolon (, ;). The apostrophe (') is a program flag used as an indication that the alphanumeric message will follow. Each card ends with a comma and semicolon (, ;) except the last card which ends with a comma and dollar sign (, $).

The characters available for the designer to work with are:

0 through 9

A through Z

. , " : ' ? ! + - * / = ( ) % & #

1. Alphanumeric Data

X, Y – The coordinate of the lower left corner of the first character.

W — The width of a character including the space between adjacent letters.

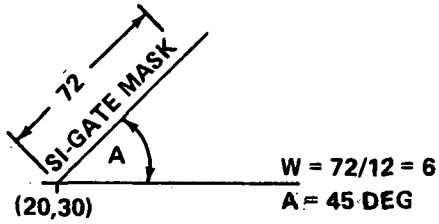
A — Will rotate the message through this angle (from the horizontal position) about the lower left corner of the first character.

W is determined as follows:

W — Total-message-length (drawing units)/number of characters.

2. Shape of Letter. The letter consists of a 5 by 7 array of squares. The ratio between width, height, and space between adjacent letters are 5:7:1. This is generally true; however, some letters such as I vary from this rule. For additional information on each letter, contact one of the writers. A distance of 2W between rows of the message will give a good appearance.

Examples:




```
F1,045,H6,X20,Y30,'SI-GATE MASK,;
F1,H12,X80,Y-65,'R,;
F2,H10,X92,Y-15,'HH2,;
F3,X-25,Y90,'HH1-2,$
```

F. Data Group "F" Flare Patterns

Data group F starts with the card identification F1, F2, F3, ..., etc., followed by M, N, S, T, A, W, H, X, and Y commands. Each card is ended with a comma except the last which is ended with a comma and dollar sign (, $). The unassigned variables will carry forward from the last pattern. Data may be extended from card to card and more than one F identifier may be put on one card.

A standard flare pattern has been established (see Figure 9 and drawing GC362330) which can be used to mount monolithic circuits, transistors, and/or diodes. This entire pattern can be placed by using this data group. The primary use of the finished product is that of a header, providing a means of connecting leads from an active device to a standard package.

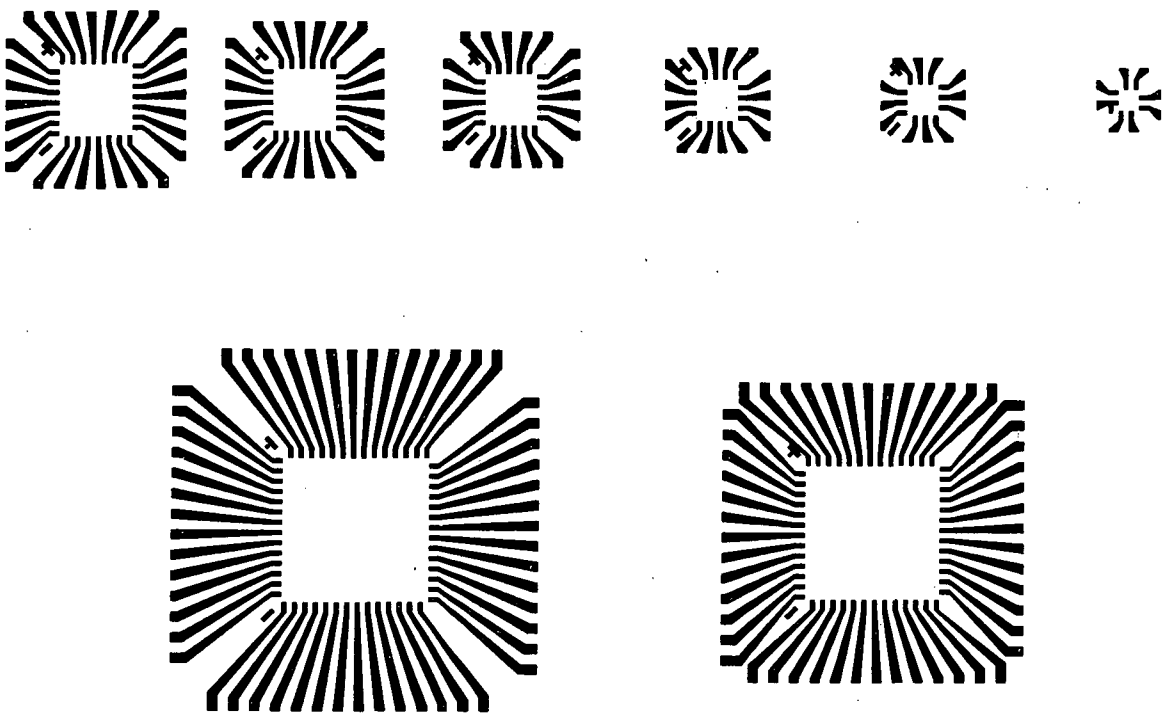


Figure 9. B/L flare-out patterns.

1. Flare Data

X, Y, — Center of the flare pattern (drawing units).

A — Will place two tabs to identify No. 1 lead side at 0-, 90-, 180-, or 270-deg position.

W — Width (mil units) as shown in dwg. GC362330

H — Height (mil units) as shown in dwg. GC362330

Examples:

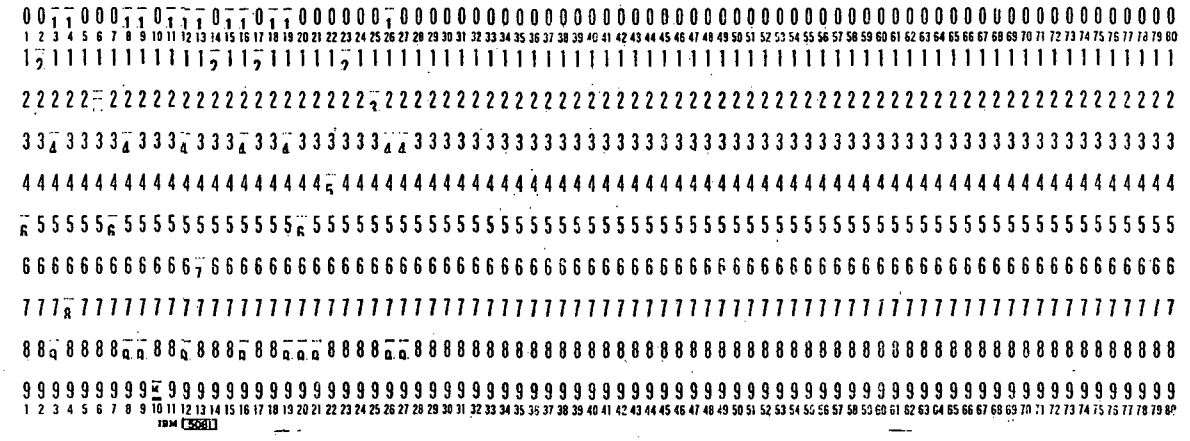
```
F1,A0,W25,H25,X-1500,Y-1500,

F2,A90,W200,H200,X-1500,Y1500,
F8,A270,Y-1000,$
```

IV. EXAMPLES OF DATA CARDS

A. Pattern and Alphanumerics

```
A1, FILE 0:  DUMMY CMOS, SILICON GATE, BEAM LEAD TEST CHIP;
A2,          MASK R004-11;
A3,          DUMMY BACK-ETCH MASK;
A4;
A5,          2 X 2 PLATE, REVERSOL PROCESSING;
A6,          BY WADE EWING, JUNE 14, 1972;$
B1,SF10,XC37.5,YC37.5,MR-1,$
C1,M2,S73.0,W4.0,H77.0,X1.0,Y37.5,
C2,M1,M2,T73.0,W77.0,H4.0,X37.5,Y1.0,
C10000,$
E1,X-25,Y90,I10,00,'HM1-2,$
```



Notes:

1. The information type-out to the MPG operator on cards A1 through A6.

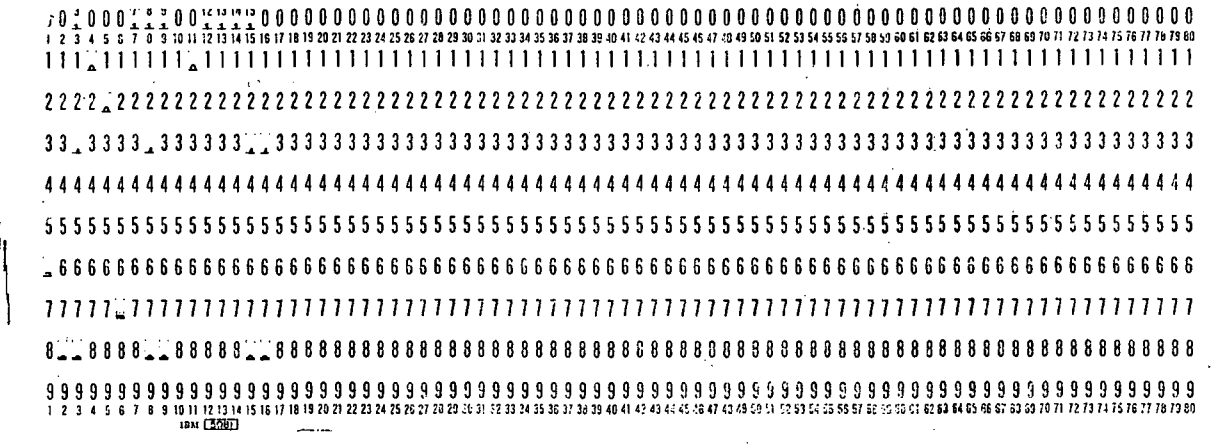
2. B1 card indicates a scale factor of 10, the drawing origin will be 375 mils in X and Y from the center of the MPG field. A mirror image of the data will be created on magnetic tape.

3. All patterns are created by the modified Mann format. Card C1 does not specify N, T, or A. N is assumed to be 1; therefore, T is not required and an A of zero is assumed by the program. The card identifier 1000 is used to indicate the end of the DATA C group.

4. E1 adds the characters "HM1-2" to the pattern; a long string of characters could have been added.

B. Patterns From C, D, and F Groups (No Alphanumerics)

```
A1; TEST TO CHECK D RING INCREMENT OVERLAPS. FLARE TAB.;
A2.COUNTERCLOCK WISE ROTATION, AND FLARE TAB.;
A2. 4X5 PLATE STRAIGHT DEVELOP. JON ROUTH 6-29-72.$
B1.SF1.XC0000.YC0000.MR-1.$
C1.M9.N1.S200.T0.H10.W190.A0.Y-800.Y0.
C2.N1.M9.S0.T200.H190.W10.A0.Y0.Y-800.;
C3.N1.T0.W15.X25.Y25.R100.W23.R52.R12.$
D.51.W10.X1120.Y2980.X1150.Y2720.;
D1.M1.N1.S0.T0.W10.A0.B90.R100.X5.Y5.
D2.R300.
R12.A270.R360.R800.$
F1.A0.W25.H25.X-1500.Y-1500.
F2.A90.W200.H200.X-1500.Y1500.
F3.A180.W200.H40.X1500.Y1500.
F4.A180.W40.H200.X1500.Y-1500.
F8.A270.Y-1000.$
```



Notes:

1. The center of this drawing is at the center of the MPG field.

2. C2 is in the modified Mann format, ended with a semicolon (;). C3 is in the strap or line-at-right-angle format with a mixture of X, Y, R, L, U, and D commands.

3. D.51 is a card added after the rest of the data cards had been prepared which is the reason for the ID number, it is in the strip (line at angle format) and ends with a semicolon (;).

4. D1, D2, and D12 are in the ARC format.

5. F1 through F8 call for various-sized flare patterns.

V. UPDATING THE MAIN PROGRAM

Update Points

Update points are provided to modify the program to fit the data cards and provide the desired outputs. The updates are as follows:

1. Files may be skipped on a magnetic tape before adding new files. This provides the capability of storing many jobs on one tape.

Example:

```
!ASSIGN M:EO, (OUTSN, PATT), (DEVICE, 9T)
!PFIL M:EO, (12)
```

The above two cards added to the assign cards section of the program will cause 12 files on the PATT tape to be skipped.

2. The file number of the Σ 5 listing may be initialized per the value given IFILE = 12. Each file of the program is then numbered successively thereafter.

3. Selection of the magnetic tapes to be written. See lines 18 through 22 of the main program. The last number assigned to each tape call-out will cause the tape to be called for or to be skipped.

If the last value assigned is

a. PATT = +1 make 9T Mann tape

b. PATT = -1 do not make 9T Mann tape

c. DISP = -1 no 7T DISP tape required

d. DISP = +1 make 7T Gerber tape

e. DISP = +2 make 7T Mann tape

If the five callouts above were in the program in this sequence, then no 9-track PATT would be called for, and a 7-track DISP tape would be called for and written in the 7T MANN format.

4. If a border is desired, then W, H, and S must be assigned values just before a "CALL ALINE" statement. (See lines 34 through 36 of the main program.)

```
16:59 AUG 14,'72 ID=0042-F01
JOB ROUTH,RD=005ROUTH(CAD),1
ASSIGN M:F1,(DEVICE,9T),(LABEL,SUBR),(IN),(SN,SURT),(BIN)
ASSIGN M:F0,(FILE,SUBS)
FMGE (ENTER,PERM)

  ASSIGN F:6,(DEVICE,9T),(OUTSN,PATT),(OUT)
  ASSIGN F:7,(DEVICE,7T),(OUTSN,DISP),(OUT),(BCD)
  ASSIGN M:B0,(FILE,PROG),(SAVE)
  ASSIGN M:F0,(OUTSN,PATT),(DEVICE,9T)
 FORTRAN LS,G0,B0
  EXT. FORTRAN IV, VERSION D00
```

```
     1.    C              MSFC MASK AND DISPLAY PROGRAM
     2.    C              PROGRAMMED BY D S WOO  (JUNE 5, 1972)
     3.
     4.    C  FORMAT OF THE DATA AND OTHER DETAILS CAN BE FOUND IN THE USERS
     5.    C  MANUAL, FOR DETAILS CONTACT DON ROUTH, S&E-ASIR AT MSFC, HUNTSVILLE.
     6.
     7.          COMMON X,Y,W,H,A,XO,YO,S,T,M,N,L,KS,NM,NB,MR,NFILE,
     8.         1 LET(100),DOG(50),COW(1100,5),IBUFF(130)
     9.    C  IFILE IDENTIFIES THE FIRST FILE OF THE COMPUTER LISTING AND
    10.    C  SHOULD CORRESPOND TO MAGNETIC TAPE FILE NUMBER.
    11.    C  ****PROGRAM UPDATE*********
    12.          IFILE=1
    13.    C  THE LAST NUMBER GIVEN PATT AND DISP DETERMINES IF THE TAPE
    14.    C  WILL BE CALLED FOR BY THE PROGRAM.
    15.    C  MANN PATT (+1), GERBER DISP (+1), MANN DISP (+2)
    16.    C  ****PROGRAM UPDATE*********
    17.
    18.          DISP=-1.
    19.          DISP=+1.
    20.          PATT=-1.
    21.          PATT=+1.
    22.          DISP=+2.
    23.
    24.    C  READ DATA GROUPS A,B,C,D,E, PRINT DATA, WRITES A GROUP
    25.    C  MESSAGES ON MAGNETIC TAPE.
    26.          LET(1)=1H ;LET(81)=NFILE=IFILE
    27.          DOG(34)=PATT; DOG(35)=DISP
    28.    110   CALL MASTER; IFILE=LET(81)
```

```
C  CALL OPTIONAL SUBROUTINES
C  IF A BORDER HAS BEEN REQUESTED ON B CARD OR FLARE PATTERNS REQUESTED
C  SET W,H,S, & THEN CALL ALINE OR CALL FLARE IS NEEDED.
C  ****PROGRAM UPDATE*********
      CALL TARGET
      CALL ALINE
C  CONVERTED TO MILS,SHIFT PATTERN, AND WRITE ON REQUESTED TAPES.
  120 CALL TAPES
      IF (DISP.GE.1.5) END FILE 7
      IF (PATT.GE.0.) KS=2; CALL MAGTAPE; KS=3; CALL MAGTAPE

C  NST IS THE FREQUENCE OF THE MANN DATA (MIL UNITS) PRINT OUT
C  IN THE COMPUTER LISTING.
      PRINT 10,NFILE; PRINT 20
      N1=1; N2=LET(82)
      NST=(N2-N1)/45+1
      PRINT 30, (I,(COW(I,J),J=1,5),I=N1,N2,NST)
  130 NFILE=NFILE+1
      IF (IFILE.LE.0 ) PRINT 40; GO TO 910
      GO TO 110

C  CONCLUSION
  910 IF (PATT.GE.0.) REWIND 6

      IF (DISP.GE.0.) REWIND 7
      CALL EXIT

   10 FORMAT(1H1,13X,4HFILE,I4,1H:,4X,24HTHE MANN DATA (MIL UNIT),/)
   20 FORMAT(9X,1HN,6X,1HX,9X,1HY,9X,1HW,9X,1HH,8X,1HA,2X,/)
   30 FORMAT(5X,I5,4F10.2,F7.1)
   40 FORMAT(1H1)
      END
```

VI. GLOSSARY OF VARIABLES AND TERMS

A. Variables

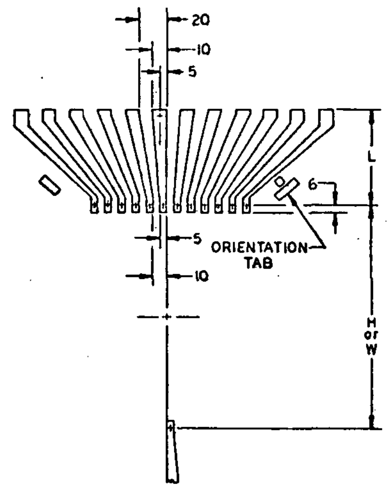
Variable	Function of the Variable and Associated Number Perform
M	Specifies the number of identical patterns in the X direction. For the first data card in each group (C, D, E, F), if no callout is made, the value one (1) is assigned by the program.
N	Specifies the number of identical patterns in the Y direction. For the first data card in each group (C, D, E, F), if no callout is made, the value one (1) is assigned by the program.
S	Shift between identical points of congruent patterns in the X direction (in drawing units). If no callout is made, the program will assume no repetitions. Used also to specify the outside dimension of the border (in mil units) when called for.
T	Same as "S" above except shift in the Y direction, T does not apply to the border.
W	Width of a rectangle, a line, or a character (in drawing units) or the flare pattern (in mil units).
H	Height of a rectangle (in drawing units) or flare pattern (in mil units).
A	Angle in degrees that the base or width side of a rectangle makes with the X axis. For the D data group, A is used to identify the angle at which the arc will begin. In the F group, A (angle) identifies one of four positions for the No. 1 lead.
B	Used in the D data group to identify the angle (deg) at which the arc will end.
I	Angle increments of rectangular segments which will be used to approximate the arc called for in the D data group. Five-deg increments will be used unless otherwise specified.

Variable	Function of the Variable and Associated Number Perform
X	Displacement in the horizontal direction from the drawing origin (in drawing units).
Y	Displacement in the vertical direction from the drawing origin (in drawing units).
R	In the C group, right displacement or +X displacement (in drawing units). In the D group, it is used to indicate the radius as measured from the X-Y point to the center of the arc (in drawing units).
L	Left motion (-X displacement) given in drawing units.
U	Up motion (+Y displacement) given in drawing units.
D	Down motion (-Y displacement) given in drawing units.

Following are variables which are used to specify more than one type command. A & B are two of the six data groups. They are used as prefixes on the data cards for these groups and are also used in D data group for the beginning and ending angles for the arc. R has a double use, it specifies the radius of arc in D data and specifies right motion for C data. S has a double use: it specifies horizontal shift for repetitive patterns and the outside dimension of the border.

B. Terms

Drawing Units	Related to final product size by (drawing units × scale factor = final product size in mil units).
Variable	One of the letters (M, N, S, T, X, etc.) as defined in the glossary.
Command	A letter, number, and comma sequence.
Pattern	A series of interconnected exposures.
Exposure	A single rectangle as created by one flash of the xenon light (of the MPG) on the photographic emulsion.



RANGE OF W OR H	N	L
25 X 25	SEE FIG. B	
22 – 31	1	10
32 – 41	2	15
42 – 51	3	20
52 – 61	4	25
62 – 71	5	35
72 – 81	6	40
82 – 91	7	45
92 – 101	8	55
102 – 111	9	65
112 – 121	10	65
122 – 131	11	75
132 – 141	12	75
142 – 151	13	75
152 – 161	14	100
162 – 171	15	100
172 – 181	16	100
182 – 191	17	100
192 – 201	18	150
202 – 211	19	150
212 – 221	20	150

NOTES:

1. ALL DIMENSIONS ARE IN MILS.
2. FORMULA TO DETERMINE NUMBER OF LEADS:

$$N = \text{Int.}\left(\frac{W \text{ or } H - 12}{10}\right)$$

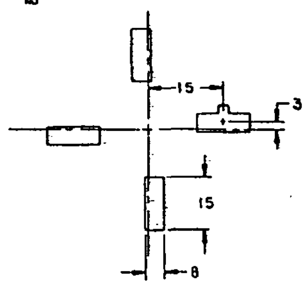


FIG. B

SEE ENGINEERING RECORDS

NEXT ASSY | USED ON

APPLICATION

UNLESS OTHERWISE SPECIFIED

ORIGINAL DATE OF DRAWING 21 AUG 72

BEAM LEAD FLAREOUT PATTERN

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

SIZE C | GC362330

CODE 14981

SCALE NONE

SHEET 1 OF 1

APPROVAL

USER'S MANUAL FOR MSFC MASK AND DISPLAY PROGRAM

By Donald Routh and Dae-Shik Woo

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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Chief, Technology Division

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Director, Astrionics Laboratory

MSFC—RSA, Ala

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