Appendix C. Mann 3000 Pattern Generator Format

The data format of the Mann 3000 Pattern Generator is a useful output format for maskmaking, since many mask makers have GCA Mann equipment, which can either work directly from this format or convert it appropriately. Electromask machines, which are also commonly used, have a similar but not identical format.

The following description is excerpted from "Type 3000 Pattern Generator Data Formats for Metric Units" from GCA/Burlington Division (there is also a format for English units, which we suggest you avoid). We assume use of 9-track tape, though the Mann 3000 can also accept paper tape or 7-track tape. The encoding is 800 bpi EBCDIC (not ASCII) with CRC and LRC characters, odd lateral parity and even longitudinal parity, and 512-character records (all this is standard data format for IBM-compatible magnetic tape).

Syntax

The true format is whatever the program accepts, which does not conform to a simple syntax, since it is not based on one; however, we have tried to formalize the format description, making safe assumptions where necessary. In the following syntax description, vertical bar | means *or*, curly brackets {} mean repetition zero or more times, nonterminals are written in lower case letters only, and everything else is a terminal.

```
tape        = <BOT> directory <EOF> {file <EOF>}
directory   = {entry} $
entry       = name filenumber numrecords
name        = namepart namepart
namepart    = cccccc | sccccc | ssccccc | sssccc | ssssscc | sssssc
filenumber  = digit digit digit digit
numrecords  = digit digit digit digit
file        = patternfile | otherfile
otherfile   = any legal EBCDIC characters
patternfile = { {newline} item {newline} } $
item        = message | exposure
message     = " {char} <CR>
exposure    = {parameter} ;
parameter   = X number | Y number | H number | W number | A number
newline     = <CR> | <LF>
number      = digit {digit}
char        = c | . | , | - | s
c           = letter | digit
s           = <SPACE>
letter      = A through Z
digit       = 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9
```

Semantics

The *directory* identifies each *patternfile* with a unique *name* (such as "_CHIP2_MASK3") made of two 6-character *nameparts* (right justified and padded with spaces if shorter). The patternfiles are numbered in order of occurrence on the tape from 0001 (up to 2047), and the *filenumbers* are put in the directory with the names. The number of 512-character records in each patternfile is also in the directory; according to Mann documentation, *numrecords* is not used and need not be correct, except that it must be 4 decimal digits to fit the format. Each directory *entry* is exactly 20 characters, so if you stick to one design per *tape*, the directory will fit in one record; if you need 25 or more entries, fill the last 12 characters of the record with spaces and use another record, even if only for the terminal $ (yes, that really is a dollar sign to terminate the file; an EOF won't work as it did on older Mann machines).

A word of caution is in order; the GCA document does not say that directory entries should be in the same order as the files, and implies that *otherfiles* may be included on the tape but must not be mentioned in the directory. But the GCA document on the 3600 format, which is in many ways similar, says that otherfiles must have a corresponding 20-character directory entry (though the characters have no meaning), and implies that their entries are in order. To be safe, do not put files other than patternfiles on the tape, and put directory entries in order.

Each patternfile is a description of a pattern to be generated (a mask layer, or reticle, for IC applications). After the operator tells the machine which pattern to run, each *item* in the file causes the machine to take an action; *messages* cause typeout on the terminal, and *exposures* cause boxes to be flashed on the plate (glass photographic plate). Messages are not of much use, except to type limericks to the operator (notice that spaces are allowed only in messages, not in exposures or between items). Exposures are the meat of the pattern generator format, and their semantics depend on the coordinate system.

The coordinate system is left-handed, with X increasing to the left and Y increasing upward as you look at the plate. All dimensions are positive, so the origin is the lower right corner. The center coordinate, for any plate size, is half the maximum coordinate. Thus the origin is not generally anywhere within a pattern, though it will be exactly at the corner of a maximum size pattern (10 cm square). See figure C.1 for the relation of the axes, the plate, and a typical exposure.

The units of measure for X and Y, which represent the center of a box, are 1 micron at the reticle (0.1 micron at the chip for 10X reticles); the range is 0 to 100000, which allows features to actually extend outside the 10 cm field, as long as their centers are within the field. All *numbers* are decimal integers, most significant *digit* first. Leading zeros should be suppressed, since the format actually restricts the number of digits that may be used to six after X or Y, four after H or W, and three after A (the digit-count limit was not indicated in the above syntax, is not a sufficient restriction, and may not even be necessary).

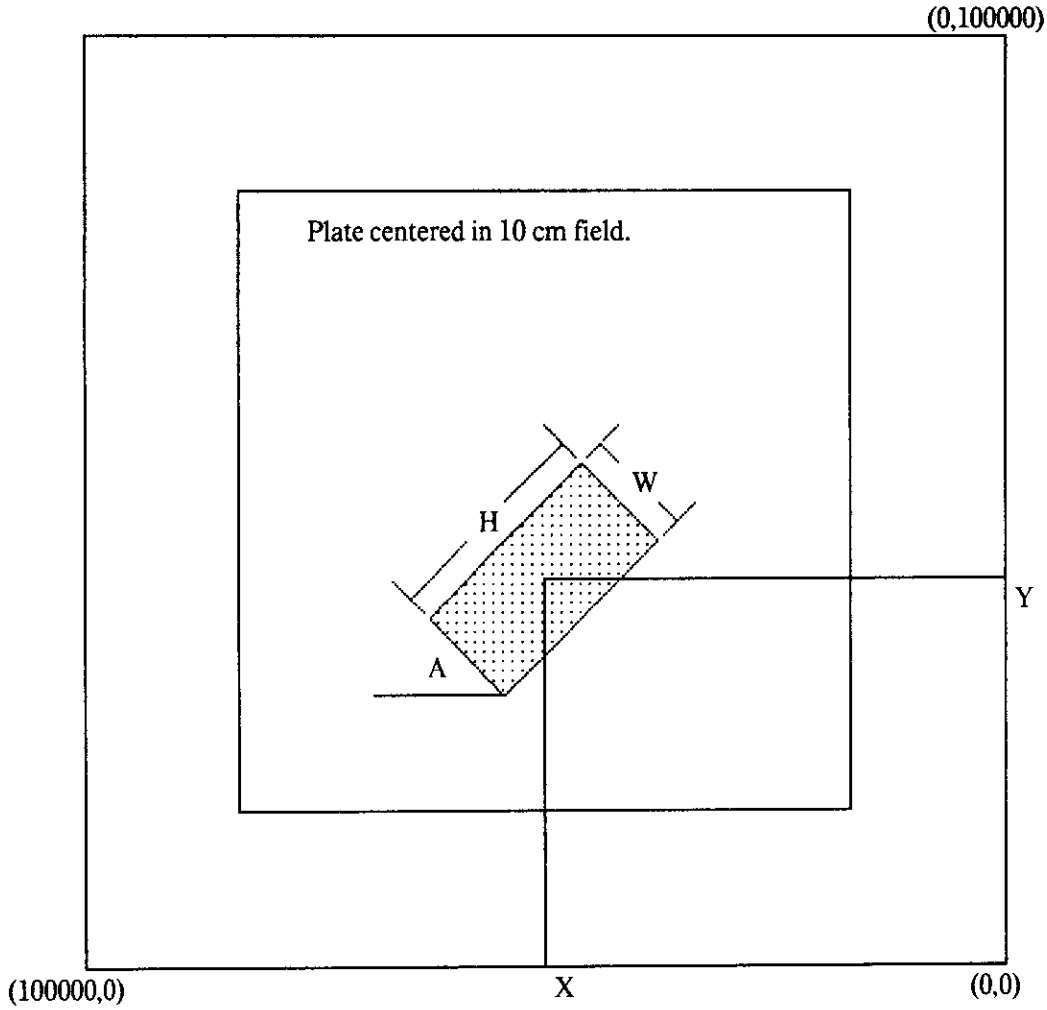

Figure C.1
Mann 3000 Coordinate System.

The height H and width W are measured in the same units as X and Y, but the range is 4 microns to 3000 microns. W is the box size along the X axis before rotation, and H is the perpendicular dimension.

The angle of rotation A is in units of 0.1 degree clockwise, in the range of 0 to 899 (89.9 degrees). If CIF is converted using dimensions directly and angles ArcTan(dir.X,dir.Y), which are counterclockwise from the +X axis, the result is the proper pattern, but mirrored. If X coordinates are then negated to fix mirroring, angles should also be negated (and everything converted to proper ranges).

As the syntax shows, each exposure consists of any number of *parameters*, terminated by a semicolon. The machine keeps track of the latest value of each of the five parameters X, Y, H, W, and A, and generates the aperature accordingly (the first exposure must specify all five). Thus, if no parameters are listed between semicolons, the same aperture should be flashed over again; in fact, the pattern generator notices this and prints a "format exception" error message. If some parameter is listed more than once between semicolons, only the latest value is used (this was useful for correcting mistakes when punching paper tapes).

CIF to Mann conversion

The conversion of CIF files to Mann format should soon be a widely available utility. Hopefully, this format description will help make it happen sooner. A major stumbling block in this effort will be *sorting*, since the pattern generator works very slowly if the exposures are not well sorted relative to the way the machine likes to work. Unfortunately, GCA has not been willing to provide an algorithm for doing a good sort. Due to the way the machine works, it is easy to sort wrong, i.e. much worse than no sort at all.

We do know some basic strategies for sorting, which we summarize here. The X dimension is called the *scan direction*, and the Y dimension is called the *stepover direction*, implying that the machine likes to scan continuously in X, while flashing everything within a narrow band in Y. But changing aperture size or angle is slow, and if a change is not finished by the time the X coordinate is reached an *overrun* occurs. Since the machine is moving in the X direction, overruns cannot be flashed immediately; rather than stop and come back, the machine saves the exposure in a buffer. When the overrun buffer is full, those exposures must then be done (which can be very slow, since they may be anywhere). To accommodate this feature, sort primarily on angle, then on aperture size, so changes occur only rarely (this also reduces the number of parameters in the patternfile). Then within each aperture sort spatially by whatever algorithm you think might work; don't try to outguess the machine.