DUCT 4.4 PICTURE INFORMATION

A DUCT PICTURE is a three-dimensional wire-frame model, i.e. curves may be interpolated to any degree of accuracy but no surface data may be extracted. For a full discussion of the use of pictures within the program see the DUCT 4.4 Reference Manual.

CURVE TYPES

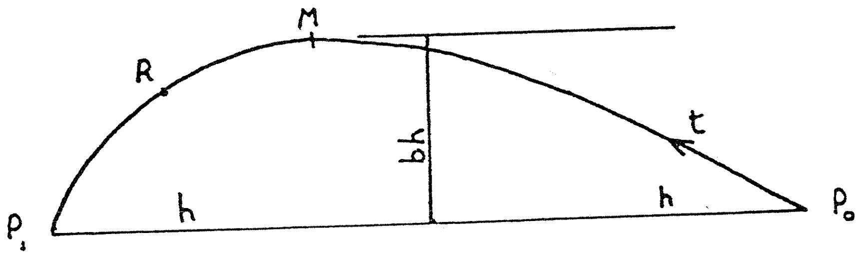
The curves in a picture may be of three basic types, straight lines, conic arcs, or Bezier spans. A picture may contain

STRAIGHT LINES

are represented by a series of three-dimensional points, or pixels, which are to be joined by straight lines.

CONIC ARCS

are represented by a series of pixels which are alternately end points and mid-points of arc spans. Therefore there are always (2n+1) pixels in a conic arc, where n is the number of spans. Each mid-point has an associated a scalar shape factor s. Consider the representation of a single span, with end points P and P , and mid point M.



A point R on the arc is given by the rational parametric quadratic expression

$$\underline{R} = \frac{f(1-2t)[(1-t)\underline{P_0} - t\underline{P_1}] + 4t(1-t)M}{f(1-2t)^2 + 4t(1-t)} \qquad (1)$$

where t is a parameter which ranges from 0 at P through 0.5 at M to 1 at P . In this equation $f = 1 + sb^2$, where s is the shape factor, and b is the bulge factor given by

$$b = \frac{2\left|(\underline{M} - \underline{P_0}) \wedge (\underline{P_1} - \underline{P_0})\right|}{\left|\underline{P_1} - \underline{P_0}\right|^2} \qquad (2)$$

This representation of an arc has the following properties:

i) M is at
the point on the arc which is furthest from the chord
P P . If s = 1, and M is equidistant from P and P
, then the arc

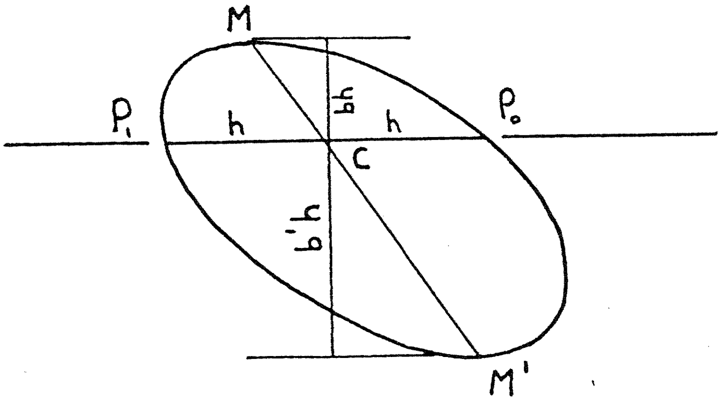
ii) If s = 1,
and M is elsewhere, or if s has any positive value ot
her than 1, then the arc is elliptic.

iii) If s = 0,
the arc is parabolic.

iv) If s < 0 and f > 0,
the arc is hyperbolic.

v) If f < 0
then equation (1) represents the ´wrong´ half of the
hyperbola. If this happens the program interpolates
the arc as a pair of straight lines PM and MP

When the arc is mutated by rotation or isotropic expansion the end and mid-points are mutated and the shape factor is unaltered. When it is expanded anisotropically or projected orthogonally it is necessary torecalculate the shape factor.



Let M be the mid-point of the complementary arc, i.e. the point furthest from the chord. This point may be found from this relation.

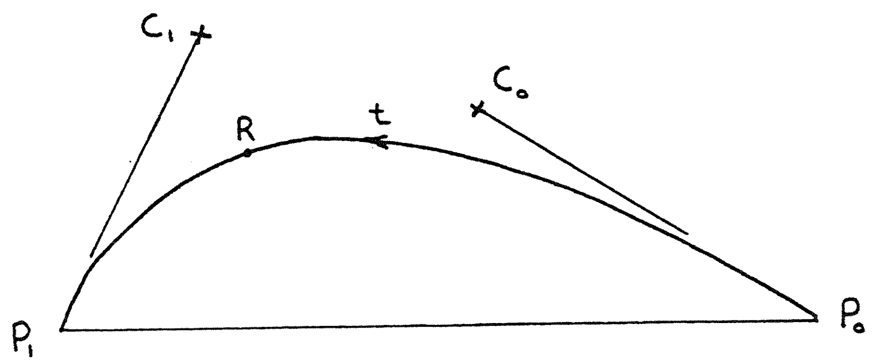
$$\frac{\underline{M}' - \underline{C}}{\underline{M} - \underline{C}} = \frac{-b'}{b} = \frac{-1}{sb^2} \qquad (3)$$

To find the shape factor after expansion or projection, it is necessary first tofind M , then to mutate M along with the other points, and then recalculate s.

When projecting in perspective the situation is more complicated because in general M does not remain the mid-point. The program does not handle this case properly.

BEZIER SPANS

are represented by a series of pixels which are successively an end point, two control points, an end point, two control points etc. Therefore, for n spans there are (3n+1) pixels. Consider a single span with end points P and P and control points C and C .



A point R on the curve is given by the parametric cubic expression

$$\underline{R} = \underline{P_0}\,(1-t)^3 + \underline{C_0}\,.\,3t\,(1-t)^2 + \underline{C_1}\,.\,3t^2(1-t) + \underline{P_1}\,t^3$$

where t is a parameter which ranges from 0 at P to 1 at P . The properties of this equation are described elsewhere, e.g. Faux and Pratt.

When the span is mutated by rotation, expansion or projection, it is necessary only to mutate the end and control points

DUCT 4.4 PICTURE INFORMATION

FILE STRUCTURE

A picture file is a character file containing the data for one picture in a fixed format.

The first line is a header, containing the file name and date. The second line contains the title and units of the current duct. There should then be a line containing only an asterisk in column two.

Only the first line is actually read by DUCT. All information down to the line containing an asterisk in column two is ignored. If the file is being generated by another system the second line can be omitted.

The next two lines contain integer and real counters:

```
  in (1X, 10I6) I1, I2, ..., I10       and
     (1X, 7F10.4) R1, R2, ..., R7      formats.
```

There is then one line in (1X, I11, 1X, I6) for each instruction.

There is then one line in (3 (1X, E14.7)) for each pixel, or (3 (1X, E14.7), 2 (1X, F10.4)) for each pixel with its associated parameters, according to the value of I1.

NB: For conic arcs the t parameter of the mid-point pixel contains the shape factor.

Following the pixel data will be any text and dimension data. This need not be defined, depending on the value of integer counter I1.

If text/dimension data is present the first line of this data specifies the number of text strings and dimensions in (1X,2I6). This is followed by the text data in (1X, I8, I3< I3, I2, 2F8.3, 17X, A) J1, J2, J3, J4, S1, S2, C1, but if there are more than 30 characters in the string it is continued onto the next line in (1X, A). The dimension data is defined after all the text strings. There is one line in 1X, 2 (I2, I8, I8), I8, I3, I3, I3, I2, F8.3) K1, K2, ..., K11, T1, for each dimension. If either the number of text strings or number of dimensions is zero that section of data is omitted.

INTEGER COUNTERS

There are ten integer counters. There are:

I1: Controls the file format. It is made up of the sum of the following parts:
   a) 4 a constant value to identify that the picture was written by version 4.3 or later of the ~~the~~ DUCT

program
b) 2 if the picture contains text or dimensions
c) 1 if the picture contains TU parameters

I2: Axis of projection. 1, 2, 3 = X, Y, Z

I3: -1, means that the picture was written by version 4.4 or later of the DUCT program and so has colours associated with each instruction

I4: Total number of instruction

I5: Total number of pixels

I6: If I6 = -2 then the picture contains only straight line moves, i.e. it has been processed by 'CONVERT PICTURE'

I7: = 2 if picture created in 2-D
= 3 if picture created in 3-D
= 0 undefined

I8, I9, I10: If any of these counters is non-zero then the picture has been probjected and only needs to have the 2-D contour pixels defined for contours to be used

REAL COUNTERS

There are seven real counters. These define the size of the picture and its projection height.

MIN	MAX		
R1,	R2	:	X limits on picture
R3,	R4	:	Y limits on picture
R5,	R6	:	Z limits on picture
R7		:	Projection height

INSTRUCTIONS

A picture always contains at least one instruction. The instructions control how the pixel data is interpreted. Each instruction comprises a pair of integers, the first is a code determining the line type, marking etc., while the second is the number of pixels in the line. The code is the sum of parts (i) to (vi) below.

i) ICOL the colour of the curve,
2048 times the colour of the curve, i.e. ICOL is
2048 if the curve is DUCT colour one, ICOL is
4096 if the curve is DUCT colour two, etc...

← important at doing toolpaths,

ii) IARC the curve type, this can be
0 pixels are linked by straight lines.
512 pixels define conic arcs, alternately end

example I saw had (6 5 0) ← and followed by end pt
in point

and mid-points.
1024 pixels define Bezier spans, alternately end points and pairs of control points.

In all cases the first pixel of the instruction is joined to the last pixel of the previous instruction by a straight line, unless IUPDN = 24, see (v) below. Whether this moves is visible depends on (v) below.

iii) IMARK the mark type, this can be

weird format types

0		no marks
64	X	cross
128	+	cross
192		square
256		diamond

iv) JMARK the position, this can be

0	mark first pixel only
32	mark all pixels with the mark defined by iii). On conic arcs and Bezier spans mark only the end points of spans and not the mid or control points.

v) IUPDN the pen control code, this can be

n.b. odd order

0	invisible move to first pixel, visible thereafter
8	all moves invisible
16	all moves visible
24	all moves visible, use last pixel of previous instruction as first pixel of this instruction.

interchangeably treated [illegible] - ignore the instruction of the last pixel

vi) IDASH the line type, this can be

0	solid continous lines for all visible moves
1	dashed lines for all visible moves
2	chained dashed lines for all visible moves

For example a code of 2048 means move invisibly to the first pixel and then draw continous straight lines in colour one to the other pixels. A code of 4897 (=4096 + 512 + 256 + 32 + 1) means move invisibly to the first pixel and then draw dashed conic arcs in colour two, marking the ends of each span with a .

TEXT COUNTERS

The counters for each text string have the following meanings:

J1: number of the associated pixel
J2: number of characters (maximum 80)
J3: colour of the text
J4: = 2 if the text height is defined in model units
    = 1 if the text height is defined in paper units
    = 0 if dimension format text string
S1: angle of text on the paper (in degrees)
S2: height of the text on the paper (in mm)

DIMENSION COUNTERS

There are twelve numbers defining each dimension:

K1, K2, K3 define the first point to the dimensioned K4, K5, K6 define the second point to be dimensioned

The first number in each triplet specifies the type of dimension point.

0 not defined
1 data pixel
2 point around a conic arc
3 point along a straight line

The remaining two numbers in each triplet are the pixel numbers of the ends of the span containing the required point.

K7 is the pixel

The remaining five numbers store parameters associated with the dimension.

K8 dimension type (see description of DTYPE in manual)
K9 colour of dimension
K10 number of decimal places to compute dimension to
K11 = 0 if unprojected (3-D)
    = 1 if projected (2-D)
T1 this is used in several different ways depending on the type of dimension:

- i) linear dimensions which are projected it stores the value of DANGLE - the angle of the dimension on the paper
- ii) for angular dimensions it holds the value of DQUADRANT - the quadrant being measured
- iii) for readial dimensions this number represents the parameters around arc of the point where the radial dimension should be drawn to

The format which controls how the value of the dimension is written is held as a text string defined at the positioning pixel. The attributes of the text determine the colour, size etc...

```
 DUCT MARK 4.4 PICTURE FILE  TEST  22 SEP 1987 09:55:50
No Title                MADE IN Units
*
    6     3    -1     4     7     0     0     0     0     0
  -45.0945   25.2207  -25.5625   42.7995   0.0000   0.0000   0.0000
      2112      1
      2072      1
      2056      2
      3096      3
-0.4450855E+02  0.1525937E+02  0.0000000E+00
 0.2190025E+02 -0.2263271E+02  0.0000000E+00
-0.4509451E+02 -0.2556251E+02  0.0000000E+00
 0.2563575E+01  0.3967437E+02  0.0000000E+00
 0.1662661E+02  0.4279949E+02  0.0000000E+00
 0.1662661E+02  0.2190025E+02  0.0000000E+00
 0.2522069E+02  0.2033769E+02  0.0000000E+00
    2     1
      3  3  2 0   0.000   3.000                 %mm
      1  7  3 1   0.000   3.000                 Pixel 1
 1     2     0 1     1     0     3  1  1  2 0 999.000
```